The mechanical and universal nature of imitation

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ABSTRACT

Ever since Aristotle, imitation has been thought of as a high level capacity enabling agents to learn new behaviors by the mere observation of a model. This view is, by far, too restrictive. By focusing on the sole cognitive dimension, most thinkers have overlooked the motivational aspect of imitation and therefore, have remained blind to the ubiquitousness of most mimetic phenomena in which no actual learning occurs. After stressing the chaotic state of the question of imitation in animal and human psychology, a criticism of the classic distinction between sophisticated imitation and low level imitation will be proposed through a historical survey. A comprehensive definition of imitation will be proposed and the notion of *tendency* to imitate will then recover the place it deserves. Its complete absence in the current debate on imitation will be interpreted as the effect of an enduring process of rationalization that goes back to Aristotle. It will then be shown that the circular reaction mechanism, bedrock of both Baldwin's and Piaget's genetic epistemologies, explains sufficiently why imitation is a mechanical tendency as well as a universal phenomenon no less affective and conative than cognitive. The conclusion will urge the necessity for any artificial or synthetic psychology to acknowledge the mechanical tendency to imitate that pervades natural psychology.

Keywords

Low level imitation, irrationality, tendency vs capacity to imitate, sensorimotor loops, circular reaction mechanism, reproduction, stability, evolution.

1. INTRODUCTION

Most psychologists and ethologists of this century have conceived of imitation as a high level capacity devoted exclusively to the learning of new behaviors (Watson 1914, Thorpe 1963, Bandura 1962, Zentall & Galef 1988). And, in the field of artificial agents, imitation is quite logically seen as a good means to acquire new skills by the mere observation of efficient models.

In spite of its wide acceptance, this clear cut idea might be extremely misleading regarding the objective of implementing imitation among artificial agents. Indeed, it is only a simplistic view which conceal an essential part of reality. For imitation is definitely not restrained to learning situations. It covers the whole range of psychological phenomena and is therefore a fairly complex notion which has to be understood if we don't want to engage in an impasse.

As everybody knows, imitation bears not only upon new behaviors but also upon behaviors which are already part of the behavioral repertoire of the imitator. For example, it is acknowledged that the baby who reproduces adult mimics or the crying of another baby is actually imitating even though these behaviors already belong to her repertoire (Meltzoff & Moore 1977, 1994). Likewise, the first experiments on imitation in the robotics domain have beared upon such behaviors as following or flocking which are not learning behaviors, but are nonetheless genuine mimetic behaviors (Mataric 1993, Dautenhahn 1995).

This restricted view of imitation as an innocent capacity of observational learning belongs to a long tradition that goes back to Aristotle. It has been perpetuated thanks to its conformity to the individualist ideology which characterizes Western thought. Indeed, by this close association between imitation and learning, Aristotle exorcised the frightening depiction made by Plato, i.e., the image of an imitation pervading the whole psychological realm. In Plato's view, indeed, all behavioral and mental phenomena, whether cognitive, conative or affective, were concerned by imitation. And the fact that imitation is not restricted to the cognitive domain is especially disturbing for the individualist since the re-production of a modeled behavior might have resulted from a mere imitation of its motivation rather than from a rational and willfull decision ; hence the scaring idea that behaving like a sheep might not be proper to the sheep. When seen as a mechanical tendency rather than a mere capacity, imitation reveals the irrational and animal background above which humanity tries to ascend but to which it remains rooted.

Unable to face this evidence, many thinkers have relentlessly focused attention on high level imitation capacities arguing that these capacities are restricted to humans as well as some apes. Therefore, the low level (no learning) imitation has been neglected. And so much for the motivational dimension of imitation.

In this paper I will try to sketch a more balanced view of imitation through a brief historical and theoretical survey. Then, Baldwin and Piaget's *circular reaction* mechanism will be detailed in order to explain why imitation is a *tendency* rather than a mere *capacity*, and why it is not circumscribed to the learning domain, bearing upon the whole psychological realm.

2. THE IMITATION CHAOS

Imitation is becoming a very fashionable topics in the behavioral and cognitive sciences (Meltzoff & Moore 1977, Zentall & Galef 1988, Whiten & Ham 1992, Donald 1993, Heyes 1993, Wyrwicka 1996, Byrne 1998). Unfortunately, it is in a state of chaos because there is currently no agreement on the very meaning of this term. As a matter of fact, during the past century, scientists never came close to a consensual definition of imitation.

The Nobel prize Jacques Monod used to say that evolution theory is particular because it seems that everybody believes understanding it. But, this is also true of imitation. Everybody thinks they know it and deal with it under the influence of the many prejudices taken from our cultural fund. And it is fair to say that our culture has a very ambivalent, indeed even anxious attitude toward imitation.

As a matter of fact, ever since the advent of scientific psychology, this theme has aroused a bewildering mixing of passion, controversies and suspicions. So much so that no clear definition has yet emerged.

It is as if each author believed in exploring a no man's land and made it one's duty to institute his most preferred categories. This resulted in a chaotic state which has been regularly denounced but yet, joyously maintained with an impressive number of redundant, arbitrary and sometimes, meaningless categories. In the thirties, Young (1930:587) wrote :

> The psychological litterature on imitation among men and among the lower animals is in a state of confusion, to which failure to agree on terms has contributed

In the seventies, Bandura(1971:4) wrote :

> Among the diverse terms applied to matching behavior are "imitation", "modeling", "observational learning ", "identification", "internalization", "introjection ", "incorporation", "copying', "social facilitation", "contagion", and "role-taking...Unless it can be shown that modeling of different forms of behavior is governed by separate determinants, *distinctions proposed in terms of the content of what is emulated not only are gratuitous, but may cause needless confusion.* (italics are mine)

Ten years ago, Galef (1988:4) wrote :

> Historical diversity in approaches to study of imitative behavior has produced incompatible conceptual frameworks for analysis of imitative phenomena. One man's example of true learning by imitation is another's paradigmatic case of "pseudo-imitation" and each can cite historical precedent for treating phenomena of interest as he does.

Consequently, the question is how shall we get our bearings in this unlikely multitude of mimetic notions which, from observational learning to copycat behavior have had such names as: *modeling, copying, matching behavior, matched-dependent behavior, vicarious learning, social learning, socially shared cognition, social support, social validation, social synchronization, interiorization, perspective taking, role taking, conversion, conformism, yielding, social facilitation, social influence, coaction, response facilitation, stimulus enhancement, local enhancement, contagion, propagation, diffusion, contamination, echophenomenon, mimicry, motor mimicry, mimesis, recruitment, following, gregarism, normalization, polarisation, induction, suggestion, emulation, identification, sympathy, empathy, affective sharing, affective responsiveness, affect attunements* etc. ?.

3. THE FUNDAMENTAL SEGREGATION

Basically, one may observe a fondamental regularity in this accumulation of categories. Indeed, the behavioral and mental reproductions to which they refer are constantly distributed among those resulting of highly complex cognitive activities and those yielded by low level psychological processes.

This is the regular expression of a habit that goes back to Aristotle and which has been maintained by the enduring concern for distinguishing mankind from animals. A concern which has not been lessened by evolution theory, quite the opposite.

Since Aristotle stated that :

> Imitation is congenial to the infant who differs from other animals in being more imitative and in acquiring his first knowledge by imitation. (Poetics, IV,2)

imitation has been closely associated to the learning processes, i.e., the cognitively complex mental activities. So much so that all other mimetic phenomena with no clear conscious, willfull or acquisitive dimensions, have been labelled differently. With some notable exceptions such as Spinoza's work, this segregation has been maintained in an informal way till the twentieth century when the endeavour to scientific achievement led Thorndike and his followers to the plotting of supposedly absolute demarcations.

Thus, the imitation's domain is currently divided in two compartments : on the one hand, observational learning and its related notions, on the other hand, contagion, social facilitation, copycat behavior etc.

4. THE FUNDAMENTAL UNITY

Now, it is of the utmost importance to be aware that, originally, this segregation did not exist. The concept of *mimesis* (the greek origin of the latin *imitatio*) covered the whole spectrum of the behavioral and mental reproductions, now more scattered than distinguished.

This unity is especially salient in Plato's *Republic* where comments are made on the role played by imitation regarding the rational education of the guardians of the city as well as the emotional contagion among the audience of a theater's tragedy. What is especially striking in Plato's conception of imitation, it's his fear :

> We have not yet, however, brought the most serious charge against imitation, namely that it is able to corrupt even good men, with very few exceptions, and that is a terribly dangerous thing. — Terrible indeed, if it does that. (605 c)

It is so intense that he will insist on an absolute control of imitation through a rigourous selection of the allowed models :

> If [our guardians] imitate they should from childhood up imitate what is appropriate to them —men, that is, who are brave, sober, pious, free and all things of that kind. (395 c)

He had, of course, quite well understood that any behavior is a potential model :

> And so in regard to the emotions of sex, and anger, and all the appetites and pains and pleasures of the soul which should accompany all our actions, the effect of imitation is the same. (606 d)

With what will be known as the " imitation taboo ", Plato let us understand three important points :

- the fact that imitation covers the whole psychological realm : cognition, conation, and affection.
- the fact that the study of imitation can't be restricted just to a problematic of capacity. For imitation has also to be acknowledged as a tendency or a propensity.
- As a tendency, imitation is socially dangerous, since it will draw behavior toward any models, whether good or bad. Rationality and will are no protection.

5. A GENERIC CONCEPTION OF IMITATION

In my opinion, Plato's insights are of great value since they help us reach the general outlook on imitation which is so badly needed. The wide area of mimetic phenomena currently looks like a war in the Balkans when the basic task of science remains the discovery of regularities or invariants. And in order to determine these invariants, we need a comprehensive or generic conception of imitation. For this reason, I propose to define it as the " **total or partial reproduction of a perceived or imagined behavior, whether overt or covert** ". No specific reference to cognition, learning, or whatever high mental activity is made here, since we are concerned with any form of psychological reproduction, whether cognitive, affective or conative.

I now would like to illustrate the interest of such a generic conception of imitation by analysing the notion of *stimulus enhancement* which has been frequently opposed to imitation since Galef (1988) brought it again into fashion. *Stimulus enhancement* is frequently proposed as a more parcimonious explanation than the imitation hypothesis in those experimental paradigms where an animal :

(1) observes a model operating on some device, for example, a joystick, in order to get, say, a food reward and

(2) reproduces the modeled behavior when put in the same experimental situation. (see e.g. Heyes *et al.* 1992)

Basically, it is argued that the reproduction of the correct behavior does not necessarily result from a representation of the modeled behavior since the attention of the imitator might have been drawn to the joystick which might have been successfully manipulated by a mere trial and error process. Therefore, what might have taken place is an :

> apparent imitation resulting from directing the animal's attention to a particular object or to a particular part of the environment. (Thorpe 1963:134)

Even if such an explanation was to gain any experimental support, which is not actually the case, the reference to an imitation process would still be necessary since, as Davis (1973) judiciously pointed out, the concept of stimulus enhancement remains completely silent about the reason why the observer's attention is drawn toward the object manipulated by the model :

> While it may be true that the probability of a correct response can be increased through a model's "directing the animal's attention to a particular object or to a particular part of the environment" (Thorpe, 1963, p 134), this would seem to raise the equally important question of *how* it is that one organism's attention is (sometimes) directed to, say, a particular manipulandum by observing another organism or its behavior. In other words, the question of what, exactly, determines the observing animal's response in these situations remains unanswered. (p 44)

In order to answer the former question, we just need to notice that the observer pays attention to the object of attention of the model. Then, the essentiel role played by imitation becomes obvious : the observer merely reproduces the attentional behavior of the model. And even if this is only a *part* of the global behavior of the model, following our definition, it is correct to say that imitation has occured.

The notion of *stimulus enhancement* appears rooted in the imitation of attentional behaviors, and is therefore conceptually equivalent to notions such as *joint visual attention* (Butterworth 1991) or *second gaze response* (Tantam 1992). These notions are nothing but three different labels of one and the same basic psychological phenomenon, namely, the imitation of attention. This unearthing of the fundamental unity of notions heretofore confined to comparative psychology, developpemental psychology and psychopathology, respectively, gives a good example of the fruitfulness of a generic definition of imitation.

6. THE MECHANICAL NATURE OF IMITATION

Our analysis of the *stimulus enhancement* explanations first suggests that the tendency to the reproduction of the attentional behavior of conspecifics is such a well known phenomenon that nobody ever mentions it. For the layman, it is certainly irrelevant to express what is already common knowledge. But this should not apply to scientific context where everything has to be made explicit. Hence, one may suppose that scientists are rather reluctant to acknowledge the existence of an imitation of attention. As a matter of fact, in spite of its theoretical relevance and its ecological validity, this notion is completely absent of the agenda of psychologists and ethologists.

But this obscure tendency to reproduce conspecifics' attentional behavior is indeed a mere aspect of the general — and no less obscure— tendency to imitation which has been Plato's obsession and which is, only implicitely, acknowledged through the huge number of low level mimetic phenomena. As a matter of fact, this very idea of a tendency to

imitate is not appearing any more in the scientific study of imitation. The only focus of attention is the *capacity* to imitate. Babies' joint visual attention capacities have been investigated in depth but absolutely nothing was said of their desire to gaze where the adults are gazing. Facial and gestual imitation capacities of newborn are studied with sophisticated paradigms, but almost nothing has been said of their enduring readiness to imitate. In sum, the fact that imitation might proceed from a mechanical tendency of the psychological organisations is never considered. Therefore, we are always restricted to a rational register when in fact, since its origins, psychology —and especially social psychology— has accumulated a huge amount of data on the processes of behavioral and mental " convergence " which occur on a mechanical, automatic or unconscious basis between individuals in interaction (Doise 1995).

It is clear that we and our culture really don't like to acknowledge this mechanical tendency. We constantly **conform** to the western individualist *Weltanschauung* (Sampson 1977, 1981, Markus & Kitayama 1994). We are desperately willing to believe that we are independant agents rather than pawns, followers. Thus, for most people, imitation :

> ...is principally a characteristic of people who are anxious, dependent, conforming and who are lacking in intelligence, in self-confidence, and in self-esteem. (Bandura 1971:36)

No wonder why the entranched individualism of the 20th century psychology has occulted the mechanical nature of imitation.

7. IMITATION AND THE RATIONALIZATION PROCESS

In order to think of ourselves as autonomous, endowed with free-will, i.e., in order to discount the importance of mimetic phenomena, we have at our disposal a multitude of rationalization routines which " explain " behavioral similarities without resorting to this disgraceful (because) irrational mimetic tendency. The principle of these rationalizations has already been illustrated with the notion of *stimulus enhancement* : it is always a matter of showing that, beyond their apparent similarity, the behaviors of each individuals are only adapted —hence rational— responses to a same reality. In a chapter dedicated to *stimulus enhancement*, Zuckerman (1932:171) stated :

> The behaviour of one monkey modifies the behaviour of another by constantly introducing into its immediate environnement "elements" and relations that were previously unnoticed. *Its response to these may be identical with the response of another monkey, since the same kind of animal is responding to the same situation.* (stress is mine)

Thus, it is quite satisfying for our attributional schemata when we can explain, for example, the fact that a crowd is looking at the roof of a building, by the presence of a potential suicide victim. The former will be seen as the necessary and sufficient explanation of the uniform attentional behavior of the members of the crowd. The invocation of tendency to imitate the attentional behavior of others seems completely irrelevant.

It is now extremely important to understand that in our traditional causal framework this explanation will be seen as absolutely correct when at the same time it is completely trivial. Indeed, it overlooks the fact that the immense majority of the passers-by composing the crowd have been prompted to look upward by the tendency to imitate the specific gaze orientation of others. As a matter of fact, a nice experiment (Milgram *et al.* 1969) has shown that most passers-by will look upward if a group of people is looking upward, even though there is nothing special to look at.

Therefore, in a fair generalization, we may state that when having to explain the similarity of some behaviors in terms of reality or in terms of imitation, we always choose reality, happily ignoring that it might be built through a mimetic process (Berger & Luckmann 1967, Salvador 1996)

8. WHICH MECHANISM ?

Now, what could be the mechanism which will explain the universal as well as the mechanical nature of imitation ?

As a matter of fact, there is a straightforward answer if one concurs with Baldwin (1895; 1902), von Uexküll (1926), Piaget (1936), Varela (1979), Eigen & Schuster (1979) or Brooks (1986) in conceiving of natural or artificial organisms as a bunch of cycles, *sensorimotor loops*, *circular reactions*, *schemas*, etc. Currently, many researchers are implicitely or explicitely using sensory-motor loops as the elementary unit of their artificial agents' organisation. Whether they called them a sensing-acting feed-back loop (Brooks 1991), a Sensory-Association-Motor architecture (Aitken 1994), a behavior (Mataric 1995), an activity module (Hendriks-Jansen 1996) etc., makes no difference. What is at stake, in each case, is the closing of the loop between motor outputs and sensory inputs through the environment. By putting back perception and action in a loop, i.e., in a circular causality, robotics rediscovered a basic principle of Baldwin and Piaget's *genetic epistemologies* : the regularities of sensory inputs are definitely not detected in the environment, they are built by action through the environment. Perception is activity-bound. Thanks to this new perspective successfully applied in various setting (e.g. Parisi 1992, Nolfi 1993, Aitken 1994, Scheir & Pfeiffer 1995, Hendriks-Jansen 1996, Rutkowska 1997), the integrity of the behavioral and/or psychological organisation, which were lost in the classical approaches of robotics and AI, has been recovered.

However, the semantics of sensory-motor loops functioning has not yet been fully understood. For no necessary connection has been established, neither with evolutionary theory nor with mimetic phenomena. In order to do so, it is convenient to replace sensorimotor loops in the evolutionary as well as social context of Baldwin's theory :

1) In his perspective, sensorimotor loops, as any organisation, will reach stability, i.e., existence, through reproduction. Therefore, alike any living forms, the sensorimotor loops which will survive are those which action leads to the very stimulation capable of triggering them again. In other words, a sensorimotor loop is a "circular reaction", i.e., a "reaction which tends to maintain, repeat or reproduce its own stimulation" (Baldwin 1906:333). The circular reaction will maintain, repeat, or reproduce itself if the stimulation produced through action is recognized, or "assimilated". For example, a crying baby produces a stimulation which assimilation or recognition will precisely lead to the reproduction or the maintenance of the cry. The termite making a pellet with a mixture of earth and saliva gives rise to an odoriferous stimulus which assimilation will stimulate its building behavior.

2) This assimilation stage is of tremandous importance since it is at the crossing of the cognitive and social dimensions of behavior (Salvador 1997). Indeed, the stimulation produced and assimilated by one circular reaction might be assimilated by another one. For example, the cry of a baby, when assimilated by another baby, will usually trigger its crying circular reaction (Simner 1971). Likewise, when assimilating the odor of the earth + saliva pellets produced by its conspecifics, the termite will resume or enhance its building activity (Grassé 1959, Salvador 1995). This is illustrated in Figure 1 where the stimulus (a) produced by the circular reaction A has been "recognized" by the circular reaction B, which assimilated it to the stimulus it usually produces. The circular reaction B is consequently triggered, and therefore produces a stimulus (b), similar to the first one, which is then re-produced or imitated (cf. Figure 1).

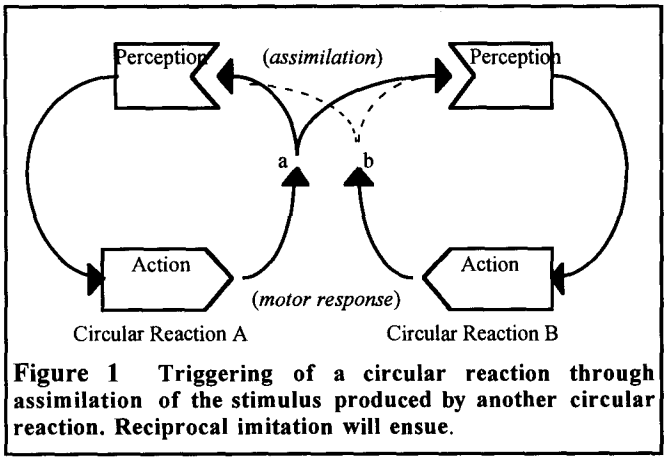

Figure 1 Triggering of a circular reaction through assimilation of the stimulus produced by another circular reaction. Reciprocal imitation will ensue.

As it is only stressing the invariant dynamics of interaction between behavioral cycles, no matter what their level of complexity, the very same principle would apply to any other interactions between circular reactions reciprocally assimilating their productions. It can model the interaction dynamics of, say, the building behavior of termites, the collective photoluminescence of fireflies (Buck and Buck 1978), the chorus of cicadas (Williams and Smith 1991) and, finally, the whole spectrum of collective behavior, from simple gregarism (herding, flocking, etc.) to more sophisticated activities such as scientific productions (Murphy 1942, Latour 1989, Lecourt 1994, Shadish & Fuller 1994, Salvador 1996, Brookes 1997).

This mechanism helps understand why:

- We won't get "novel behavior almost for free" (Rutkowska 1997) since what is imitated is mainly what is already in the behavorial repertoire of the imitator. If there's any difference, it has to be a slight difference which will not impair assimilation
- Imitation is mechanical : insofar as the stimuli of the model are assimilated, they will initiate the action to which they are paired and which will precisely lead to their reproduction. This is the most basic expression of the well-known phenomenon of ideomotricity (see Prinz 1987). In such a context, willfull or deliberate imitation appears for what it is: a *post hoc* rationalization.
- Imitation is a universal phenomenon. Insofar as behavioral or psychological organisations are indeed cyclic in nature, all schemas, no matter what their level of complexity, will manifest this circular reaction dynamics and are therefore concerned by the mechanical tendancy to reproduce what has been assimilated. Furthermore, as a circular reaction or a schema instanciate the three basic aspects of psychology, namely, the cognitive (*assimilation*), the conative (*action oriented toward an invariant stimulation*) and the affective one (*energy level*), we understand why imitation covers the whole psychological realm. As a matter of fact, as I have hypothesized elsewhere (Salvador 1995, 1996), this coordination dynamics based on reciprocal assimilation and imitation between circular reactions is utterly homologous to the phenomena of frequency and phase locking which is ubiquitous among the physical, chemical and biological oscillators. Because of their cyclical nature, the perception/action cycles, of any level of complexity, are plain oscillators. Therefore, regarding the behavioral sciences, it comes as no surprise that imitation should be as ubiquitous in the behavioral sciences as the resonance and synchronization phenomena are in the physical and natural sciences (see Winfree 1980, Glass 1989, Strogatz & Stewart 1993). This homology opens wide avenue for a modelization of imitation in terms of dynamic systems (see Strogatz & Stewart 1993).
- Since exposition to a modeled behavior favour the reproduction of the corresponding schemas in the imitator's repertoire, imitation serves a role of selection and stabilization among the pool of schemas. Hence its evolutionary dimension which, despite a lamarckian character is of tremandous importance regarding cultural phenomena (Tarde 1903, Dawkins 1976, Girard et al. 1987)

9. CONCLUSION

It has been shown that the concept of imitation encompasses a lot more than the mere *learning by observation*. For imitation bears on the conative and affective aspects of behavior as much as it bears on the cognitive one. The mechanical nature of imitation as well as its ubiquitousness have been rooted in the circular reaction mechanism which is just the natural functioning of sensory-motor loop structures. Finally, I would like to stress the fact that acknowledging the tendency to imitate seems quite necessary in order to the neutralize the rationalist prejudices which hinder our access to the essentiel factors of behavior. Indeed, the suggestion that rationality and free-will are first of all *petitio principii* invites the study of the processes through which rationality and intentionality actually emerge from a sensorimotor, hence mechanical, organisation. In other words, we have to understand how rationality emerges from mechanical or irrational behaviors. Therefore, we don't have to be shy in implementing irrational mimetic behaviors in our robots. These mimetic behaviors are the clay of which we are modeled.

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