Proceedings of the 1st European Conference on Cognitive Sciences (ECCS'95)
St Malo, France, 4-7 April 1995

SWARM INTELLIGENCE, COLLECTIVE ACTION AND IMITATION

L.-L. Salvador

Laboratoire de Psychopathologie
28, rue Serpente, 75006 Paris, France

1 Introduction

1.1 foreword

The objective of this study is to reflect on the close and generally misunderstood relationship between collective action and imitation. I shall attempt to show that collective action, whether it is considered from the affective, cognitive or conative domain, has to be conceived in mimetic terms. Such a proposition will appear original and/or audacious depending upon the context. From the standpoint of 19th century psychology, it would appear as a mere commonplace: from Bagehot (1873) to Lebon (1895) through Tarde (1890) and Baldwin (1895), imitation is *the* explanatory principle of the behavior of groups, crowds and whatever society. However, considered from the point of view of current psychology, this proposition will run counter to most schools of thought: the roaring individualism established at the beginning of this century with behaviorism has not been questionned by cognitivism and thus remains entrenched. In such a context, a fully mimetic psychology is almost unacceptable (Winnykamen 1993). This is why, prompted by a pragmatic more than polemical concern, I shall, in the main, address myself to the specialists of DAI, inviting psychologists to refer to my doctoral thesis (Salvador 1995) in which are outlined and evaluated the thousand and one ways 20th century psychology has invented in order to avoid speaking of imitation.

For reasons of time and space, I shall limit my proposal to the case of **reactive** agents - agents deprived of the ability of symbolic treatment- or, in other words, to the **swarm intelligence** facet of collective intelligence. Thus I shall not concern myself here with rational, conscious, intentional imitation to which one tends to refer almost exclusively on account of the reassuring control seemingly exercised by the will. Suffice to say that this sophisticated imitation which allegedly characterises human learning is nevertheless entirely based on automatic, mechanical imitation (cf. Salvador 1995) to which I am going to refer and which has to be our logical starting point.

1.2 the *one / multiple* relation and imitation

In order to see the central role played by the mimetic theme, one just needs to grasp the essence of collective action which appears to be encapsulated in the simple fact that *one* action is performed by a *multiplicity* of agents (Fig.1). The relation *one/multiple* leads necessarily to similarity or *mimesis* because, if several agents are engaged in the same activity it will always be possible to say that they are doing the same thing ; hence they appear similar in this respect. This will hold true whatever the diversity of sub-tasks involved in the focal action. Thus, for

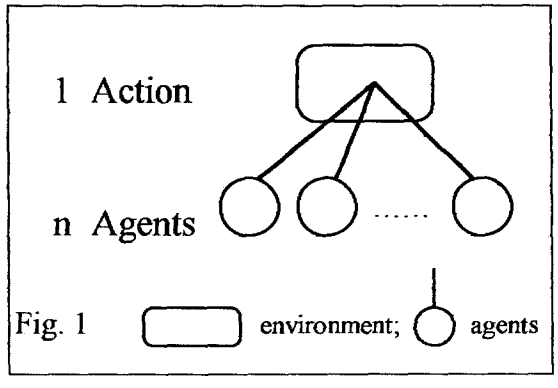

Fig. 1

example, the clown, the trapezist and the lion-tamer, despite having different acts are, nevertheless, all circus artists pursuing the same objective, performing the same task: to present the most attractive show. The similarity of the agents with respect to the action they perform collectively can be perceived in two radically opposed ways depending upon whether the agents are judged independant or, on the contrary, susceptible to being influenced by one another. In the first case, the similarity will be explained by reference to a similar environment. The environment being the same for all, it would provide the same stimuli resulting in the same actions from similar organisms. In other words, agents have the same (*idem*) behavior because they are in relation with the very same (*ipse*) cause.

It is usual here to refer to the *stigmergy theory* proposed by Grassé (1959) to explain the building behavior of termites:

> « The basic idea is that no direct interactions are necessary to coordinate the work of a group, but that interactions between the nest and the workers is enough. The working termites modify their environment, providing new stimuli. These new stimuli induce new behavioural responses which in turn modify the environment. With this succession of stimulus-reaction, the society is able to produce a structure. It is the work itself which assumes the coordination of the workers'activities. « (Deneubourg *et al.* 1992:125)

Hence, the behavior of each of the agents is considered as independant from that of the others and dependant only upon environmental stimuli. The actions of the others play a role, but only inasmuch as they change the environment and, more precisely, the work (*ergon*) which alone spurs (*stigma*) the agent. Depending upon its state of progress, the nest will stimulate in its turn one or the other reaction, which will result in a new state, therefore provoking further reactions, and so on...

To this *individualist* view is opposed the more *social* interpretation according to which it is the behavior manifested by some agents which gives rise to a similar behavior among other agents. Whether one speaks of *group effect, social facilitation, coaction, behavioral contagion* or, more simply, of imitation, this perspective is, anyhow, radically opposed to the former view because in this case, the behavior of an agent is caused by the behavior of other agents and not by the environment alone (Fig. 2). In both cases, the agents have the same (*idem*) behavior and the same (*idem*) rapport with the environment, but in the former case this twofold similarity is supposed to be the effect of a same (*ipse*) environmental cause whereas in the second case, it is caused by the mimetic reproduction of the behavior - and, especially, orientation behavior toward the environment- of others.

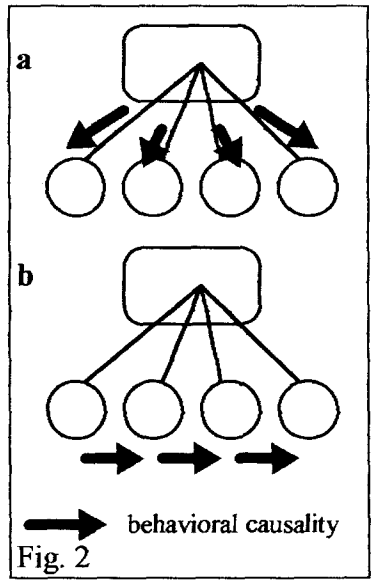

Fig. 2

1.3 Objectives

I would like to show here that the first perspective, although quite natural in the context of our individualist *zeitgeist*, is only a theoretical abstraction, a borderline case of no practical interest, an oversimplification of the second perspective and that it is, thus, always in the mimetic context that it is appropriate to explain or to model the emergence of collective action. Thus, for example, when one states that a crowd is looking at the roof of a building because of a potential suicide victim, one is correct, of course, but only trivially, having overlooked the fact that, initially, each member of the crowd was prompted to look upward by the specific gaze orientation of others, that is to say, by a tendency to imitate their gazing.

I shall now analyse some characteristic examples of collective action which have been previously explained in an individualistic fashion, and in each case, I shall underline

the arbitrary nature of such an explanation and the necessity of the mimetic one. These examples will cover the three psychological areas -namely the cognitive, affective and conative ones-, hence, they will, I trust, adequately show the unavoidable nature of the mimetic approach in the study of collective action.

2. Stigmergy Theory

The conclusion -adequately summarized by Deneubourg *et al.*- of Grassé's outstanding study of the building behavior of termites seems irrevocable: « The workers are indifferent to the behaviour of their companions » (Grassé, 1959:79). This author wants us to acknowledge that termites dig up the soil, mix it up with saliva and deposit their pellets in heaps, lines, blades, pillars and arches according to the objective stimuli furnished by the state of progress of these different shapes, i.e., without reference to the behavior of other workers.

This clear-cut conclusion is somehow paradoxical because, as we shall see, the data presented by Grassé does not support his claim and one is drawn to suppose that this author has been influenced by the behaviourist orthodoxy of his era, which only accepts Stimulus-Response explanations -remember that, at the outset, *stimulus* had almost the same meaning as *stigma* because it designated the sting of the cattleman. Thus, in the section *Influence of the group on behavior*, Grassé observes that:

> « The stimulating action of the group at work on the individual is obvious. One notes that: 1) as the work progresses the number of workers increases ; 2) individual work intensifies as the number of workers increases. » (Grassé 1959:48) (*translation is mine*)

Here, Grassé makes judicious reference to the notion of *social facilitation* which, in essence, designates nothing more than an imitation bearing on the conative and affective -i.e. motivational- aspects of action (cf. Salvador 1995). Grassé notices that in the absence of this group facilitation, the constructions will not be completed:

> « Small groups do not fail because their work capacity is weak. Their failure is due to inadequate social stimulation. » (Grassé 1959:47) (*translation is mine*)

Now, the issue is whether, after such reports, one can still reasonably claim that « the workers are indifferent to the behaviour of their companions » ? Obviously not or, at least, not regarding the conative and affective -i.e. motivational- domain.

With regard to the cognitive domain, is it certain as Grassé states, that only the objective parameters, such as the density of the heaps, or the height of the pillars determine the exact location of deposit of the earth-pellet ? Nothing is less assured, because as Grassé shows us, the termites perceive the location and shape of the constructions according to their odours, and in particular, the odour of the saliva produced by their fellow creatures to form the pellets. The worker is able to locate *where its peers have deposited their pellets*, and not only *able* but *eager* too, because, as Grassé noticed, the more recent and fresh the deposit of others the more likely is the worker to make its deposit in the very same place.

Thus, a closer reading of Grassé reveals that, from start to finish, the building activity of termites is determined by mimetic behaviour whatever cognitive, conative or affective aspects are considered. Therefore, the independance of the agents postulated by the stigmergy theory appears quite arbitrary. The nest, far from being the *first cause* of similar building behaviors among termites is rather a structure emerging as a result of the mimetic convergence of these building behaviors.

In order to understand how Grassé came to a conclusion so discrepant with his own observations, it is necessary to represent the building behavior of termites as would Baldwin (1895) , Piaget (1936), or von Uexküll (1936), i.e. as a *circular sensorimotor reaction* which can be defined as a reaction triggered by the very products -or effects- of its action (Fig. 3). Elsewhere (Salvador 1995), I explained at length that this *circular reaction* (*CR*), invented by Baldwin (1895) and reused by Piaget under the appellation of *assimilation cycle* or *schema*, is the necessary and sufficient explanation of any mimetic behavior whatsoever. Here, I will just point out the fact that imitation -simply defined as the reproduction of a given behavior by an agent after the perception of an other agent performing the same behavior- is straightforwardly explained if one observes that any *CR* will necessarily be triggered by a stimulation that would be close enough to those usually produced by the *CR* itself because a *CR* is, precisely, a reaction triggered by its own productions and those alike. Thus, for example, we can understand the fact that a baby starts crying on hearing the cry of another infant as the triggering of the *crying CR* of the imitating baby by the *assimilation* of the sound produced by the *crying CR* of the model. The central role played by *assimilation* has been underlined by Simner (1971) who experimentally observed that more similarity between the two cries leads to more imitation.

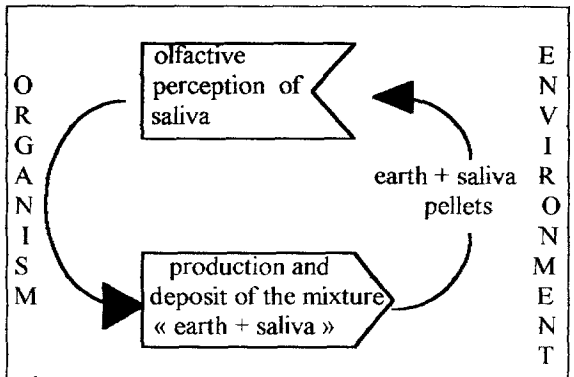

Fig. 3 Termites' building *circular reaction*

This explanation apply immediately to the *social facilitation* observed by Grassé since the mixture of earth and saliva produced by the building *CR* of a termite can be assimilated by the building *CR* of its peers which will, hence, engage in the same activity. This is a mimetic phenomenon since the activity of a « model » *CR* is reproduced by the « imitating » *CR* of a congeneric peer (Fig. 4).

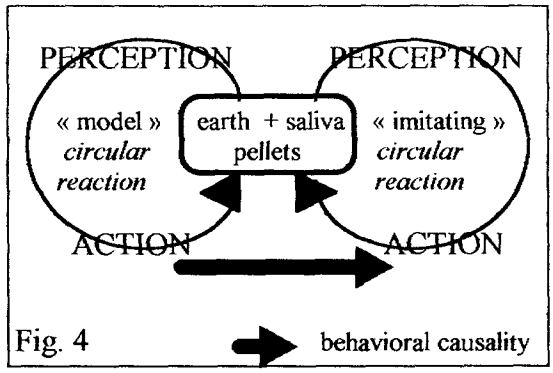

Fig. 4

When claiming that the nest alone determines the building behavior of workers who are supposed to be indifferent to the behavior of their companions, Grassé arbitrarily « opens » the *CR* and, flattening it, obtains the traditional and long criticized *reflex arc* (Dewey 1896, von Uexküll 1935, Varela 1988) to which the nest is the *input* and the building behavior the *output* (Fig. 5).

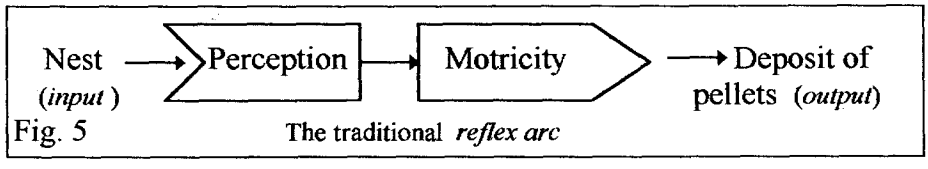

Fig. 5 The traditional *reflex arc*

Because of this shift from *circular* to *linear* causality, the nest appears at the beginning of the causal serie and, thus, receives a fallacious status of *first cause*. This is, of course, quite arbitrary since the functionality of a circular process, as for example the functionality of a bicycle chain, depends on *each* of the links which form the chain. Hence, wherever you are to « open » a circular causality, you will be right , but only trivially, if you are to state that the first item of your new linear causality is the cause of all what comes after.

If, in the opposite the stage « earth + saliva » is not set apart from the behavioral cycle, i.e., if one is to respect the integrity of the *CR*, one understands easily that the nest appears at the point of convergence and accumulation of a whole bunch of *CR*s which « imitated » each other by reciprocal assimilation of their production. The nest is the focal point of a bundle of converging *CRs* which engender it as much as it engenders them. This bundle of *CRs* being cut by Grassé, the nest obtains a fallacious autonomy, it seems to be only a cause and no longer an effect (Fig. 6).

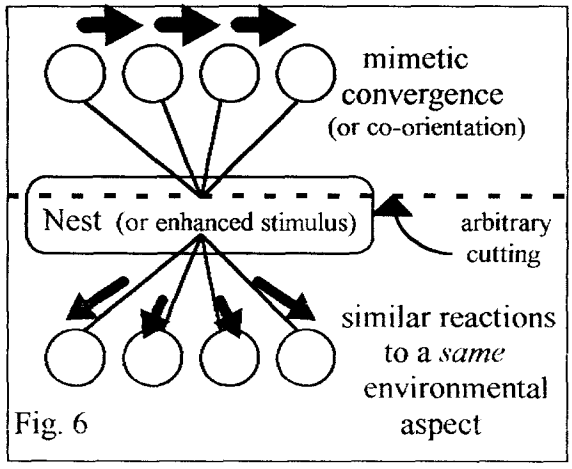

Fig. 6

The stigmergy theory illustrates almost the whole history of the scientific study of imitation. As a matter of fact, since the beginning of the 20th century, we observe regular attempts to understand the behavioral similarity of social agents as the same (*idem*) effect of a same (*ipse*) cause and a clear avoidance of the mimetic explanation. The arbitrariness of this treatment revealed in our analysis of the stigmergy theory is, interestingly enough, expressed by the double meaning of the word « identity », which designate the same (*idem*) as well as the unique (*ipse*). The unique thing, far from being autonomous regarding its « identity », obtains it through the agreement that may or may not intervene between its multiple « identifications » or « assimilations ». Without this agreement of the multiple on the unique, without this similarity of perspectives on a same (*ipse*) thing, there is no unique thing, there is no identity.

3. Stimulus Enhancement

Let us now consider another example of collective action: let it be the case of a duck confined with its fellows in an enclosure who, escaping after the discovery of a hole in the mesh, is soon followed by the other members of the flock. Obviously, the first duck behavior has been reproduced by the others, and, as such, has allowed their collective escape. But is it imitation ? For both psychologists and biologists, from Watson (1914) to Galef (1988) through Thorpe (1963), the answer is negative, imitation is not concerned because what occured is supposed to be a mere *stimulus enhancement*. This means that the first duck simply underlined or enhanced a relevant aspect of the environment to which all the ducks reacted in the same way. These authors would, as Grassé did with his idea of stigmergy, make us believe that an environmental stimulus alone is responsible for the ducks' behavioral similarity. As with Grassé, this line of reasoning holds only if we ignore the obvious fact that the ducks, first of all, paid attention to what their fellow creature was interested in and hence, reproduced -i.e. imitated- its perceptive orientation, its exploratory attitude. This genuine imitative act is the first responsible for the salience of the stimulus, as already seen with the case of the crowd looking at a potential suicide victim: most of the passers-by discovered the latter's existence simply by « adopting », i.e., reproducing the perceptive attitude of the crowd. It follows that the appropritate explicative schema for the so-called *stimulus enhancement* phenomenon is exactly the the same as for *stigmergy* theory ; one just has to replace « nest » by « enhanced stimulus » (cf. Fig. 6). Here again, because of the cutting up of the circular causal chain -cf. the hash marks- the stimulus is given a role as *first cause* and this implicitly deny the mimetic convergence of perceptive orientations without which the stimulus would have remained unnoticed, being thus unable to exercise its causal power.

4. Pheromones and Communication

Imagine an ant X coming upon a path marked by the pheromones of a fellow ant Y. If X were to take up this path, would it be (1) the receiving and decoding a message with adapted subsequent reaction or (2) more simply, an imitation ? This question may appear unseemly given the undisputed tendency to categorize this phenomenon as one of *social comunication*. No one as ever intimated that what we might have here is a case of imitation. And yet, does not ant Y **reproduce** the behavior previously exhibited by ant X ? Does it not take up the same path to explore the same space ? Why is it so difficult to see this as an example of imitation ?

This blindness toward imitation is easily explained if we understand that when considering the pheromone as a means of communication or as a kind of symbol, we are, in fact, cutting up the behavioral cycle of the ant at the level of the pheromone which coming then first in the behavioral sequence, appears naturally as the *first* and *necessary* cause of the subsequent behavior. If , in the opposite, we comprehend the pheromone with the *circular reaction* to which it belongs, we understand that ant Y 's circular reaction *assimilated* the pheromone emitted by ant X's circular reaction and being thus triggered, imitated the latter.

As in the case of the termites' nest; we tend to see the pheromone as independant of the ants'exploratory schema given its topological independance from the ants' body. Therefore, we have difficulties seeing the reaction of Y to X's pheromone as being a direct reaction to the latter's behavior, but this is, indeed, the case (cf. Galef 1988).

The two situations of communication just surveyed -communication *via* pheromone and communication *via* the mixture of earth and saliva- are not isolated cases. Their common mimetic dynamic is not mere coincidence as more and more studies draw a close link between imitation and the emergence of communication (cf. Malatesta & Izard 1984, Nadel 1986, Lewis & Feinman 1991) As a matter of fact, is a communication anything else but the *reproduction* by the « receiver » of what is meant by the « transmitter » ? If we agree with Piaget (1945) on the equivalence between *schema* and *signifié* (meaning), it is clear that what we have here is a process in strict accord with the usual definition of imitation.

By the way, I can't help pointing to the fact that the structuralist motto concerning the autonomous existence of symbolic structures is strictly equivalent to Grassé's position regarding the termites'nest and is therefore open to the same criticisms. We cannot explain the similarity of the *signifiés* by appealing to the identity, « ipseity » or universality of the *signifiant* because nothing entitles us to consider the *signifiant* as a first cause. Quite the opposite, we should rather acknowledge that, as the pheromone or the mixture « earth + saliva », the *signifiant* is generated by the mimetic convergence of similar schemas or *signifiés*. Therefore, I would like to caution the reactive D.A.I. specialists against using a ready-made communication or symbolism. Communication has to emerge from interactions between agents and imitation plays here a central role.

5. Conclusion

We have seen that the essence of collective action is to be found in the relation *one / multiple* resulting of the fact that several agents accomplish the same task and this can be interpreted in one of two ways. First, one can merely see here the iterated effect of the one and same cause: the same (*ipse*) stimulus provoking the same (*idem*) activity (Fig. 2 a). Second, one can also conceive of *idem* as the cause of *ipse* since the imitation of a given behavior implies the **reproduction** by the imitator of the model's orientation toward the

environment ; the imitator will then necessarily manifest the same (*idem*) oriented behavior toward the very same (*ipse*) environmental aspect. Here, the behavioral causality runs from one agent to another and the environmental stimulus plays a role only as a consequence of the mimetic convergence of the agents towards it (Fig. 2 b). This latter view is not a mere antithesis of the former because it comes from a circular conception of causality, i.e., it does not deny that a causality runs from *ipse* to *idem* but rather underlines its insufficiency. As a matter of fact, *ipse* explains *idem* as much as the latter explains the former (Fig.7). Various examples illustrated this idea that the first explanation is but a simplified version of the second.

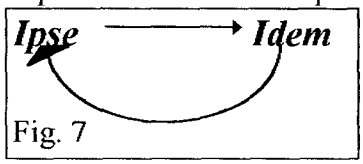

Fig. 7

The circular causality perspective can easily be recovered from the linear explanation by merely questioning about the origins of the *first cause* invoked. For example, many attempts to undermine the mimetic approach rely on situations such as the case of people who open up their umbrellas when it rains and who, it seems, do not imitate each other, even though they engage in the same behavior. To counter this argument we only need to replace it in a genetic context: when and how did the stimulus « rain » acquire the power to activate the opening of umbrellas ? Do we have here, as in the case of gravity, a causality that has exercised its influence since the beginnings of time ? Or isn't it rather the result of some *social learning*, i.e., a process during which a given agent ends up reproducing the adaptative behavior of another agent ? Obviously, this is a case of reproduction of a behavioral model that might have been quite different. The rain itself explains nothing for there are so many countries around the world where people do not open umbrellas when it rains.

Given that the first explanation -the *unicist*, *symbolist*, or even *sacrificial* idea that *ipse* alone is the cause of *idem*- can always be deconstructed so as to reveal the *idem* behind the *ipse*, being as such reduced to the mimetic explanation, we can assert with some confidence that the mimetic perspective can alone give a full account of collective action. The latter should therefore be seen as resulting of the mimetic convergence of the circular causalities, the *circular reactions*, or the sensorimotor loops that constitute the agents.

I understand that, given its wide span, such an assertion will probably be puzzling for the reader. That's why I shall now propose two application exercises:

(1) Ant-hill D.A.I. models (Collins & Jefferson 1992, Drogoul *et al.* 1992) have usually a serious shortcoming: space is arbitrary limited. Whether this limit comes from an obstacle explicitely incorporated in the model or of a mere programming trick, it constitutes anyway an imposed reality not collectively built up by the agents. This precludes a mimetic feature of crucial import ; which one ? The matter is the gregarious behavior, i.e., the tendency to adopt the same spatial location than its fellow creature which characterises most animal societies. Hence, a herd of herbivores exists only insofar as each animal tries anytime to occupy the same space as its fellow creatures. Without this gregarious tendency, ant-hills, herds or animal groups whatsoever would not exist as such, for the individual animals would just scatter about in nature. Given that imitation has been a relentlessly contested notion since the beginning of the 20th century, biologists preferred talking about *interattraction* (Grassé 1986, Le Masne 1993). This term is purely descriptive and has no explanatory value but, as it puts the accent on affectivity, it lays aside the conative and cognitive aspects of gregarious behavior and hence, makes imitation less obvious. Once again, this is just a degenerated and rechristened form of imitation -which I call a *euphemism* of imitation. Anyhow, *interattraction* is of absolute generality among animal groups but, has it been acknowledged in computer simulations of animal societies over the past few years ? As far as I know, Reynolds (1987) is the one in a few, if not the only one who, ***only implicitly***, gave his *animats* - some artificial birds

called *Boids*- mimetic behavioral rules enabling a « natural » genesis of the group. And yet, is not positioning in « space-time » a fundamental aspect of behavior ? It is of such importance that men, however different or distinct they may be, once they have come together in the same place, are termed an *assembly* (from the latin *similis*).

(2) Cognitive psychology has come progressively to acknowledge that cognition could be social, and then, the notion of *socially shared cognition* has been introduced (Resnick *et al.* 1991) to explain situations where the cognitions of one subject « influence » those of another. But can't we then ask if the notion of *sharing -social sharing* at that !- has any explanatory value. Does it not follow from the fact that two agents *share* the same (*ipse*) representation that they have similar (*idem*) representations ? And if this similarity resulted from one influencing the other, how can we reasonably avoid references to imitation ? It is clear that the notion of *sharing* is at best a metaphor that points implicitly to a make-believe unity whose *sharing* constitutes, no less implicitly, a fake explanation of the similarity of the *sharings*.

In the same vein, should we not wonder if the term « kenetics » (from the greek *koïnon*, what is common) suggested by Ferber (1994) to designate the science of collective action, is not itself another way heading off any discussion about similarity ? Is not this designation going to focus once again our attention on a unique entity -what is common-, therefore hiding the fact that all agents have the **same** relation to « what is common ».

If I were in a position to suggest a name for the science of collective action, in my opinion, the most fitting term would be « mimetics ». This naive wish should make it clear to the reader that my position is not, in the least, critical regarding DAI. Indeed, I only followed the path opened by DAI when cutting itself loose from classic AI with a more or less explicit contesting of the apparent unity of intelligence. By revealing the multiplicity underneath, by trying to understand the process whereby the multiple comes to form a unity, DAI realizes *ipso facto* a tremandous work of *deconstruction* of invaluable epistemological and ontological significance.

The mimetic perspective offered here partakes of this *deconstructivist* spirit firstly because it disputes explanations based on a unique entity whose collective origin remains veiled (cf. Girard 1977, Girard *et al.* 1987) and, secondly, because the underscoring of the efficacy with which imitation can polarize the attention of a whole population on a same environmental characteristic allows us to understand why attention has always been diverted from imitation and why a population's behavior seems therefore always regulated or controled by the entity on which it centered mimetically.

Finally, for those who still hesitate on the importance of imitation in the realm of collective action, I just would like to stress the fact that everything simply hangs on their acceptance of the circular conception of behavior. Indeed, as far as one is reasoning in terms of circular causality, imitation is a logical consequence because, as we can see in figure 4, two similar circular reactions can't but enter into reciprocal imitation. Actually, *this is true of any circular causalities, whatever their behavioral, biological, chemical or physical nature.* There is no question of giving here a full fetched analysis of this statement. I will just point to the fact that ***circular reactions* are nothing but *oscillators*** hence, they will inevitably manifest the most characteristic « behavior » of oscillators, i.e., the tendency to « lock » in frequency and phase (Glass & Mackey 1988). Now you have a good idea of what I meant by **mechanical imitation**. And you can foresee the potential scope of the mimetic perspective.

6. References

Bagehot W (1873) *Lois scientifiques du développement des nations*. Germer & Baillière. Paris.

Baldwin JM (1895) *Mental development.* New.York. McMillan
Collins RJ & Jefferson DR (1992) AntFarm: Towards Simulated Evolution in CG Langton *et al.* (eds.) *Artificial Life II.* Redwood City, Addison-Wesley.
Deneubourg JL, Theraulaz G, Beckers R (1992) Swarm-Made Architectures in Varela FJ & Bourgine P (eds.) *Toward a Practice of Autonomous System.* Cambridge. MIT Press
Dewey J (1896) the reflex arc concept. *Psy.Rev.* 3, 357-37O
Drogoul A et al. (1992) A behavioral simulation model for the study of emergent social structures. in Varela FJ & Bourgine P (eds.) *Toward a Practice of Autonomous System.* Cambridge. MIT Press
Ferber J (1994) La Kénétique: des systèmes multi-agents à une science de l'interaction. *Revue Internationale de Systémique.* 8(1), 12-23.
Galef BG (1988) Imitation in animals in TR Zentall & BG Galef (eds.) *Social Learning.* Hillsdale. LEA
Girard R (1977) *Violence and the sacred.* Baltimore. The John Hopkins University Press.
Girard R, Oughourlian JM & Lefort G (1987) *Things Hidden since the Foundations of the World.* Stanford. Stanford University Press.
Glass L & Mackey MC (1988) *The Rhythms of Life.* Princeton, NJ. Princeton University Press.
Grassé PP (1959) La reconstruction du nid et les coordinations interindividuelles chez *Bellicositermes Natalensis* et *Cubitermes sp.* La théorie de la stigmergie: essai d'interprétation du comportement des termites constructeurs. *Insectes Sociaux.* 6, 41-8O
Grassé PP (1986) *Termitologia.*Paris. Masson.
Lebon G (1895/1963) *La psychologie des foules.* Paris.PUF.
Le Masne G (1993) *Sociétés Animales.* Encyclopédia Universalis
Lewis M & Feinman S (1991) *Social Influences and Socialization in Infancy.* New York. Plenum Press.
Malatesta CZ & Izard CE (1984) The Ontogenesis of Human Social Signals: from Biological Imperative to Symbol Utilization. in NA Fox & RJ Davidson (eds.) *The psychobiology of affective development.* Hillsdale, NJ. LEA
Nadel J (1986) *Imitation et Communication entre Jeunes Enfants.* Paris. PUF.
Piaget J (1936) *La Naissance de l'Intelligence chez L'Enfant.* Neuchâtel. Delachaux et Niestlé.
Piaget J (1945) *La Formation du symbole chez l'enfant.* Delachaux et Niestlé. Neuchâtel
Resnick LB, Levine JM & Teasley SD (eds.)(1991) *Perspectives on Socially Shared Cognition.* Washington. Am.Psych. Ass.
Reynolds CW (1987) Flocks, Herds, and Schools: a distributed behavioral model. *Computer Graphic.* 21(4), 25-34
Salvador LL (en préparation) *Imitation et Attribution de Causalité: la Genèse Mimétique du Soi, la Genèse Mimétique du Réel.* Thèse de doctorat de l'Université de Paris V.
Simner M (1971) Newborn's response to the cry of another infant. *Dev. Psy.* 5, 136-15O
Tarde G (1890) *Les lois de l'imitation.* Paris. Alcan.
Thorpe WH (1963) *Learning and Instinct in Animals.* London.Methuen.
Uexküll J von (1935/1965) *Mondes animaux et Monde Humain.* Denoël. Paris
Varela FJ (1988) *Les sciences cognitives.* Paris. Seuil.
Watson JJ (1914) Behaviour: an introduction to comparative psychology. NewYork. Holt.
Winnykamen F (1993) Imitation. in P. Champy (dir.) *Dictionnaire Encyclopédique des Sciences de l'Education et de la Formation.* Paris. Nathan.