

# Cultural Evolution and Memetics

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## Glossary

**Culture:** the attitudes, beliefs, and behaviors that, for a certain group, define their general way of life and that they have taken over from others.

**Cultural evolution:** the development of culture over time, as conceptualized through the mechanisms of variation and natural selection of cultural elements

**Replicator:** an information pattern that is able to make copies of itself, typically with the help of another system. Examples are genes, memes, and (computer) viruses.

**Meme:** a cultural replicator; a unit of imitation or communication.

**Memplex (or meme complex):** a collection of mutually supporting memes, which tend to replicate together

**Memetics:** the theoretical and empirical science that studies the replication, spread and evolution of memes

**Fitness:** the overall success rate of a replicator, as determined by its degree of adaptation to its environment, and the three requirements of longevity, fecundity and copying-fidelity.

**Longevity:** the duration that an individual replicator survives.

**Fecundity:** the speed of reproduction of a replicator, as measured by the number of copies made per time unit

**Copying-fidelity:** the degree to which a replicator is accurately reproduced.

**Vertical transmission:** transmission of traits (memes or genes) from parents to offspring

**Horizontal transmission:** transmission of traits between individuals of the same generation

**Memotype:** a meme in the form of information held in an individual's memory.

**Mediotype:** a meme as expressed in an external medium, such as a text, an artefact, a song, or a behavior.

**Sociotype:** the group or community of individuals who hold a particular meme in their memory.

## Definition

Cultural traits are transmitted from person to person, similarly to genes or viruses. Cultural evolution therefore can be understood through the same basic mechanisms of reproduction, spread, variation, and natural selection that underlie biological evolution. This implies a shift from genes as units of biological information to a new type of units of cultural information: *memes*. The concept of meme can be defined as an information pattern, held in an individual's memory, which is capable of being copied to another individual's memory. Memetics can then be defined as the theoretical and empirical science that studies the replication, spread and evolution of memes. Memes differ in their degree of fitness, i.e. adaptedness to the socio-cultural environment in which they propagate. Fitter memes will be more successful in being communicated, "infecting" more individuals and thus spreading over a larger population. This biological analogy allows us to apply Darwinian concepts and theories to model cultural evolution.

## Introduction

The transmission of cultural traits is a process that in many ways resembles the spread of an infectious disease: the carrier of a certain idea, behavior or attitude directly or indirectly communicates this idea to another person, who now also becomes a carrier, ready to "infect" further people. For example, after you heard your neighbor whistling a catchy tune a couple of times, you may well start whistling it yourself, thus being ready to infect some more people with the tune. Similarly, after you hear your friends recommend a new electronic tool they have bought, you may well buy one yourself, and, if you like it, start recommending it to those acquaintances who do not know it yet. Thus, cultural traits can be seen as analogous to *mind viruses* (Dawkins, 1993; Brodie, 1996), *idea viruses* (Godin, 2002) or **thought contagions** (Lynch, 1996), which are reproduced from mind to mind via imitation or communication. A truly successful trait is one that spreads like an epidemic, infecting the whole of the population, in order to end up as a

stable, endemic component of that population's culture. For example, the tune may become part of the repertoire of "evergreens" that everyone knows, and the tool may become as widespread as the mobile phone or color television.

This virus metaphor is attractive in that it suggests a new perspective and new methods, such as epidemiology (Aunger, 2002), for studying the dynamics of culture. However, in order to turn it into a well-founded scientific theory, we need a deeper understanding of the underlying assumptions and implications of this analogy. For this, we can turn to the science that studies viruses and other self-reproducing systems: biology.

It is an old idea to see a correspondence between cultural and biological evolution, with cultural entities undergoing similar processes of variation, reproduction and natural selection as organisms or genes. Around the end of the 18<sup>th</sup> century Western linguists discovered the similarities between different languages. Sir William Jones gave birth to the field of language evolution studies, more specifically in the search for the origin of languages, and their "common descent" (van Wyhe, 2005). The German linguist August Schleicher attempted to recreate this common ancestor of languages, publishing tree-diagrams of languages as early as 1853, six years before Darwin published his *Origin of Species*. In an 1870 article one can already read: "How does a new style of architecture prevail? How, again, does fashion change? (...) or take language itself (...) it is the idea of 'Natural Selection' that was wanted" (Müller, 1870). The American philosopher and psychologist William James (1880) pointed out in a presentation to the Harvard Natural History Society that: "A remarkable parallel, ..., obtains between the facts of social evolution on the one hand, and of zoölogical evolution as expounded by Mr. Darwin on the other."

By the end of the 20<sup>th</sup> century, the parallel study of cultural and biological evolution got a new impetus with the introduction, by Richard Dawkins (1989, first edition 1976), of the concept of *meme* (for a review see (Aunger, 2004)). A meme, named in analogy with a gene, is defined as a cultural replicator, i.e. an element of culture such as a tradition, belief, idea, melody, or fashion, that can be held in memory and transmitted or copied to the memory of another person. The core idea of memetics is that memes differ in their degree of fitness, i.e. adaptedness to the socio-cultural environment in which they propagate (de Jong, 1999; Heylighen, 1998). Mutations and recombinations of existing ideas will produce a variety of memes that compete with each other for the attention of people. Fitter memes will be more successful in being communicated, "infecting" more individuals and thus spreading over a larger population. The resulting evolutionary dynamics is one of variation creating new meme variants, followed by natural selection retaining only the ones that are most fit. Thus, the Darwinian principle of the survival of the fittest can be seen to underlie cultural evolution as well as biological evolution (Aunger, 2001, 2003; Durham, 1991; Lumsden & Wilson, 1981).

The memetic perspective on culture is complementary to the traditional social science perspective, which focuses on the characteristics of the individuals and groups communicating rather than on the characteristics of the information being communicated. This does not imply a "memetic reductionism", which would deny individual control over what you communicate. It just notes that in many cases the dynamics of information propagation and the ensuing evolution of culture can be modeled more simply from the

"meme's point of view" than by analyzing the conscious or unconscious intentions of the communicating agents.

Over the past thirty years, several models of cultural evolution have been proposed that study the propagation of memes or similarly defined cultural traits (e.g. "culturgens" (Lumsden & Wilson, 1981) or "mnemons" (Campbell, 1974)). Most of those models are purely theoretical, proposing various conceptualizations, implications and speculations based on the memetic perspective (e.g. Blackmore, 2000; Dennett, 1995; Flinn & Alexander, 1982; Hull, 1982; Lake, 1998). Some studies are mathematical in nature, applying techniques from mathematical genetics or epidemiology to quantitatively estimate the spread of particular types of memes within a population (e.g. Cavalli-Sforza & Feldman, 1981; Lumsden & Wilson, 1981; Boyd & Richerson, 1985; Lynch, 1998). Others are computational, simulating the transmission of knowledge or behaviors between software agents (e.g. Gabora, 1995; Best, 1997; Bull, Holland & Blackmore, 2001). A few are observational case studies, where the spread of a particular cultural phenomenon, such as a chain letter, an urban legend, or a social stereotype, is investigated qualitatively or quantitatively (e.g. Goodenough & Dawkins, 2002; Schaller et al., 2002; Chielens, 2003, Bangerter & Heath, 2004).

However, in spite of these advances, the memetic perspective on culture is not very well developed yet, and remains controversial (Aunger, 2001; Atran, 2001; Edmonds, 2002). There are several reasons why memeticists have not yet been able to convince the bulk of social and cultural scientists of the soundness of their approach.

First, the analogy with the gene, and its embodiment as DNA, seems to indicate that a meme should have a clear, well-delineated, stable structure. (Although one should note that natural selection was proposed by Darwin well before genes were postulated by Mendel, and a century before their structure was elucidated by Watson and Crick). Cultural entities, such as beliefs, ideas, fashions, and norms, on the other hand are typically ambiguous, difficult to delimit and constantly changing. Memetic models that are based on "hard", explicitly defined units therefore only seem applicable to a very small subset of cultural phenomena, such as chain letters. However, the biological analogy does not imply such rigidity: unlike higher organisms, the genes of bacteria and viruses too are in a flux, constantly mutating and exchanging bits of DNA with other organisms, but that does not imply that they do not obey evolutionary principles.

A second criticism of the memetic approach is that people are not passive "vehicles" or "carriers" of ideas and beliefs, the way they may carry viruses. Individuals actively interpret the information they receive in the light of their existing knowledge and values, and on the basis of that may decide to reject, accept, or modify the information that is communicated to them. In other words, individuals and groups actively intervene in the formulation and propagation of culture. In that sense, cultural evolution is Lamarckian rather than purely Darwinian.

A final criticism is that memetic models have not yet been sufficiently subjected to empirical tests (Edmonds, 2002; Chielens & Heylighen, 2005). Part of the reason is that most memetic theories do not make sufficiently concrete predictions to be falsifiable by observation. Most of these theories remain very speculative—often hardly better than a form of "armchair philosophy". Moreover, until now there simply have been very few empirical studies of how memes propagate, whether in the laboratory (e.g. Lyons &

Kashima, 2003) or in real life (e.g. Bangerter & Heath, 2004), and even fewer links have been established between these observations and theoretical or mathematical models.

We will try to address these criticisms in the remainder of this article. First, we will discuss the issue of how to define a meme in an as accurate way as possible. Then we will review the process of transmission of memes between individuals, emphasizing the active role played by an individual's cognitive structure. This will give us a basis to review the dynamics of memetic propagation across a population, and the mathematical and simulation models that have been used to study it. To introduce empirical tests, we will first discuss the criteria that determine the fitness of a meme, specifying which memes are most likely to spread. We will then summarize a few experiments and case studies in which the predictive value of such selection criteria was tested. Finally, we will discuss some potential future applications of memetic research.

## Defining the meme

### Replicators

The original definition of a meme by Dawkins (1989) was based on the concept of *replicator*. A replicator is a system that is able to make copies of itself, typically with the help of some other system. Examples include real and computer viruses, which need respectively a cell and a computer processor to make copies of themselves. The fundamental example discussed by Dawkins is the gene, the string of DNA that carries the information on how to make a protein, and that is copied with the help of the cellular machinery whenever a cell divides. A meme too is a replicator, as it is copied whenever information is transmitted from one individual to another via communication or imitation.

Because replicators can be reproduced in different quantities, they are subject to natural selection: the one that tends to produce the largest number of replicas over an extended time span will win the competition with less productive replicators. To succeed in this, according to Dawkins (1989), a good replicator should exhibit the following characteristics:

- *longevity*: the longer any instance of the replicating pattern survives, the more copies can be made of it. A drawing made by etching lines in the sand is likely to be erased before anybody could have reproduced it.
- *fecundity*: the faster the rate of copying, the more the replicator will spread. An industrial printing press can churn out many more copies of a pamphlet than an office-copying machine.
- *copying-fidelity*: the more accurate or faithful the copy, the more will remain of the initial pattern after several rounds of copying. If a painting is reproduced by making photocopies from photocopies, the picture will quickly become unrecognizable.

Dawkins called memes the “new” replicators, in the sense that they appeared very recently compared to genes. The reason for this evolution is clear: the typically human ability of imitation, i.e. learning new ideas, knowledge or behavior by copying what another individual already learnt, provides a tremendous shortcut for the multiple

experiences of trial-and-error that are otherwise necessary to discover a useful new behavior pattern (Campbell, 1974). While some other animals are capable of limited imitation—e.g. songbirds learn songs from each other, and apes can imitate simple behaviors (Bonner, 1980)—this capability is best developed in humans (Blackmore, 2000). This accounts for our ability to develop a culture that is passed on from generation to generation, thus accumulating ever more useful knowledge in the course of its evolution. In that sense, memes can be seen to be responsible for the extremely fast development of human society and its subsequent dominance of the ecosystem.

## Mememes vs. Genes

When we compare the two most important replicators, genes and memes, we immediately notice a number of fundamental differences. Genes can only be transmitted from parent to offspring. Memes can in principle be transmitted between any two individuals. For genes to be transmitted, you need one generation. Memes can be transmitted in the span of minutes. Meme propagation is also much faster than gene spreading, because gene replication is restricted by the relatively small number of offspring a single parent can have, whereas the number of individuals that can take over a meme from a single individual is almost unlimited. Moreover, it seems much easier for memes to undergo variation, since the information in the nervous system is more plastic than that in the DNA, and since individuals can come into contact with many more different sources of novel memes. On the other hand, selection processes too are more efficient because of “vicarious” selection (Campbell, 1974): the carrier of a meme does not need to be killed in order to eliminate an inadequate meme; it suffices that he witnesses or hears about the troubles of another individual due to that same meme.

The conclusion is that cultural evolution will be several orders of magnitude faster and more efficient than genetic evolution. It should not surprise us then that during the last ten thousand years, humans have hardly changed on the genetic level, whereas their culture has undergone the most radical developments. In practice the superior *evolvability* of memes also means that in cases where genetic and memetic replicators are in competition, we would expect the memes to win, even though the genes would start with the advantage of a well-established, stable structure (Blackmore, 2000), as we will discuss further when reviewing computer simulations of such dual evolution.

While memes have a much higher fecundity than genes, their plasticity implies a much lower copying-fidelity: a message as received and understood by an individual will rarely be identical to the one that was expressed, as illustrated by the many misunderstandings and reinterpretations during communication. Yet, we should not conclude from this that effective communication is impossible: if you believed that, you would not be reading this article, hoping to assimilate the main ideas presented by its authors. The reason for such mixture of accurate transmission with creative reinterpretation is that, most fundamentally, humans are cognitive agents. This means that they process incoming information depending on the knowledge they already have and the computing machinery they are endowed with, selectively retain some of that information in their memory, and selectively express some of that information to other agents. Generally, the transmission of information by an agent will change both the agent,

who has learned something new, and the information, which will be affected by the knowledge the agent already had.

Therefore, a meme reaching an agent, if it is reproduced at all, will typically be transmitted in a changed form, possibly recombined with other information learned earlier. This explains why it is often so difficult to define or pinpoint an individual meme. In that sense, cultural evolution is Lamarckian: characteristics acquired during the lifetime of the meme's carrier can be transmitted to later carriers. Lamarckian evolution, while not being Darwinian in the strict sense, is still subject to the principle of natural selection: acquired characteristics too will be passed on selectively, depending on their fitness. Natural selection by definition will pick out the memes who survive this transmission process relatively unchanged. Therefore, the fittest memes, such as certain songs, religious beliefs, scientific laws, or brand names, will have a stable, recognizable identity, even though they may differ in appearance, as exemplified by the many renditions of a song or joke. All such memes together define the culture shared by a community.

This identity will be reinforced by positive feedback that characterizes the non-linear interaction between meme and carrier: the more people encounter a particular version of a meme, the more they will tend to adapt their own version to this common prototype, the more commonly they will express this version, and thus the more people will encounter it. In this way, a variety of versions that are constantly being exchanged within the same group will tend to *converge* to a single, canonical version (Axelrod, 1997). A newcomer to this group with a variant version will be extensively subjected to the accepted version, and is likely to eventually give in to this *conformist pressure* by adopting the majority version (Boyd & Richerson, 1985).

This *winner-takes-all* dynamics, where the initially most frequent variant comes to dominate all others, is elegantly illustrated by computer simulations of the evolution of language, in which many communicating individuals who use different words for the same concept quickly converge on a single word (Steels, 1997). Similarly, most systems of ethics or religious belief tend to actively suppress any variant from their canonical version. This explains why in spite of the great variability of memes, we generally have no problems determining whether an individual belongs to a certain religious or linguistic group (Heylighen & Campbell, 1995). Note that such non-linear reinforcement does not exist for genes, since genes are transmitted only once, from parent to offspring. Moreover, once a gene is given, it can no longer be affected by the presence of other versions in the population.

Another fundamental difference between memes and genes is that for memes there is no equivalent for the traditional distinction between *genotype* (the information carried by the genes and passed on to the next generation) and *phenotype* (the specific appearance of an organism as determined by genes and environmental influences). In biological evolution, the genotype is the site of evolutionary variation (since variations in the phenotype are not passed on during reproduction) and the phenotype the site of selection (since it is the organism as a whole that survives and reproduces, or is eliminated). In memetics, we can distinguish three levels:

- 1) the *memotype* denotes the information as held in an individual's memory;
- 2) the *mediotype* denotes that information as expressed in an external medium, such as a text, an artefact, a song, or a behavior;

- 3) the *sociotype* denotes the group or community of individuals who hold that information in their memory (Blackmore, 2000).

Variation and selection take place on all three levels. A memotype can vary or be eliminated (forgotten) while residing in an individual's brain. A mediotype can similarly mutate (e.g. via a printing error) or be lost, and a sociotype can change when new individuals are added to the group, who may introduce different memes, or be eliminated (as when an unsuccessful tribe dies out). In conclusion, the processes of variation and selection, while analogous at the deepest level, are much more complex for memes than for genes.

### Delimiting the memetic unit

What are the elements that make up a meme? In order to analyze meme structure, we can use some concepts from cognitive science, the discipline that studies mental content. Perhaps the most popular unit used to represent knowledge in artificial intelligence is the *production rule*. It has the form “if condition, then action”. The action leads in general to the activation of another condition or category. A production rule can thus be analyzed as a combination of even more primitive elements: two *concepts* or *categories* and a *connection* (the “then” part, which makes the first category entail the second one). For example, a meme like “God is omnipotent” can be interpreted as “if a phenomenon is God (it belongs to the category of God-like entities), then that phenomenon is omnipotent (it belongs to the category of omnipotent entities)”.

Production rules are connected when the output condition (action) of the one matches the input condition of the other. This makes it possible to construct complex cognitive systems on the basis of simple rules. In memetics, such systems are called *meme complexes* or *memeplexes*. For example, a scientific theory or a religious system of belief may be represented as a collection of mutually connected propositions or production rules, such as “God is omnipotent”, “God is good”, “God punishes bad people”, “if you steal, you are bad”, etc. This collection of rules together determines a knowledge system that allows making inferences, such as “if you steal, God will punish you”. Even more concrete perceptual or behavioral memes, such as a tune, might be modeled in this way, as concatenations of production rules of the type “if C (musical note distinguished), then E (note produced and subsequently distinguished)”, “if E, then A”, and so on. (In fact, genetic information too can be modeled using networks of “if... then” productions: a DNA string is activated by the presence of certain proteins (condition) to which it responds by producing specific other proteins (action), see (Kauffman, 1993)).

Production rules—or at least a simplified, binary representation of them, called “classifiers”—can be used to build computer simulations of cognitive evolution, using genetic algorithms, i.e. algorithmically applied operators that perform the equivalents of mutation, recombination, and selection on the basis of “fitness” on such strings (Holland et al., 1986). Although classifier models generally do not take into account distinct carriers, this looks like a promising road to study the evolution of memeplexes formally and computationally. As we will see later, though, simulations of cultural evolution are usually limited to the mutation and spread of simple memes, ignoring the cognitive

structures and processes that support inferences and that create new meme(plexe)s out of combinations of existing ones.

Even if we would model memes as connected sets of production rules, we still have the problem of how many production rules define a single meme(plex). If we call a religion or a scientific theory a meme, it is clear that this will encompass a very large number of interconnected rules. In practice it will be impossible to enumerate all rules, or to define sharp boundaries between the rules that belong to the meme and those that do not. For example, should you believe in the existence of Hell, the creation of the world in seven days, and the virginity of Mary to be called a Catholic?

A pragmatic criterion that can be used in this regard is to define a meme or memeplex as the smallest collection of propositions or memory items that tends to replicate as a whole (cf. Wilkins, 1998). For example, a proposition like “God is omnipotent” on its own, without specification of God’s other characteristics, is much too abstract to be clearly understood or applied, and as such is unlikely to replicate well. However, in combination with a number of other propositions, like “God is good”, “God is the creator of the world”, etc., that flesh out, apply, and support this abstract idea, the package will make much more sense, and be more likely to be passed on to other individuals. Similarly, the first three notes of a melody are unlikely to be remembered as a unit, but the first eight, as in the beginning of Beethoven’s fifth symphony, may well be.

It remains that often we can add or subtract a few production rules (such as the virginity of Mary) from a memeplex without significantly changing its chances of replication. Therefore, in practice it will rarely be possible to determine the precise boundaries of a meme(plex). However, this should not detract us from considering memes while analyzing cultural evolution. Indeed, the same problem besets genetic models of biological evolution: as yet, it is in practice impossible to specify the exact combination of DNA codons that determine the gene for, say, fair skin, big ears or altruism. The biochemical definition of a gene as a string of DNA that codes for one protein is not very useful when studying evolution, since most practical functions require a combination of proteins, most proteins exhibit a combination of functions, and much of the DNA is non-coding, but therefore not necessarily useless, as it may contain control information that determines the activation of other DNA strings.

As Dawkins (1989) notes, we do not need to know the constitutive elements or boundaries of a gene in order to explain the evolution of particular characteristics, such as altruism or fair skin, for which such a gene would be responsible. It is sufficient that we can distinguish the effects of that gene from the effects of its rival genes (alleles). If we can determine the fitness differences resulting from these effects, then we can make predictions about which type of genes will win the competition in a particular situation, and thus which characteristics the species is most likely to evolve. For example, knowing that people with lighter skin need less sunlight to produce sufficient vitamin D, we can predict that in Northern regions natural selection will favor genes for light skin over genes for dark skin—whatever DNA codons make up these respective genes.

The same applies to memes. If, for example, we observe that one meme (say Catholicism) induces its carriers to have more children than its competitors (say Anglicanism), and that the children tend to take over their memes from their parents, then, *all other things being equal*, we can predict that after sufficient time this meme will

dominate in the population. This prediction does not require any explicit definition of the meme of Catholicism, but only the ability to distinguish it from its competitors. Of course, in practice it is never the case that all other things are equal, but that is the predicament of all scientific modeling: we must always simplify, and ignore potentially important influences. The question is to do that as wisely as possible, and to maximally include relevant variables without making the model too complex.

## Dynamics of meme replication and spread

To be replicated, a meme must pass successfully through four subsequent stages:

- 1) *assimilation* by an individual, who thereby becomes a carrier or *host* of the meme;
- 2) *retention* in that individual's memory;
- 3) *expression* by the individual in language, behavior, or another form that can be perceived by others;
- 4) *transmission* of the thus created message or mediotype to one or more other individuals.

This last stage is followed again by stage 1, thus closing the replication loop. At each stage there is selection, meaning that some memes will be eliminated. Let us look in more detail at the mechanisms governing these four stages.

### Assimilation

A successful meme must be able to “infect” a new host, that is, enter into its memory, and thus acquire its *memotype* form. Let us assume that a meme is presented to a potential new host. “Presented” means either that the individual encounters an existing mediotype form of a meme, or that he or she independently discovers the meme, by observation of outside phenomena or by thought, i.e. recombination of existing cognitive elements. To be assimilated, the presented meme must be respectively *noticed*, *understood* and *accepted* by the host. Noticing requires that the mediotype be sufficiently salient to attract the host's attention. Understanding means that the host recognizes the meme as something that fits in with his or her cognitive system. The mind is not a blank slate on which any idea can be impressed. To be understood, a new idea or phenomenon must connect to cognitive structures that are already available to the individual. Finally, a host that has understood a new idea must also be willing to believe it or to take it seriously. For example, although you are likely to understand the proposition that your car was built by little green men from Mars, you are unlikely to accept that proposition without very strong evidence. Therefore, you will in general not memorize it, and the meme will not manage to infect you.

### Retention

The second stage of memetic replication is the retention of the meme in memory. The longer the meme stays, the more opportunities it will have to spread further by infecting other hosts. This is Dawkins's (1989) *longevity* characteristic for replicators.

Just like assimilation, retention is characterized by strong selection, which few memes will survive. Indeed, most of the things we hear, see or understand during the day are not stored in memory for longer than a few hours. Although you may have clearly assimilated the news that the national party won the Swaziland elections with 54% of the votes, you are unlikely to remember this a week later—unless you live in Swaziland, perhaps. Retention will depend on how important the idea is to you, and how often it is repeated, either by recurrent encounter or by internal rehearsal.

## Expression

To be communicated to other individuals, a meme must emerge from its storage as memory pattern or memotype and enter its mediotype phase, i.e. assume a physical shape that can be perceived by others. This process may be called “expression”. The most obvious medium for expression is speech. Other common means are text, pictures, behavior, and the creation of artifacts such as tools, buildings or works of art. Expression does not require the conscious decision of the host to communicate the meme. A meme can be expressed simply by the way somebody walks or manipulates an object, or by what he or she wears.

Some retained memes will never be expressed, for example because the host does not consider the meme interesting enough for others to know, uses it unconsciously without it showing up in his or her behavior, does not know how to express it, or wants to keep it secret. On the other hand, the host may be convinced that the meme is so important that it must be expressed again and again to everybody he or she meets.

## Transmission

To reach another individual, an expression needs a physical carrier or medium that is sufficiently stable to transmit the expression without too much loss or deformation. Speech, for example, uses sound to transmit an expression, while text will be transmitted through ink on paper or electrical impulses in a wire. The expression will take the form of a physical signal, modulating the carrier into a specific shape—the mediotype—from which the original meme can be re-derived. For example, mediotypes can be books, photographs, artifacts or CD-ROMs.

Selection at the transmission stage happens through either elimination of certain memes, when the mediotype is destroyed or gets corrupted before it is perceived by another individual, or through differential multiplication, when the mediotype is reproduced into many copies. For example, a manuscript may be put into the shredder or turned into a book that is printed in millions of copies. Especially since the emergence of mass media and mass manufacturing, the transmission stage is the one where the contrast between successful and unsuccessful memes is largest, and where selection can have the largest impact.

## Meme fitness

The overall survival rate of a meme  $m$  can be expressed as the meme *fitness*  $F(m)$ , which measures the expected number  $N(m)$  of memes at the next time step or generation  $t+1$  divided by the average number of memes at the present time  $t$ . This fitness can be expressed in a simplified model as the product of the survival/multiplication rates for each of the four stages, respectively assimilation  $A$ , retention  $R$ , expression  $E$  and transmission  $T$ :

$$F(m) \equiv \frac{N(m, t+1)}{N(m, t)} = A(m).R(m).E(m).T(m)$$

$A$  denotes the proportion of mediotypes encountered by the host that are assimilated.  $R$  represents the proportion of these assimilated memes that are retained in memory. Therefore,  $A \leq 1$ ,  $R \leq 1$ .  $E$  is the number of times a retained meme is expressed by the host.  $T$  is the number of potential new hosts reached by a copy of the expression. Unlike  $A$  and  $R$ ,  $E$  and  $T$  do not have an upper bound, although  $E$  is likely to be more restricted than  $T$ . Note that  $F$  is zero as soon as one of its components ( $A$ ,  $R$ ,  $E$ ,  $T$ ) is zero. This expresses the fact that a meme must successfully pass through *all* four stages in order to replicate. Also note that for a meme to spread ( $F > 1$ ), you must have at least  $E > 1$  or  $T > 1$ .

## Dynamics of spread

From the standard definition of fitness  $F$ , we can derive the rate of growth for the number  $N(t)$  of meme copies at time  $t$ . This determines the speed with which the meme spreads through the population of carriers:

$$\frac{dN}{dt} \equiv \frac{N(t+1) - N(t)}{1} = (F - 1).N$$

This results in a traditional exponential growth if  $F > 1$ , exponential decay (and eventual extinction) if  $F < 1$ , and stability if  $F = 1$ . This model is too simple if the population is finite. In that case, we need to take into account the total size of the population of potential carriers  $K$ , which functions as the “carrying capacity” of the socio-cultural environment in which a meme proliferates. The increase in the number  $N(t)$  of memes can be represented by the following Verhulst type of equation:

$$\frac{dN}{dt} = (F - 1).N\left(1 - \frac{N}{K}\right)$$

This equation expresses the fact that the growth in meme number ( $dN$ ) is in first instance proportional to the number ( $N$ ) that is already there—since more memes produce more copies of themselves—, but eventually limited by the number  $K$  of potential hosts in the population, so that growth becomes zero when the population reaches this limit ( $N = K$ ).

The function  $N(t)$  that is the solution to this differential equation is the logistic function with its characteristic *sigmoid* (S-like) shape.

## Interactions between memes

The dynamics of a single growing meme population  $N(m)$  could be extended to several interacting memes  $N_i = N(m_i)$ . Here we should add an interaction term  $A_{ij}$  which describes the strength of the influence of meme  $i$  on meme  $j$ . This influence can be positive ( $A_{ij} > 0$ ), which means that an increase in  $i$  produces an increase in  $j$ , i.e.  $i$  helps  $j$  to grow. A negative influence ( $A_{ij} < 0$ ) means that the growth of  $i$  suppresses the growth of  $j$ . A neutral relation ( $A_{ij} = 0$ ) means that the spread of the one does not influence the spread of the other. This applies to memes from independent domains, such as “God exists” and “apples are healthy”. If we now consider the reciprocal influence ( $A_{ji}$ ), we can distinguish the following specific types of interaction:

- $A_{ij} > 0, A_{ji} > 0$ : the memetic species  $i$  and  $j$  can be seen as *mutualists*, that help each other to spread, e.g. by reinforcing each others’ message. An example could be “God is good” and “God is great”.
- $A_{ij} < 0, A_{ji} < 0$ :  $i$  and  $j$  are rivals or *competitors* (Best, 1997): an increase in the one produces a decrease in the other. Examples are “God is good” and “God does not exist”.
- $A_{ij} > 0, A_{ji} < 0$ :  $i$  and  $j$  stand in a *predator-prey* type of relationship, i.e.  $i$  grows at the expense of  $j$ . This may happen when  $i$  (e.g. relativity theory) is a more advanced version of  $j$  (e.g. Newtonian mechanics), so that carriers of  $j$  would quickly convert to  $i$ , but non-carriers of  $j$  would be more difficult to convince of  $i$ ’s value.

The overall dynamics can be represented by the following system of non-linear differential equations:

$$\frac{dN_i}{dt} = N_i \cdot \left( \sum_j A_{ij} N_j + B_i \right)$$

$A_{ii}$ , the influence of meme  $i$  on itself will here normally always be negative and equal to  $(1 - F_i)/K$ , while  $B_i = F_i - 1$ , as in the previous equation for a single meme. Such dynamical models quickly become very complex to solve, but are not fundamentally different from traditional growth and competition models used in population biology, epidemiology, or studies of the diffusion of innovations (Rogers, 2003). However, they do not take into account the dependence of a meme on its carrier, nor the specific communication channels between carriers.

## Social structures

One way to make the model more realistic without adding too much complication is to consider the structure of the social space in which the potential carriers of a meme reside. Here we make the additional assumption of continuity, namely that a meme cannot jump

from one carrier to another without there being some form of proximity or relationship between the carriers.

## Horizontal transmission and the evolution of cooperation

The simplest form of relationship is the one between parents and their offspring. Parent-to-child transmission (or more generally transmission between generations) is called *vertical transmission* (Cavalli-Sforza & Feldman, 1981). Memes belonging to domains such as religion, language, ethics, and general culture are commonly transmitted in this way. This form of propagation is analogous to the transmission of genes. Therefore “vertical” models of cultural evolution find results similar to those of biological evolution. This means that vertically transmitted memes, such as established religions, will typically reinforce or elaborate genetically transmitted behavioral patterns and thus directly contribute to biological fitness (Cullen, 1999).

The same does not apply to *horizontally transmitted* culture, i.e. memes exchanged between members of the same generation (Cavalli-Sforza & Feldman, 1981). Here what is good for a meme (e.g. slavish imitation of fads and fashions) is not necessarily good for the biological individual or gene pool, since genes and memes are subjected to different kinds of natural selection. This may promote the evolution of parasitic memes that are deleterious to their carriers, as we will discuss further.

However, in addition to the fact that it spreads new information more quickly, horizontal transmission also offers another benefit that vertical transmission lacks. A classic problem in biological evolution is the *evolution of cooperation* (Dawkins, 1989; Heylighen & Campbell, 1995): given that genes are selected to promote their own good, with a disregard or even hostility toward any rivals that compete for their scarce resources, how can we explain cooperative or altruistic behavior where an individual invests more in helping another than in his or her own good? In the animal world, cases of altruism, such as among social insects, are usually explained via *kin selection*: individuals will help others as long as these are related to them, i.e. share their genes. In human society, however, people often help strangers that are totally unrelated. The initially proposed explanation of *group selection*, namely that groups of individuals that help each other survive better than groups of selfish individuals, has the shortcoming that, within altruist groups, it are the selfish profiteers that do best, and thus spread their genes most (Dawkins, 1989).

Horizontal transmission of cooperation norms solves this problem, since the members of a cultural group are all *memetically related* to each other, sharing their memes rather than their genes. Therefore, cultural kin selection will extend to all members of the group (Evers, 1998). This entails a selective pressure for memes to support the fitness of the whole group of their carriers, e.g. by promoting cooperation. Moreover, selfish profiteers will not be able to undermine the cooperation produced by such altruism-promoting memes because of conformist pressure (Boyd & Richerson, 1985; Heylighen & Campbell, 1995), or what we have called “winner-takes-all”: when one meme establishes a majority position it will eventually get imposed on *all* members of the group, thus suppressing the appearance of selfish dissidents—or at least not allowing them to make any converts and thus spread their memes. This cultural solution to the cooperation paradox in biological evolution appears to have been developed more

or less independently by different meme theorists (Boyd & Richerson, 1985; Heylighen, 1992; Evers, 1998; Blackmore, 2000).

## Topologies of communication

Horizontal transmission will generally follow existing social or geographical topologies. This can be modeled in two different ways:

- 1) individuals are situated in a *space* (typically a two-dimensional plane, or its discrete equivalent, a two-dimensional lattice of cells);
- 2) individuals are considered as nodes in a (social) *network*, which are connected by ties of acquaintance or trust.

The basic assumption in these models is that memes diffuse *continuously* across the space or network. This means that, in first instance, communications are considered to be *local*, i.e. agents exchange memes only with their direct neighbors in the space or social network. The neighbor can pass on the meme to its neighbors, and so on, so that a meme eventually may spread across the whole population.

When a population consists of different clusters or local communities, that have little communication with each other, this will typically lead to different cultures establishing themselves in different communities (Boyd & Richerson, 1985; Axelrod, 1997). The reason is that intense communication within each community will produce a “winner-takes-all” dynamics where by chance or local adaptation one of several variant memes becomes dominant. Memes from other communities, however, will only rarely be encountered, so that they will generally not receive enough reinforcement to displace the established memes.

Recent research in complex networks, including social networks, has shown that such networks commonly have a *scale-free structure* (Albert & Barabasi, 2002). This means that a few agents, the so-called “hubs” of the network, have a great many social ties, while most agents only have a few links. The implication for cultural diffusion is that memes hosted by “hub” agents will have a disproportionately large effect, and are much more likely to spread widely. A similar effect has been observed in the spread of sexually transmitted diseases, such as AIDS, where the infection of a few hubs in the network (in this case individuals with a large number of sexual partners) may make the difference between a large-scale epidemic and a few isolated infections. This observation has provided inspiration to researchers in “viral” marketing, who look for methods to make publicity for a brand or product by creating a “buzz”, i.e. a positive message about their product that is propagated via word-of-mouth (Marsden & Kirby, 2005; Marsden, 1998). Their strategies focus on identifying and targeting the “opinion-leaders” within a community, i.e. those central individuals that many know and tend to imitate.

Although it is in principle possible to make analytical models of the propagation of memes across space or across networks, calculating the precise spread in a realistic environment is far too difficult. Therefore, these processes are typically explored via multi-agent computer simulations.

## Computer simulations of cultural evolution

Cultural transmission of rules, norms or information is a common ingredient in many social simulations (e.g. Bura, 1994; Axelrod, 1997; Doran, 1998; Hales, 1998; Flentge, Polani & Uthmann, 2001), that are based on an “artificial society” of interacting software agents (Epstein & Axtell, 1996). However, such memetic propagation is often added merely as one of the many assumptions within a complicated model of a specific type of socio-cultural evolution, such as the evolution of a shared vocabulary (Steels, 1998) or of cooperation norms (Hales, 1998). There have been relatively few simulations that have explored cultural evolution in the broadest sense. We will now discuss some typical examples that illustrate the wider issue.

Probably the first explicitly memetic simulation, *Meme and Variations*, was made by Gabora (1995, first written 1992). The assumptions underlying this, and related simulations of cultural diffusion (e.g. Denaro & Parisi, 1996; Baldassarre & Parisi, 1999), are the following: agents search the best solution for a particular problem. They can either find a solution on their own through trial-and-error, or they can take over a solution from another agent, by observing the solutions each of their neighbors has found and imitating the best one. The result of the simulation is that the agents collectively find the best solutions if they partially imitate others, partially explore individually. If they only imitate, there is no creativity and the best solution cannot be improved. If they only explore individually, lots of search is needed to merely rediscover what was already known elsewhere. In the ideal situation, which is achieved by trying out different parameter values for the simulation until one has found the optimal mix of innovation and imitation, good solutions will spread very quickly throughout the population, but this without preventing the discovery of even better solutions by certain agents.

This simulation investigated the relative effectiveness of, and interaction between, *individual learning* and *cultural diffusion*. An older classic simulation (Hinton & Nowlan, 1987) investigated the relative effectiveness of, and interaction between, *individual learning* and *genetic evolution*. Inspired by this work, Best (1999) studied the three-way interactions between individual learning, genetic evolution, and cultural evolution. In Best’s simulation, agents can acquire knowledge that allows them to maximize their fitness in three ways: 1) by inheriting it, possibly with variations, from their parents (vertical, genetic transmission); 2) by copying it from another, fitter agent (horizontal, cultural transmission); 3) by individually discovering it via trial-and-error. The simulation showed that cultural transmission, just like individual learning, can enhance genetic evolution, accelerating its convergence to the optimal solution. Moreover, cultural transmission appeared superior to individual learning in that it produced convergence more quickly.

Best (1999) also examined the situation in which cultural and genetic evolution pursue opposite goals, and found that in this case genetic evolution normally wins the competition. However, Bull, Holland & Blackmore (2001) further investigated this situation by allowing cultural evolution to be much more rapid than genetic evolution, as is normally the case. They found that under these conditions memetic effects are stronger than genetic effects, and the only way genes can still keep some control over the process is by evolving mechanisms to filter out particularly harmful memes.

These simulations of cultural evolution are still rather simplistic, in the sense that agents literally copy any knowledge exhibited by a fitter agent. In practice, individuals do

not a priori know which individual is fitter, and when they receive a message, this information will interact with the knowledge they already had. Van Overwalle & Heylighen (2006) have proposed a more realistic simulation model in which agents do not just copy a message, but actively “reinterpret” it, based on their previous experience. Agents are modeled as simple neural networks that learn from experience. A message corresponds to a pattern of activation over the nodes in such a network, and communication to the spread of that activation from agent to agent via variable inter-agent connections. The strength of the connection between two agents represents the degree of trust of the one in the information received from the other. This trust is learned on the basis of the degree to which information received previously from that agent is confirmed by own knowledge. Unlike most multi-agent simulations, the Van Overwalle & Heylighen (2006) model is supported by solid empirical evidence, in that it manages to accurately reproduce the results of several classic communication experiments, including the Lyons & Kashima (2001, 2003) study of meme transmission that we will discuss in a later section.

### **Selection Criteria for Memes**

Since mathematical models and computer simulations of meme spread necessarily have to make plenty of simplifying assumptions, and cannot incorporate all the specific social, psychological, linguistic and cultural factors that influence the propagation of a meme, they are not very useful in predicting which concrete memes will be successful and which will not. Yet, such predictions are necessary if we want to arrive at an empirically testable theory, which can be applied to practical problems. One way to arrive at a more practical, predictive model is to formulate general selection criteria that distinguish fitter memes from less fit ones. All other things being equal, *a meme that scores better on one of these criteria is predicted to become more numerous* than a meme that scores worse. This is a falsifiable hypothesis that can be tested through experiments or observations. It suffices to operationalize the criteria so that satisfaction of a criterion can be objectively measured.

Many authors have proposed criteria for memetic success, and a few (e.g. Heylighen, 1993, 1997, 1998; Hale-Evans, 1995; Castelfranchi, 2001) have compiled lists of such criteria. Since these proposals, while related, are all different, we need to examine more clearly what is needed for a good list of criteria. First, such criteria should be formulated to be as much as possible independent or non-overlapping, so that a piece of information can vary along one dimension of evaluation without varying along the others. Second, without becoming too restrictive, they should be defined as precisely, concretely and unambiguously as possible, so that different observers using these criteria can come to the same conclusions.

To illustrate the importance of these methodological considerations, let us review some proposed criteria, and point to their shortcomings. For example, one might naively propose that fit memes should be *attractive* to their receivers. While this is true in a general sense, it helps us very little in operationalizing meme fitness, as we cannot say what makes a meme attractive without becoming much more explicit about its properties. A somewhat more sophisticated hypothesis may propose that good memes should be *communicable* (Schaller, Conway & Tanchuk, 2002). Again, this is obviously correct, but communicability has so many different aspects, depending on the meme itself, its

audience, the used medium, etc., that we might as well say that it simply should be a good meme. A more specific criterion, used e.g. by (Heath, Bell & Sternberg, 2001), is *plausibility*. The problem here is that people may use very different procedures to estimate plausibility, e.g. by looking at the source of the information, the available evidence for it, or their own previous experience.

We will here summarize the criteria proposed by Heylighen (1993, 1997, 1998), which are based on an extensive review of relevant cognitive, social and communicative mechanisms. At the most abstract level, there are three classes of entities that information depends on: the object that it refers to, the subject who assimilates and remembers it, and the communication process that is used to transmit it between subjects. These determine three categories of selection criteria, *objective*, *subjective* and *intersubjective*:

#### Objective criteria

- *Distinctiveness*: information that refers to something precise, distinct or detailed, can be confirmed more easily by observation
- *Invariance*: information that remains valid over a wide range of contexts or situations, is more stable and broadly applicable
- *Evidence*: information that is supported by independent observations, is more reliable

#### Subjective criteria

- *Utility*: information that is valuable or useful to its carrier is more likely to be remembered and passed on
- *Affectivity*: information that provokes strong emotions is more likely to be remembered and passed on: this typically stimulates instinctive reactions, such as fear, desire or disgust (Heath, Bell & Stenberg, 2001).
- *Coherence*: the better information fits in with the knowledge that individuals already have, the more easily they will understand and accept it (Thagard, 1998)
- *Simplicity*: short, simple messages are easier to assimilate, remember and transmit
- *Novelty*: information that is unexpected will attract more attention
- *Repetition*: repeated exposure to the same message helps it to be assimilated and retained

#### Intersubjective criteria

- *Publicity*: the more effort an individual puts into spreading a message, the more people will receive it
- *Formality*: messages formulated explicitly and unambiguously are less likely to be misinterpreted
- *Expressivity*: information must be easy to express in a given language or medium
- *Authority*: an authoritative, trustworthy source of the information makes it more likely to be accepted
- *Conformity*: information confirmed by many people is more easily accepted (Boyd & Richerson, 1985)
- *Collective utility*: information, if adopted by a group, may help the group to function better, and therefore to grow or function as a model for others. Examples are standards, linguistic conventions, and traffic rules.

## Parasitic memes

Memes being communicated undergo natural selection. Some memes are transmitted easily, thus reaching a large number of people, while others are rejected, misunderstood, forgotten or otherwise eliminated from circulation. This means that the memes best adapted to the underlying cognitive and communicative processes will spread farthest. We may assume that our brain, general culture, and social structures have evolved so as to maximize the fitness of society and its members. This means that they should be good at assimilating useful memes, and at rejecting bad ones (e.g. Blackmore, 2000). For example, we know that we should not accept things without evidence, and that some sources are more reliable than other. Insofar that these socio-cognitive guidelines, as exemplified by the above list of selection criteria, efficiently filter out poor-quality information, successful memes will also increase the fitness of their carriers.

However, since no system is foolproof, these mechanisms will not always be reliable. This leaves a niche for memes to evolve that propagate well, apparently satisfying the criteria that people intuitively use, but without delivering any benefit to their carriers. We may call such memes *selfish* (Heylighen, 1992) or *parasitic* (cf. Cullen, 1999), as they free ride on the effort invested by individuals to gather and communicate useful information. Such information parasites succeed by faking the criteria that we use to recognize high-quality information. This is similar to the way many biological organisms mimic other phenomena, such as viruses that mimic the cell's own DNA, so that they are reproduced for free by the cellular machinery. Memes have therefore been described as “mind viruses” (Dawkins, 1993; Brodie, 1996), since they similarly exploit our cognitive machinery to get themselves replicated.

There are plenty of examples of such parasitic memes. Perhaps the most studied from a memetic point of view are *chain letters*, whose only purpose is to have themselves replicated and sent to as many people as possible (Goodenough & Dawkins, 2002; Bennet, Li & Ma, 2003). A more modern variant are *virus hoaxes* (Chielens, 2003; Chielens & Heylighen, 2005), i.e. email messages that warn the receivers for a non-existent type of computer virus, and urge them to pass on this warning to as many people as possible. Probably the most dangerous information parasites are certain *religious cults* (Cullen, 1999), which indoctrinate their followers to make as many converts as possible, while isolating them from alternative sources of information, so that they tend to develop a view of reality that is so distorted that it may end fatally, as in the mass suicides of the Heaven's Gate cult. *Pseudosciences* too can be dangerous, parading as solid scientific theories, but asserting statements that at best are not supported by the facts, like in astrology, at worst fatally wrong, like in certain quack cures for cancer. Somewhat more benign are *urban legends* and various *rumors* and *fads*, which tend to spread in waves, being passed on from person to person but without any authoritative source or real evidence. Bangerter & Heath (2004) have tracked the evolution of one such legend, the *Mozart effect* (i.e. the unfounded belief that babies listening to classical music become more intelligent), starting from its source: a scientific experiment that merely found that after listening to music adults temporarily scored better on certain tests—perhaps simply because they were more relaxed.

Several memeticists (e.g. Dawkins, 1993; Brodie, 1996; Lynch, 1998) have investigated the many tricks that memes use to appear more acceptable than they deserve to be, including the following. *Self-justification* means that the components of a memplex mutually justify each other, but without independent support. An example is: “God exists because the Bible says so”, and “You should believe the Bible because it is the word of God”. *Self-reinforcement* means that a meme stimulates its host to rehearse itself, e.g. by repeated study, meditation, prayer, etc. *Intolerance* means that a meme indoctrinates its host to a priori reject any potentially competing memes. *Proselytism* occurs when a meme urges its host to maximally spread the meme to other hosts, like in the case of chain letters. *Baiting* occurs when a meme promises its carriers a reward if they only accept and spread the meme. All these tactics are common in religious cults, which promise their adherents that they will go to Heaven if they believe the teachings, pray, and spread the word, while they will burn in Hell if they dare to doubt (Dawkins, 1993).

Parasitic memes have been the subject and inspiration of most empirical approaches to memetics, since their spread is relatively easy to track, and since they are prime illustrations of the way in which cultural evolution is fundamentally different from genetic evolution.

## Empirical Tests

Memetics has often been challenged and has known some very virulent critics. One of the main criticisms is that there are no empirical data to back up the theories that were put forth, and in that sense memetics is merely a way of thinking rather than a scientific discipline (Edmonds, 2002; Gil-White, 2005; Greenberg, 2005). This criticism is to some degree justifiable. The lack of a universally accepted meme definition and the vagueness of meme boundaries (cf. Atran, 2001) indeed make empirical studies less evident. Yet, there have already been a few empirical studies of meme propagation in different conditions, both in the laboratory (e.g. Lyons & Kashima, 2001, 2003) and in real life (e.g. Goodenough & Dawkins, 2002; Bennet, Li & Ma, 2003; Chielens, 2003). More generally, we must note that memetics is an approach that illuminates important aspects of culture, society and communication that more traditional approaches, such as sociology, psychology or history, tend to neglect. Empirical tests cannot confirm or falsify this perspective as a whole, but merely specific implementations of it. This is analogous to the observation that experiments in psychology or sociology can test particular theories within their field, but not the field as such.

Within the memetics field, one simple way to test specific theories is by considering the memetic selection criteria they imply (Chielens & Heylighen, 2005). We can then measure the apparent success rate of different memes, and examine its correlation with the degree to which the memes fulfill the proposed selection criteria. Heath, Bell & Sternberg (2001) applied this approach to investigate the criteria of *affectivity* (which they call *emotional selection*) and *plausibility*. From the affects, they focused on disgust because this is a relatively simple emotion whose strength is easy to measure. When comparing different urban legends that contained an element of disgust (e.g. the story of a man who discovers a dead rat in the cola bottle he has just been drinking from), they found that the more disgusting variations typically had spread more

widely than the less disgusting ones. The same applied to more plausible variations. Chielens (2003) used a similar method to examine the spread of virus hoaxes. He used both expert and non-expert surveys to score different hoaxes on different criteria, including novelty, simplicity, utility, authority and proselytism. In this case, the spread of the hoax correlated most strongly with its *novelty*. Schaller, Conway & Tanchuk (2002) examined the correlation between the *communicability* of traits, i.e. the probability with which subjects would speak about a particular trait, and the frequency of these traits. They found that for traits used to describe different ethnic groups, the most communicable traits are also the ones that are most widely spread and persistent in society. Pocklington & Best (1997; Best 1997; 1998) used automatic text analysis to measure how often a certain discussion subject was mentioned in a particular discussion group on the net. They found evidence for memetic competition between mutually *incoherent* subjects, meaning that an increase in the one correlated with a decrease in the other.

While these studies merely observed existing patterns of spread, Lyons & Kashima (2001, 2003) performed a laboratory experiment in which they deliberately produced a memetic transmission chain. They created a fictional story and asked the participants in the experiment to subsequently tell the story from person 1 to person 2, from 2 to 3, and so on, like in the game of “telephone” or “Chinese Whispers”. The story involved a fictitious tribe, the Jamayans, about which all participants had received some background information. After several experiments, a statistical analysis of the story elements that remained at the end of the transmission chain (i.e. as reported by the last person to hear the story) found a number of systematic selection effects. These seem to confirm four of the previously mentioned criteria:

- 1) *coherence*: elements inconsistent with the background information were more likely to be left out;
- 2) *novelty*: elements that the speakers assumed were already known by the listeners were more likely to be left out;
- 3) *simplicity*: details or embellishments that did not affect the story line tended to be left out;
- 4) *conformity*: when the participants were told that the majority of them believed that the Jamayans were, e.g., peaceful, they were more likely to leave out elements inconsistent with this fact than if they thought that this was only a minority opinion.

Experiments on memes “in the wild” are more difficult to control than in such a laboratory situation. Because of ethical concerns it is hardly possible to release a well-doctored meme upon the world to observe how it evolves. Another problem is that it is hard to track memes once they are released. Even when feedback is asked or if mechanical trackers are included in the meme (for example, images included in an email message that are automatically downloaded from a controlled server each time the message is opened), it is hard to see whether the meme has already been changed by the time these devices are triggered.

In conclusion, empirical memetics research remains in its infancy. However, experiments have already shown that it is possible to quantitatively confirm or falsify a number of non-trivial memetic predictions. It is to be hoped that many more studies along

these lines will be carried out. As long as memetics has not been thoroughly investigated empirically, it is likely to remain a theoretical niche framework used only for description rather than prediction.

## **Future Directions**

The theory of memetics and cultural evolution holds out great promises for a better understanding, anticipation and control of fundamental social problems that depend on the propagation of ideas and behaviors. This will require more extensive empirical observations and tests, more detailed computer models of the interaction between memes and their hosts, and a better conceptualization of what a meme precisely is. A first basic result that should come out of such research is a concrete and reliable list of criteria that characterize successful memes, i.e. ideas or cultural traits that propagate widely and easily across large populations. This would allow us not only to recognize such memes, but to some degree to design or improve them.

The ability to create successful memes is the Holy Grail of marketing research (Godin, 2002), which is constantly on the look-out for techniques to create a “buzz” and have their publicity message or brand name (Marsden, 2002; Marsden & Kirby, 2005) become as widely known as possible. Another application of these principles lies in public education. For example, if the government makes a campaign to convince people to stop smoking, it would be very useful to have the campaign designed according to sound memetic principles. This should take into account both the characteristics of the message itself (e.g. being sufficiently simple and unambiguous), of the intended audience (e.g. being consistent with what the audience already believes, while being sufficiently novel to attract their attention), and of the way it is transmitted (e.g. having the meme expressed in a common medium by people considered trustworthy).

Memetic selection criteria can be applied not only positively, to help spread a beneficial idea, but negatively, to prevent or suppress harmful memes. Examples are the idea that it is cool to smoke, false rumours and scares that may promote panic or accentuate social prejudice, fundamentalist ideologies that incite hatred or terrorism, and dangerous superstitions, such as the belief that you can cure AIDS by having sex with a virgin. A better understanding of memetic dynamics may help us to understand how such mind viruses arise and spread. It may moreover help us to “immunize” the population by educating them about basic memetics, so as not to be misled by apparently plausible—but fundamentally misleading—cults, fads and superstitions (Dawkins, 1993; Brodie, 1996).

Another basic result of future memetic research should be a complex dynamical model of the interactions between individuals, groups, and the memes they carry. This should allow making longer-term predictions about the interactions between different groups and subcultures within our globalizing society. A crucial issue in this regard is whether minority cultures will eventually be assimilated into the majority, or on the contrary become polarized, asserting their divergent habits and beliefs ever more forcefully (Axelrod, 1997; Van Overwalle & Heylighen, 2006). Two concrete examples are minority languages, such as the Welsh still spoken in Britain, where there is a tendency for the subculture to be slowly erased by the majority culture, and the culture of Islamic immigrants in Europe, where there is a tendency towards polarization in the sense

of increased radicalism. Neither complete assimilation nor polarization are desirable outcomes, but at first sight they seem like the most likely results of the “winner-takes-all” dynamics created by the pressure to conform to the group one has most contact with. A more detailed theory of cultural evolution may help us to find a middle way that preserves cultural diversity without exacerbating conflicts, and to pinpoint the crucial factors that can steer the dynamics in one direction rather than another.

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