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BASIC QUESTIONS IN MEMETICS: LIFE-CYCLE, REPRODUCTION AND RESOURCES

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1. Introduction

The basic understanding of any organism starts with the description of its morphology, environment, behaviour and its life-cycle by which it propagates itself. Memes are no exceptions. Although various studies have addressed these basic questions (Ball, 1984; Gabora, 1996; Pocklington, 1997; Lynch, 1998) and, of course, most major work about cultural evolution has something to say about it (Dawkins, 1976; Boyd & Richerson, 1982; Lumdsen & Wilson, 1982), there is still no general conclusion, and there is still no general terminology. The lack of a proper description of the memetic life-cycle is especially disturbing since in its absence it is hard to evaluate the weight of different selective forces, it is hard to build any mathematical model concerning meme population-dynamics or demography and it is hard to decide the importance of different kind of resources. The aim of the present paper is to give a detailed description of the memetic life-cycle and to investigate some of its consequences.

The structure of the article is as follows. In the second section basic definitions for life, replicators, and interactors are proposed. In section 3 a model of memetic reproduction and life-cycle is presented. The main assumptions of the model are discussed in the next section. Section 5 examines the nature of necessary and sufficient resources for memetic reproduction. Section 6 lists the main properties of memes from a modelling point of view. Finally, section 7 concludes.

2. Replicators, interactors and the definition of life

To build a logical model we should have logical and clear-cut definitions. Moreover, the nature of the definitions should depend on the problem which we want to attack. From a population biological point of view any definition of replicators and interactors should enable us to decide between life and death, between living systems and reproductive vehicles and should enable us to tell whether an entity under question is a replicator an interactor or both.

Living systems have two major properties:
(1,) First, they are all non-equilibrium open systems (Maynard Smith, 1986; Szathmáry, 1989) with an inherent stability, which is maintained by self-regulating processes (Gánti, 1987). That means that there is an energy and substrate flow between the organism and the environment, and the organism is on a higher energetic state than its surrounding, moreover, this higher state needs and active maintenance via energetic input. In other words, a living organism increases the entropy of its environment in order to maintain its own state of low entropy. With Schrödinger

words: organisms live by 'eating negative entropy'.
(2,) Third, they are all capable to evolve (Maynard Smith, 1986). That follows from the fact that they are all results of evolution by means of natural sel ection. Thus, every living system has the property of self-reproduction, heredity and variation.

With these two major properties in mind we want to create a definition which, on the one hand, excludes every non-equilibrium system which is not a living one (such as fires or whirls (Maynard Smith, 1986)), and on the other hand, excludes every self-replicating system which is not a living one (such as certain crystals, for instance silicates (Szathmáry, 1984)).

The classical definitions of replicator and interactor by Hull (1988) are as follows:

A replicator is 'an entity that passes on its structure largely intact through successive replications.'

An interactor is 'an entity that interacts as a cohesive whole with its environment in such way that this interaction causes replication to be differential.'

With our requirements in mind I propose the following definition, first for living systems in general:
(Definition 1.) 'A self-replicating non-equilibrium open system with inherent unity and stabi
lity, capable to evolve.'
Second, we want to define interactors as living systems so the following definition can be proposed:
(Definition 2.) 'A non-equilibrium open system with inherent unity and stability, which interacts with the environment and with other interactors in order to create and maintain the conditions for some replicator to replicate.'
With this definition I want to emphasise that interactors are living systems, and that their function is to create and maintain sufficient conditions for replicators to replicate. Differential reproduction is not an essential property, it is just the result of the fact that different interactors are coded by different replicators.
Finally, I think that Hull's definition for replicators is correct so I want to give a loose and a strict definition only for living replicators. The broad definition is as follows:
(Definition 3.) ' A living replicator is a replicator which is either itself an interactor or it is a part of an interactor.'
This definition can help us to decide whether a gene, a meme, a virus, or a computer virus is a living replicator or not. For instance, one of the most subtle problems of biology whether a virus is a living organism or not. I argue that if it is within the host cell then it is as living as any other DNA in that cell. But what about virions outside cells? And what about other reproductive vehicles, such as seeds, pollens, eggs and so on? I will discuss this problem a little bit later. First, let us see the strict definition. A ccording to this:
(Definition 4.) 'A living replicator is a replicator which is either itself an interactor or it is a part of an interactor and capable of creating and maintaining a lineage of interactors through geological times.'
This definition helps us to make the difference between dependent and independent replicators. Any independent replicator should fit the above definition. Currently we know only one type of them: the genes. All other replicators (memes, viruses, computer viruses) do not fit this definition, they are all dependent on the interactors coded by the genes.

Finally, the concept of phenotype is defined as:
(Definition 5.) 'A trait, a behaviour or a tool by which an interactor interacts with its environment or with other intaractors.'

3. The life-cycle of memetic reproduction

In order to describe the life-cycle of memetic reproduction first we should decide what is a meme. Although it is intuitively easy to understand, creating an exact definition has challenged the fiel
d of memetics up to the hilt. For the purpose of the present model Dawkins' original definition will suffice (1976). That is, a meme is a unit of cultural transmission, a replicator which has the properties of replication, heredity and variability. To depict a life-cycle, however, we should go a little bit further and we should ask that what counts as a living meme? Is an article, a book, a film, a song, a clothes a living meme or only those memes represented in human brains should be counted among the livi
ng ones? I vote for this latter possibility and later on I will discuss it in more detail. I argue that the former ones are just reproductive transmitting vehicles (RTV-s) and a formal analogy with viruses exists from this respect. There is a difference however, memes can be transmitted either directly or indirectly. The direct transmission is from human to human and can make use of the entire repertoire of human communication: language, gestures, body contact, etc. The indirect one takes the form of human
- transmitting vehicle - human, where a transmitting vehicle can be anything ranging from stones, wood, paper and other materials to TV, radio, phones, or computer nets. To complete the description of the life-cycle, the phenotype - memotype relation should be discussed. It is a widely accepted assumption that memes behave similarly from this respect to genes, that is, they cannot be selected directly, instead they code for some phenotypic trait which, interacting with the environment and with other organis
ms will determine the reproductive success of that particular meme (Ball, 1984, Wilkins, 1998). That is, memetic reproduction fits in the scheme of generalised selective processes depicted as generate - test - regenerate cycles (Plotkin, 1994, Wilkins, 1998). I argue that this is not the case. The reproductive success of memes are not linked to their phenotypes and that some memes have no phenotype at all! Sure enough, a successful phenotype can enhance the meme reproductive success but its not a necessary
condition. What counts is the meme relation to other memes.

Based on these assumptions the following general model for a memetic life-cycle can be proposed (Fig.1.). An active meme (M) lives in its host organism, in an infected human brain (IHB). It can reproduce either directly (DT) via human communication or indirectly (IT) via transmitting vehicles (RTV). The aim of the transmission and the criteria of success is to infect an uninfected human individual (UHB). Both direct and indirect transmission can
be influenced (dashed lines) by the meme's phenotype (PH), it can increase or decrease it but its existence is not a necessary condition for reproduction. Sometimes, however, even the phenotype can transmit the meme (songs, gestures). This form of reproduction is called as phenotypic transmission (PT).

Figure.1. The memetic life-cycle. See explanation in the text.4. The main assumptions of the model First, we should discuss the problem whether memes in books, films, journals should be counted as l
iving memes or that living memes must reside in the brains of (living) humans. Some argues that living memes can exist outside of a human brain (Wilkins, 1998), however, I have already indicated I vote for the opposite case. The argument is as follows. First, books, pictures or tapes are not interactors (Def.2.). They are not non-equilibrium open systems, and they cannot interact actively with their environment. Only humans are interactors. Second, living replicators have to reside in interactors (Def.3.).
Hence memes have to reside in human brains in order to be counted as living ones. One can argue that memes are interactors themselves. That is true but they can only interact with each other in human brains. Two books cannot interact with each other (unless you put one on the top of other) neither can two articles in the same journal. But then what is the status of the memes in a newspaper or in a book? They are not living ones but certainly they are not

dead. Now, we can recall the problem of viruses and b
iological reproductive vehicles such as seeds or eggs. I have argued in the previous section that books and films and radio programs have the same status, they are memetic reproductive vehicles (RTV-s). So the question is the same. Is an egg, a pollen, a seed, a book, or a film contains a living replicator or not? The answer is yes and no at the same time. We cannot tell. The problem is similar to that of Schrödinger's cat. Until you open the box you cannot tell whether the cat is dead or alive. Until you t
ry to germinate a seed or incubate an egg you cannot tell whether any of them are living or not. Each egg, each seed has a potential to develop into a living organism, but that is just a potential. The only thing one can say is the probability of germination or hatching. The situation is similar with memetic reproductive vehicles. One cannot tell whether a book or a newspaper contains a living meme or a dead one. The only thing one can tell is the probability of infection if a human reads them. This approac
h may seem to be a strange one but its certainly not a new one. It is widely applied, just for to the other end of the living dead continuum. If someone finds an ancient writing what is the way to find out whether it is written in a dead language or in a living one? The finder probably shows it to a lot of people and if no one understands (that is, the meme written in that language is unable to infect any people) then the language is declared to be dead.

Next, the problem of the phenotype should be disc
ussed. I argue that the widely accepted analogy with genes (Ball, 1984; Wilkins, 1998), i.e. memes should have phenotypes and they are selected upon it, is false. Memes need not have phenotypes. Have you ever seen the phenotype of God? In theory three types of meme can be distinguished. Memes which always express their phenotypes, memes which sometimes express their phenotypes, and memes which have no phenotypes at all. For the first class human gestures can be cited as examples, provided they reproduce by
imitation. The vast majority of the human memes falls into the second category. Finally, our abstract ideas and notions such as God, freedom, right and wrong are examples for the last type of memes. To highlight the second class, let us take the example of scientific theories. One would think that a scientific theory surely have to have a phenotype otherwise what is the use of it? Note, however, that any theory first should infect at least some person (the influential the better) in order to gain access to
the resources which are necessary to produce the phenotype of the given theory. Second, theories are not evaluated solely on the basis of their phenotypes, i.e. on their success or failure to predict certain kind of observable phenomena, but rather frequently on the basis of meme relations. For instance, the theory of socio-biology was accepted or refused in the USA usually on the basis of ideological motivations, or the theory of the inheritance of acquired characters spread in the Soviet Union for politic
al reasons in spite of the contradicting evidence.

5. Memetic resources

The present model helps us to differentiate between various memetic resources. That on turn can serve as a basis for a memetic niche definition (Számadó, forthcoming). Since active memes must reside in the brains of humans the primary resource for memetic reproduction is the human brain. Direct transmission does not requires any extra resource. Reproductive (or secondary) resources are the necessary inputs for the production
of reproductive transmitting vehicles (RTV-s), i.e. for indirect transmission. Finally, the phenotypic (or tertiary) resources are those which are required to produce the memes phenotype. As we have seen from the previous section only the primary resource is necessary for successful reproduction. The presence or absence of secondary and tertiary resources, i.e. the production of RTV-s or the phenotype can enhance the success of a meme but not a necessary condition

for reproduction. Finally, there is a four
th kind of resource. That is the computational time of the human brain (Dawkins, 1976).

Science is an appropriate example for this classification. Since the human brain is the primary resource of memetic reproduction, the observation that PhD. students are the most prized resources is not surprising at all (Wilkins, 1998). Publication space in scientific journals, proceedings, books are secondary resources, and labs, grants and other equipment are tertiary resources.

6. Basic properties of memes

O
n the basis of the present scheme it is possible to classify the most important properties of a meme from a modelling point of view.
The meme as a replicator has three widely accepted properties:
Survival: how long it can persist in a brain of a human.
Copying fidelity: the precision of the copying process.
Reproductive activity: either direct or indirect reproductive attempts per unit time.

The meme as an interactor has two (rather descriptive) properties:
Popularity: it shows how attractive or re
pulsive the meme for a given other meme.
Tolerance: it shows how attractive or repulsive are the other memes from the point of view of the investigated one.
Basically, the popularity and the tolerance are the two sides of the same coin. These relations can be best represented in a matrix form, when each row gives the tolerance values of a meme to others and each column tells how other memes like the meme under question. There are zero values in the main diagonal.

The process of indirect reproduction ha
s the following properties:
Fundamental potential: it shows that how successfully can a given meme infect peoples in the form of the given RTV (which crucially depends on the popularity of the meme among the already presented memes found in the uninfected human brain).
Realised potential: how much proportion of the fundamental potential is realised.
For instance, the fundamental potential gives how many people can remember to the meme provided he/she have read it in the journal, have seen it on the TV, e
tc. But obviously, not every one has read that journal or has seen the given program on TV, so the realised potential shows that actually how many people have read that journal, have seen that TV program, etc. and can remember to the meme.

The process of direct reproduction has the property of:
Efficiency: which tells the proportion of successful infections as a result of direct transmission (which is also depends on the popularity of the meme).

Finally, a meme can have phenotypic properties by whic
h it can modify both its own or any other meme's any properties, or any encoded properties of any other kind of replicators (genes).

7. Conclusions

The present model depicts a scheme of a general memetic reproduction. It helps us to tell the difference between living and dead replicators, between interactors and reproductive transmitting vehicles. Most of the problems of the field arise from the confusion of living memes or phenotypes of memes with

RTV-s which can be traced back to Dawkins (1976)
. For example, a plan of car in a human brain is the living meme, a plan on the drawing board is an RTV, and finally, the car is the phenotype. If one reads a book and remembers it then the story in her/his brain is the meme. The book, however, is not the phenotype! It is only an RTV. In a similar way: a mail on the Internet is not a meme (Pocklington, 1997; Best, 1997), neither a meme relics (Lynch, 1997) or a phenotype (Dawkins, 1982), it is an RTV. Sometimes, however, the phenotype can transmit the meme
(songs, gestures). This possibility was realised by Denett (1995) and he called the transmitting objects as "meme vehicles". However, it is important even in this case to differentiate between the phenotype and between the RTV-s. Both may transmit the meme, but that is the RTV's only function which does not hold for the phenotype. Furthermore, the model allows to differentiate between the primary, secondary (reproductive) and tertiary (phenotypic) resources. Finally, it describes the main properties of a me
me which should be taken into account in a population dynamical or demographical model. For example, it shows that if someone measures the daily frequency of a given type of a mail on the Internet (Pocklington, 1997; Best, 1997) it gives only the reproductive activity of that given meme (i.e. how many RTV-s (mails) does it produce during a day) and not the reproductive rate (i.e. how many mature offspring was produced).

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