Collective intelligence: An emergent semiotic system

Francesco Consiglio
Universidad de Granada, Spain
e-mail: consiglio@ugr.es
orcid.org/0000-0003-0439-8362

ABSTRACT

The main idea I shall argue for in this article is that collective intelligence can be explained as a result emerging from the activity of a group of individual agents, all of which act within the framework of a common semiotic system, such as the cultural structures shared by them all and representing their common ground, the cultural niche where they born and grow up (their collective imagery, for instance).
The main deal, here, will be to detect the bases of the feedback loop mechanism which permits the development of this emergent semiotic structures. Also, I shall explain how human groups indeed constitute a very sophisticated case of multi-agent system, a collective intelligence whose main feature is its social ontology.

WORK TYPE
Article

ARTICLE HISTORY
Received:
10–September–2018
Accepted:
22–December–2018

ARTICLE LANGUAGE
English

KEYWORDS
Collective Intelligence
Multi-Agent Systems
Semiotic Systems
Niche Construction
Emergence

NOTES ON CONTRIBUTOR

Francesco Consiglio is a member of the research project "Habla interna, metacognición y la concepción narrativa de la identidad" (MINECO: FFI2015-65953-P) and of the FiloLab Excellence Unit at the University of Granada, Spain. He is CPhil in Philosophy of Mind at the University of Granada. He studied at the universities of Siena (Laurea Triennale in Filosofia), Parma (Laurea Magistrale in Filosofia) and Salamanca. He mainly focused, during his studies, on Theory of Knowledge and Philosophy of Mind. More recently, he focused on Theory of Collective Intelligence and social cognition. He published both articles and translations in various Spanish and Italian journals of philosophy and he gave talks in various congresses around Europe.

HOW TO CITE THIS ARTICLE

Consiglio, Francesco (2018). «Collective intelligence: An emergent semiotic system». *Disputatio. Philosophical Research Bulletin* 7, no. 8: a009.

Collective intelligence: An emergent semiotic system

Francesco Consiglio

§1. Introduction

THE MAIN IDEA I SHALL ARGUE FOR IN THIS ARTICLE is that collective intelligence can be explained as a result emerging from the activity of a group of individual agents, all of which act within the framework of a common semiotic system, such as the cultural structures shared by them all and representing their *common ground*, the *cultural niche* where they born and grow up (their collective imagery, for instance).

What I defend is that, as any multi–agent system, also a social group develops its own self–organizing 'rules'. I shall suggest that these rules are emergent and irreducible to any particular agent; moreover, they work as guidelines —as constraints— for the possible actions afforded at any concrete time T to any agent A, member of the considered group. In this sense, these rules are the real 'motor' of any problem–solving strategy undertaken by the whole group[1].

The main deal, here, will be to detect the bases of the feedback loop mechanism which permits the development of this emergent system of rules. Also, I shall explain how human groups indeed constitute a very sophisticated case of multi–agent system, a collective intelligence whose main feature is its social ontology.

1.1. What a multi–agent system is

The concept of the *multi–agent system* has been developed in informatics to respond to some of the main criticisms of classical artificial intelligence, which mainly pointed out the lack of *embodiment* of 'intelligent' programs in a physical, real and interactive environment (e.g. Dreyfus, 1979 and Searle, 1991)[2]. Till the 1970s, the model of intelligent machine had reflected the parameters of the famous *Turing Test*: a program, to be considered intelligent, had to be able to appear as a human–like agent to a human observer through its behaviour (e.g. good responses to generic questions about human practises, such as: "Do you like playing tennis?")[3]. Hence, the focus is on projects for machines which, individually, can act in an

1 This is because the group itself can be seen as an 'information network' whose nodes are the very agents. See Francesco Consiglio, «Information networks and systemic properties. An epistemological perspective». *Disputatio. Philosophical Research Bulletin* 6, nº 7 (2017): pp. 309–321.

2 See Jacques Ferber, *Les Systèmes Multi–Agents: vers une intelligence collective* (Paris: InterÉditions, 1995). See p. 5 and ss.

3 Alan Mathison Turing, «Computing Machinery and Intelligence». *Mind* 49 (1950): pp. 433–460.

intelligent way. For this reason they are defined expert systems, artificial agents (computers) able to individually reproduce specific technical competencies. It is in the 1980s that the paradigm changes: it is now acknowledged that intelligence «is not an individual characteristic, separable from the social context in which it takes place»[4]. An individual agent develops its cognitive capacities in relation to its surrounding counterparts which it interacts with. Intelligence is not an 'innate program' with a genetic basis: «the others are necessary for our cognitive development and what we call 'intelligence' is in the same measure due to both the genetic basis defining our neuronal structure and the *interactions* [italics are mine] we can have with the surrounding world and, in particular, with the human society»[5]. These are the years in which the ecological approach proposed and defended by James J. Gibson takes root[6]: both the subject and the object are situated in an environment, which is not anymore a neutral container, but deeply influences and directs the cognitive dynamics of an agent. So, the concept of multi–agent system tries to introduce in informatics the theme that intelligence derives from interactions among many agents situated in an environment, forming «a group of interacting entities, being each entity *locally* defined with no global detailed vision of all the actions of the system. […] we pass from the notion of *program* to that of *organization* [italics are mine]» [7]. Therefore, we have to imagine a system where the coordination among its parts emerges «from an interaction among relatively autonomous and independent entities, called *agents*, which work inside a community, in complex ways, entailing cooperation, conflict or competition, to survive and to perpetuate themselves»[8]. The main characteristic feature which marks the difference between a multi–agent system approach and a classic systemic approach is just the stress put on the emergence of an organization from *local action and interaction* among the agents of the system. The programmer only knows the *base conditions* of the system, the fundamental rules of local interaction, and he ignores its future evolutions, which follow the dynamics typical of chaotic systems and are widely unforeseeable[9].

What is, therefore, an *agent* in this system? Well, it is an entity «able to act in an environment, […] able to directly communicate with other agents»[10], an entity partially autonomous «which only has a partial representation [of its] environment, which has competences and offers services, which can potentially reproduce, whose behaviour *tends to satisfy its objectives* [italics are mine]» [11]. Hence, an agent has no systemic vision, it just has a partial one, a situated one, which is limited to the achievement of its personal objectives. It moves in a work space, the environment it shares with its counterparts and in which it tries to

4 Ferber, cit., p. 6. The translation from French is mine, here and where not differently indicated.

5 *Ibidem.*

6 James Jerome Gibson, *The ecological approach to visual perception* (Boston: Houghton Mifflin, 1979).

7 Ferber, cit., p. 7.

8 *Idem*, p. 8.

9 *Idem*, p. 9.

10 *Idem*, p. 13.

11 *Ibidem.*

fulfil its aims, finding adequate responses to the interposed obstacles. A multi–agent system, therefore, is composed of a work space (which, in some sense, represents its 'skeleton'); it is composed of the agents moving inside this space (which represent, altogether, its active component) and of a set of *objects*, which «are passive, so they can be perceived, created, destroyed and modified by the agents»[12]. These *manipulanda* should be conceived as Lego bricks interlocking structures, indefinitely manipulable. Or, to say it better, the 'limits' of what can or cannot be done are set by the same agents, who build and destroy structures, modifying the shape of the work space. Each new structure offers new and different *affordances*[13], new practical meanings which represent —being stimuli for particular responses— real *conditions* for the actions that the individual agents composing the system gradually undertake.

1.2. Why a multi–agent system

The concept of multi–agent system develops, as I pointed out in § 1.1, in a very specific technical context and historical period: complex system and bio–inspired informatics of the 1980s and the 1990s. So, why should this paradigm be used nowadays to understand group intelligence? The answer is that, for its structural features, it seems to be an explanatory paradigm which permits us to avoid individual intentionality in the design and the development of a community. It does not entail any *conscious*, negotiated, construction of the rules by the agents.

First of all, in a multi–agent system all the cognitively relevant information is contained in the *work space*: no individual agent represents the global system, nor its dynamics altogether. Each agent has a partial and limited perspective, a *local* one. It takes all the information it needs from the work space it is acting in. Each piece of information is a real physical stimulus, an *affordance*, a practical meaning (what one can or cannot do in a specific context) which is generally *implicit* in the structure of the environment where the agent acts: if an agent A builds a wall in the work space, it will be an obstacle for the agent B to move in that particular direction. The piece of information "you cannot pass this way" is contained, for B, in the same structure of the space it is moving in, without necessity to negotiate it with A.

Hence, in a multi–agent system, information is spatial, situated and *contextual*: the piece of information "you cannot pass this way" only exists for B and just in case B is heading against the object 'wall' built by A, while for A that very object 'wall' is a *tool* (not an obstacle!) to reach its local purpose: the affordances of the same object 'wall' are different (they contain a different *piece of information*) for A or B.

Moreover, the multi–agent system represents a particular case of *distributed memory* (*scilicet*, in the work space): no one of the agents remembers or plans long sequences of actions conceiving them in a context, instead each of the agents *leaves traces* of its action, modifying the environment it acts in.

12 *Idem*, p. 14.

13 See Gibson, cit.

The distributed memory (in the work space) of the system is therefore composed of the traces which each agent *locally* produces. There is no command centre, there is not a CPU recollecting information and managing it in a centralised way to plan the development of the system, rather all information available for the system is situated in an external space, an environment *physically accessible* to all the agents composing the considered system. Each response to a stimulus, each trace, is a kind of *exogram*[14], an external memory record which constitutes a new condition for any future action.

In this sense, the particular cooperation/competition rules among the agents of the system are *emergent*: let's imagine for instance a system in which the agents A, B, C and D have (each one by itself) the aim to lay out some bricks scattered in the work space, gathering them all in a unique point. The following rules (the 'genetic program') are given to each of them: 1) "When you find a brick, pick it up"; 2) "if you are carrying a brick and you find another one, drop it off in that point"; 3) "if you have been carrying a brick for more than *n*–minutes, drop it off". The agents will start collecting bricks and gathering them in different points of the space (X, Y, Z …) until a bigger heap (X) will be recognised as the most appropriate deposit and the other heaps (Y and Z) as bricks 'scattered' in the work space. The rule "gather the bricks in the point X" is emergent. But, even more important is the fact that it is the very *shape* of the work space that makes X an *index* (semiotically speaking) of the correct deposit feeding back into the responses of A, B, C and D, directing their behaviour.

§2. The work space as an adaptive space: the example of the ecological niche

Now, if it is clear that the environment is not neutral for an agent but, instead, it actively feeds back into its behaviour, then neither the agent is neutral for the space surrounding it. Rather, each agent tries to adapt the *space* where it works for a better and easier achievement of its purposes. David Kirsh, in a famous article, points out that «[a] creature has at least three logically distinct strategies for improving its fitness. It can *adapt* to the environment, *migrate* to new surroundings, or *adapt the environment itself*»[15]. The agents dwelling in a specific space, do not restrict themselves to an automatic and passive reaction, simply adapting to those stimuli it offers, rather they develop 'redesigning' strategies of that very environment to make it more suitable for their purposes, because it is evident that «creatures with some active control over the shape of their environment will have an adaptive advantage over those who adapt only passively to existing environmental structures»[16]. Redesigning the environment

[14] See Merlin Donald, «The Exographic Revolution: Neuropsychological Sequelae». Lambros Malafouris & Colin Renfrew (eds.), *The cognitive life of things. Recasting the boundaries of the mind* (Oxford: Oxbow books, 2010): pp. 71–79: «Lashley (1950) called a memory record stored inside the nervous system an 'engram'. […] Memory records stored outside the nervous system (for example, clay tablets, papyri, printed books, government archives or electronic data banks) can be called 'exograms'» [Donald, 2010 : 71].

[15] David Kirsh, «Adapting the Environment Instead of Oneself». *Adaptative Behavior* Vol. 4, No. 3/4 (1996), p. 415.

[16] *Idem*, p. 416.

does not just mean to change its physical appearance: I have already underlined that the physical structure of the environment contains implicit information about how to use it; that information is characterized by different affordances for each agent moving in it. So, a smooth wall is an obstacle for a cat willing to climb it, while it constitutes a normal 'walking surface' for a spider. Considering what I have said so far, it appears evident how *physically* modifying an environment also implies changing its affordances, that is, its level of 'employability' for a particular agent or a different one. To make easier achieving a particular purpose will therefore entail, for the agent, to produce a *physical modification* of the surrounding space: if A needs to reach the object X on the other side of a river, building a bridge to cross it does not change just the physical appearance of the environment, but *the very nature of the task* A needs to complete.

Summarizing:

> In environment redesign, the creature remains in the same geographical region and is itself responsible for the change in environment. The global environment does not present the creature with a range of pre–existing habitats, differing in salient respects, from among which the creature then chooses. Rather, the creature itself actively creates the changes from a different pre–existing environment.[17]

Hence an habitat is not simply selective, but adaptive: in it selective obstacles *are not fixed*; instead, the agents acting in it continuously modify these obstacles, producing an ecological niche which is suitable for them. But the changes each agent makes in the habitat (in the 'work space') building its ecological niche, modify the selective obstacles for the other agents sharing the same space: for instance, a beaver dam modifies the selective obstacles for the fishes living in the river. It is a trace left by an agent which *indicates* what 'can be done' to the others agents in the system.

In this sense the work space of a multi–agent system, has to be conceived as an adaptive space in which each agent works to build, through its local actions, its own 'ecological niche', modifying spatial indices and *indirectly* conditioning the behaviour of the other agents of the system.

§3. Ecological agents and emergent rules: stigmergy and feed–back loops

Hence, we are talking about agents *situated* in an ecological niche: between the agent and the niche a mutual influence dynamics develops. Paraphrasing Kirsh, they reciprocally 'redesign' themselves. But what mechanism can explain the environment redesigning, the emergence of information structures, the very indirect coordination among the agents, through the mediation of the 'work space'? An appropriate concept has already been coined within the 'swarm intelligence' studies, that is studies about cognitive skills typical of herds, flocks, schools, but in a more obvious way of social insects: I am talking about *stigmergy*.

[17] *Idem*, p. 428.

Stigmergy is generally defined as «an indirect, mediated mechanism of coordination between actions, in which the trace of an action left on a medium stimulates the performance of a subsequent action»[18]. Composed of *stigma* (stimulus/sign) and *ergon* (work), it is a technical term originally developed in a specific branch of biology, by the entomologist Pierre–Paul Grassé[19]. He shaped this concept as an answer to the so called 'paradox of coordination' characterizing the cooperative behaviour of social insects[20], that is: how is possible that individuals whose intelligence is extremely limited, who have no global idea of what happens all around them, can nevertheless produce cognitively complex responses? He found a solution observing the behaviour of a termite colony: each time an agent had completed a task, it produced changes in the *structure of the work space* it shared with other agents; namely, it was changing the *affordances* of the environment, its practical meanings; it was leaving available *indices* in the 'work space'.

In this sense, the work space shared by all the agents of the multi–agent system has to be conceived as the *niche* they are living in, the ecological space they collectively build unloading in it much implicit information. Stigmergy can, therefore, be defined as the basic dynamics of any theory of the *niche construction*, considering that

> The niche–construction perspective […] contrasts with the conventional perspective [on the evolution and selection of species] by placing emphasis on the capacity of organisms to modify environmental states. […] In doing so, *organisms co–direct their own evolution* [italics are mine], often but not exclusively in a manner that suits their genotypes, in the process modifying patterns of selection acting back on themselves as well as on other species that inhabit their environment.[21]

Hence, to summarise, the fundamental principle of stigmergy affirms that the work produced by an *agent* in a *medium* leaves a *trace* which stimulates a subsequent activity by the same

18 Francis Heylighen, «Stigmergy as a universal coordination mechanism I: Definition and components», in *Cognitive Systems Research* 38 (2016a), p. 6.

19 See Pierre–Paul Grassé, «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* 6/1 (1959): pp. 41–80.

20 See Eric Bonabeau *et alii*, «Self–organization in social insects». *Trends in Ecology & Evolution* 12/5 (1997): pp. 188–193; Eric Bonabeau, *Swarm intelligence: from natural to artificial systems* (Oxford: Oxford University Press, 1999).

21 Kevin Neville Laland & Michael J. O'Brien «Cultural Niche Construction: An Introduction». *Biological Theory* 6/3 (2012a), p. 191.

The Niche Construction Theory includes studies on animal niche construction [Kirsh, 1996; Sterelny, 2007], human niche construction [Sterelny, 2007; Kendal, Tehrani & Odling–Smee, 2011; Laland & O'Brien, 2012b], social niche construction [Ryan, Powers & Watson, 2016] and cultural niche construction [Laland & O'Brien, 2012a], all of them arguing that «Evolution entails networks of causation and feed–back in which previously selected organisms drive environmental changes, and organism–modified environments subsequently select for changes in organisms» [Kendal, Tehrani & Odling–Smee, 2011 : 785].

agent or a different one which shares the same medium. This implies a feed–back loop between the *stimulus/sign* ↔ *work*; a condition implies an action which modifies that very condition, yielding a new action (condition → action → condition[1] → action[1]…). Following this principle it seems natural to describe stigmergy as a kind of situated and distributed cognition[22]: communication among the agents is mediated by the environment, namely the *medium*. In this sense it is important to point out that the trace *stimulates* the action, it does not *determine* it; it makes a response more likely, but not necessary. The stronger and more evident the trace is, the more likely for it is getting a correspondent response. To make possible for this mechanism to produce an actual coordination, the medium has to be accessible, and then *modifiable*, for each of the involved agents.

The image we get is that of a massively *parallel* distributed cognition system: each agent realises individual computations which produce an effect in the medium while it is trying to reach its local purpose, a *trace* which, as a side effect, is also a *cue* for the agents sharing that medium, making possible in this way an indirect communication among them. So, the trace is a consequence of an action and then it contains information about that action, which can be made explicit through an *abduction*: the trace is, in the particular perspective of the agent, an obstacle, a *cognitive challenge* it has to overcome to achieve its local goal.

In this context, I must underline that there are two fundamental kinds of stigmergy we can distinguish in terms of the type of sign used to communicate: one is called *sematectonic stigmergy*[23], while the other one is called *marker–based stigmergy*[24]. The first one refers to the transmission of a meaning by means of the 'structures' moulded in the *medium*: for instance, opening a foraging path indicates a track to follow, while a heap indicates a deposit point; on the other hand, marker–based stigmergy is characterized by a more punctual and precise information which has a *symbolic* feature: two concrete examples are releasing pheromones to signal, for instance, an interesting foraging source (the stronger the pheromone track the more likely an agent reacts) or, in the case of ants, releasing formic acid signals a danger, an attack. This last example is particularly interesting to explain the development of a symbolic function through the natural selection of an efficient algorithm like *enemy → formic acid*: Edward Wilson and Bert Hölldobler[25] remarked how, from a spontaneous and repeated defence reaction (the acid throw) in front of a danger, that chemical secretion got a symbolic value strongly linked with the information "there's an enemy out there". Therefore, Francis

22 See John Sutton, «Distributed Cognition. Domain and dimensions». *Pragmatics & Cognition* 14/2 (2006): pp. 234–247.

23 See Edward Osborne Wilson, *Sociobiology: The new synthesis* (Cambridge, MA: Harvard University Press, 1975).

24 See H. Van Dyke Parunak «A survey of environments and mechanisms for human–human stigmergy». In D. Weyns, H. V. D. Parunak, & F. Michel (Eds.), *Environments for multi–agent systems* II, (Heidelberg: Springer, 2006): pp. 163–186.

25 See Bert Hölldobler & Edward Osborne Wilson, *The Superorganism. The Beauty, Elegance, and Strangeness of Insect Societies* (New York: Norton & Company, 2009).

Heylighen[26] noted how, in peircean terms, we could define the first sematectonic case as an indirect kind of communication through indexes, while in the second case of marker based stigmergy, we could speak of symbolic communication. This is why in the former case the sign consists of a consequential indication, implicit in the physical state of the medium, while in the latter case the semantic connection is based on the relation between a marker and a state of things established by an agent through a continuous use of it.

Bearing in mind that stigmergy is actually a good label to define any dynamics in which an action is stimulated by a sign and each response is, more or less, otherwise–directed by the external information distributed in the environment, the main feature of a stigmergic system seems to be the very *role of signs* in the distributed cognition of the agents.

§4. Social niche and cultural niche: two semiotic systems

If the ecological niche is a space of affordances and indices (that is, signs), of 'appropriate structures' an agent builds in its ecosystem to make it more suitable, to make easier for it to achieve its local purposes in there, then social niche and cultural niche, exactly like the ecological niche, have to be conceived as systems of signs (namely, *semiotic systems*), in which the emergent structures, rich in implicit information, are the very rules of collective behaviour (laws) and the practices of the culture (rituals).

In the case of human beings, ecological, social and cultural niche are contiguous and interrelated: for instance a city is a *physical environment*, a modified and structured space, but also it is the place of the associate and cooperative life: a square is not just an open space, but also *a meeting place*; even more, the structures of the city can have a second meaning, a *symbolic* one, and in this way they represent a cultural niche: a house is not just a *shelter*, but also a *home*.

Actually, «Human niche construction, through modification of the environment, creates *artifacts* [italics are mine] and other ecologically inherited resources that not only act as sources of biological selection on human genes […] but also facilitate learning and mediate cultural traditions»[27]. We should consider those artifacts as *signs* which mediate the indirect communication, the stigmergy, among the agents of the same cultural niche (the 'work space' we are considering) conceived, therefore, as a semiotic system.

As already observed *en passant* by Francis Heylighen[28], we can use a peircean terminology to distinguish between a sematectonic stigmergy and a marker–based one (see *supra*, § 3), respectively through *indices* and *symbols*. Although, I guess that this little intuition about the semiotic feature of stigmergy reminds us of an important element: the semiotic framework lets us overcome the gap between a human and a non–human stigmergy. What changes is not the indirect communication *mechanism*, but the *kinds of signs* employed by the agents.

26 Heylighen, cit.

27 Laland & O'Brien, (2012a), p. 197.

28 Heylighen, cit.

Now, in his semiotic writings Peirce describes a sign as a representation which refers to an object. There are three fundamental types of sign: *icons*, *indices* and *symbols*. An icon is a sign which represents its object by means of a likeness with it; it is completely independent of any interpreter because its semiotic value is due only to its likeness with the referent, like the image —the visual information— contained in a painting (which is an hypoicon). An index is, in contrast, a sign which directly represents a state of things, a relation (often causal), for instance a footprint on the sand is an index of the man who walked there a few minutes before; its semiotic value is not relative to any particular subject, but directly dependent on the state of things it represents. Finally, a symbol is a type of sign which mediates a semiotic relation between the referent and the interpreter, because of a stable association, based on an interpreter acquired habit.

Once we have considered this context, it is easy to understand in what sense, in the case of the ant–like stigmergy, opening a foraging path *indicates* a track to follow, while a heap *indicates* a deposit point; at the same time, in the human social niche, closing a street with a gate indicates that the passage is forbidden. It is exactly what David Kirsh refers to with the words «redesigning the environment» (see *supra*, § 2) and, indeed, the manipulation of signs plays a key role on many levels in the construction of our social niche: in the stock market, for instance, the price of a good is a marker symbolising the demand/offer relation of that good. It mediates among the different interests of the 'selfish' and autonomous agents acting, locally, in that medium (*scilicet* the market) and the economic order emerging from all these individual actions (the emergent contextual rules) is a collective macro–phenomenon, *a priori* unforeseeable in its structure and in the development of its rules[29].

Moreover, an iconic artefact, an hypoicon such as a painting, is also an exogram[30], a complex sign which influences the redesigning of the cultural niche. I would like to underline, in addition to what I said, that also the way in which a piece of iconic information is gradually modified by the collective manipulation of the agents of a system, follows a stigmergic dynamic: a certain iconography emerges through repeated and gradual contributes given by each agent of the system, it is not planned *ab ovo*[31].

The main advantage of the sign, then, is just that it is by definition an 'information bearer', *independently* of the connection with a particular agent (interpreter). If this is clear for both an icon and an index, it is less certain for a symbol. I noticed, actually, that the semantic value of this one is due to an associative habit established by the interpreter between a sign and its referent. Nevertheless, it is certain that a symbol is not a simple, atomic element, but it always contains an iconic or indexical component which are, instead, independent of the interpretation of a specific agent. What is interesting about this autonomous feature of signs is therefore that the influence of the information they convey has not just a synchronic range,

[29] See Leslie Marsh & Christian Onof «Stigmergic epistemology, stigmergic cognition», in *Cognitive Systems Research* 9/1–2 (2008): pp. 136–149.

[30] See footnote 14.

[31] Francesco Consiglio, *Mindshaping through images* (forthcoming).

but also a *diachronic* one. The Manichaean symbol of the Warrior of Light who opposes, fights and defeats the Darkness of Evil[32] contains the same iconic information we find in another symbol such as the Archangel Michael, who wears an armour and fight the Devil. Two different symbols with two different referents (because of the associative habit of different interpreters) convey, nevertheless, *the same iconic information* and they do it on a diachronic level because that iconic information is conveyed in concrete hypoicons (for instance a painting or a fresco) which are some of the *artefacts* we manipulate to build our cultural niche (the 'work space' of our multi–agent system), whose importance has been underlined by Laland and O'Brien[33].

§5. Structured space: extended or scaffolded mind?

At this point, we know that the cultural niche of a human group is its 'work space' inasmuch as it is considered like a multi–agent system; that the members of the group are the 'agents' of the system; that the artefacts are the 'objects' which the 'agents' of the system manipulate. We know, as well, that these artefacts are *signs* and, for this reason, they are 'information bearers' independent of particular agents and with both synchronic and *diachronic* influence on the system. In terms of Merlin Donald, they are exograms, external memory records.

But, how can we move from these elements to arguing that a community, a cultural group, develops a 'collective mind'?

In an article immediately debated and already famous in philosophy of mind, Andy Clark and David Chalmers present the Extended Mind Thesis[34]: a subject with some memory difficulties (A) notes down useful information in a notebook, while a normal subject (B) stores them in the brain using his biological memory; when A reads the information recorded in its notebook he does not do anything different from B, who instead 'read' the information recorded in his biological memory; A's mind extends in the notebook, because it makes part of the cognitive system which 'remembers' the information. All the strongest objections to this thesis attack the *principle of parity* defended in it (*scilicet*, the functional equivalence between the biological memory and the 'notebook–like' memory). Here is not important to deal with the legitimacy of this principle. Rather, the main feature of the Extended Mind Thesis regarding the focus of this article, is the claim that the artefacts a subject manipulates make part, at least in a complementary[35] way, of his cognitive processes.

If a subject A deposits the information X in an exogram K, following the Extended Mind Thesis, the exogram K makes part of A's mnemonic process ('strong' thesis) or it is at least *complementary* to A's mnemonic process ('weak' thesis). Assuming the 'weak' thesis, what

32 See Hans Jonas, *The Gnostic Religion* (Boston: Beacon Press, 1958).

33 See footnote 27.

34 Andy Clark & David Chalmers «The Extended Mind», *Analysis* 58 (1998): pp. 10–23.

35 See John Sutton «Exograms and Interdisciplinarity: History, the Extended Mind, and the Civilizing Process», Richard Menary (ed.) *The Extended Mind* (Cambridge, MA: MIT Press, 2010), p. 204.

would happen if the exogram K in which the agent A deposited the information X were situated in a medium (a 'work space') also accessible to the agents B, C and D? It happens that K is *complementary* to the mnemonic processes of B, C and D as well: if John leaves the grocery list on the table and Luke takes it and uses it to buy what lacks in the pantry, the grocery list is a complementary artefact for the mnemonic process of both John and Luke.

But exograms, as we already know, are not only 'grocery lists': a painting, a papyrus, a stele covered by glyphs or the cave paintings of Altamira are exograms. They are signs which mediate the indirect communication among the agents of the system, both synchronically and diachronically. They are tools the agents use (or produce) in the attempt to adapt the selective space, in the attempt to build their own niche. As noted by Kim Sterelny[36], actually, the Extended Mind Thesis is nothing more than a particular case of niche construction or of «intelligent use of space», in the words of Kirsh[37]. In this sense, the cultural niche construction, which is a form of structuring the environment with cognitive 'scaffolds' (the signs in the 'work space'), appears to be an extension of the cognitive processes of the agents of the system in a physical space, the space of the niche, in which they share the artefacts, the exograms, the signs which redesign their behaviour; a space in which the same cognitive dynamics are, therefore, collective.

§6. Conclusion: the cultural structure as a collective 'mind'

Returning to social ontology, laws, *written* or transmitted through *oral formulae*, practices, codified and preserved in the *rituals* of a community, are external structures of information conveyed by specific exograms. Exograms gradually and collectively built by the agents living in a certain cultural niche.

Because they are *signs* always available in the 'work space', in the cultural niche of a collective, these oral or written *formulae* and these *rituals* which codify the *mos* of the community appear to be artefacts situated in a certain time and space, which influence both synchronically and diachronically the behaviour of the agents of the system. Modifying the artefact entails modifying the information it conveys: modifying a scene of a ritual implies changing the *prescription* it contains. Although, it is not necessary to modify the ritual through a collective and conscious action of all the members of the community: it is sufficient that an agent of the system interprets an element in a slightly different way, then another agent who does the same and so on to see the emergence, on a systemic scale, of a substantial modification of the cultural niche.

Now, the American anthropologist Roger Keesing, in the 1970s, already affirmed that culture is a «system of knowledge»[38], a «superbrain that enables humans to solve survival problems in a wide range of environments [but] imposes costs of its own: ritual, myth,

36 Kim Sterelny «Minds: extended or scaffolded?». *Phenom Cogn Sci* 9 (2010): pp. 465–481.

37 David Kirsh «The intelligent use of space». *Artificial Intelligence* 73 (1995): pp. 31–68.

38 Roger M. Keesing, «Theories of Culture», in *Annual Review of Anthropology* Vol. 3 (1974), p. 89.

cosmology and magic»[39]. Yet culture is not just a 'cognitive device', a 'tool' the members of a community use to overcome the cognitive challenges the environment where they live puts in front of them: it implements collective *beliefs*, collective *purposes*. The cognitive processes of its members depend on the exograms they use, these processes extend in those exograms and therefore, when the members of a community share the same exograms, they are actually sharing their own extended cognitive processes. Hence, «culture can be compared to a tissue»[40] whose nodes are the exograms and, just as the information shared in the work space by the agents of a multi–agent system feeds back to them reprogramming their behaviour, the semiotic system which is the cultural niche feeds back to the agents who build it as well, re–modulating their behaviour. We can define this tissue as the collective —emergent— 'mind' of a human group.

Acknowledgements

This article is a modified and extended version of one published in Quaderni della Ginestra 22 (2017), with the title "Intelligenza di gruppo e sistemi multi–agente". The research which resulted in this article has been partially funded by the research project "Habla interna, metacognición y la concepción narrativa de la identidad" (MINECO: FFI2015–65953–P) and by the Subprograma de Formación del Personal Investigador (FPI) (MINECO: BES–2016–077237).

References

Bonabeau, Eric *et alii* (1997). «Self–organization in social insects». *Trends in Ecology & Evolution* 12, no. 5: pp. 188–193. doi: 10.1016/S0169-5347(97)01048-3

Bonabeau, Eric *et alii* (1999). *Swarm intelligence: from natural to artificial systems*. Oxford: Oxford University Press. PMCid:PMC16356

Clark, Andy & Chalmers, David, (1998). «The Extended Mind». *Analysis* 58: pp. 10–23. doi: 10.1093/analys/58.1.7

Consiglio, Francesco (2017). «Information networks and systemic properties. An epistemological perspective». *Disputatio. Philosophical Research Bulletin* 6, no. 7: pp. 309–321. doi: 10.5281/zenodo.1489224

Consiglio, Francesco (Forthcoming). «Mindshaping through images».

Donald, Merlin (2010). «The Exographic Revolution: Neuropsychological Sequelae», in Malafouris & Renfrew (eds.) *The cognitive life of things. Recasting the boundaries of the mind*, Cambridge: Cambridge University Press, pp. 71–80.

Ferber, Jacques (1995). *Les Systèmes Multi–Agents: vers une intelligence collective*. Paris: InterÉditions.

Gibson, James Jerome (1979). *The ecological approach to visual perception*. Boston: Houghton Mifflin.

Grassé, Pierre–Paul (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

[39] *Idem*, p. 91.

[40] See Francesco Remotti, *Cultura. Dalla complessità all'impoverimento* (Roma–Bari: Laterza, 2011), p. 290. The translation is mine.

constructeurs». *Insectes Sociaux* 6, no. 1: pp. 41–80. doi: 10.1007/BF02223791

Heylighen, Francis (2016a). «Stigmergy as a universal coordination mechanism I: Definition and components». *Cognitive Systems Research* 38: pp. 4–13. doi: 10.1016/j.cogsys.2015.12.002

Hölldobler, Bert & Wilson, Edward Osborne (2009). *The Superorganism. The Beauty, Elegance, and Strangeness of Insect Societies*. New York: Norton & Company.

Jonas, Hans (1958). *The Gnostic Religion*. Boston: Beacon Press.

Keesing, Roger Martin, (1974). «Theories of Culture». *Annual Review of Anthropology* 3: pp. 73–97. doi: 10.1146/annurev.an.03.100174.000445

Kendal, Jeremy, Tehrani, Jamie, & Odling–Smee, John (2011). «Human niche construction in interdisciplinary focus». *Phil. Trans. R. Soc. B* 366: pp. 785–792. doi: 10.1098/rstb.2010.0306

Kirsh, David (1995). «The intelligent use of space». *Artificial Intelligence* 73: pp. 31–68. doi: 10.1016/0004-3702(94)00017-U

Kirsh, David (1996). «Adapting the Environment instead of Oneself». *Adaptive Behavior* 4, no. 3–4: pp. 415–452. doi: 10.1177/105971239600400307

Laland, Kevin Neville & O'Brien, Michael J. (2012a). «Cultural Niche Construction: An Introduction». *Biological Theory* 6, no. 3: pp. 191–202. doi: 10.1007/s13752-012-0026-6

Laland, Kevin Neville & O'Brien, Michael J. (2012b). «Genes, Culture, and Agriculture. An Example of Human Niche Construction». *Current Anthropology* 53, no. 4: pp. 434–470. doi: 10.1086/666585

Marsh, Leslie & Onof, Christian (2008). «Stigmergic epistemology, stigmergic cognition». *Cognitive Systems Research* 9, no. 1–2: pp. 136–149. doi: 10.1016/j.cogsys.2007.06.009

Parunak, H. Van Dyke (2006). «A survey of environments and mechanisms for human–human stigmergy». In Danny Weyns, H. Van Dyke Parunak, & Fabien Michel (Eds.), *Environments for multi–agent systems* II, Heidelberg: Springer, pp. 163–186.

Ryan, P. A., Powers, Simon T. & Watson, Richard A. (2016). «Social niche construction and evolutionary transitions in individuality». *Biology & Philosophy* 31, no. 1: pp. 59–79. doi: 10.1007/s10539-015-9505-z

Remotti, Francesco (2011). *Cultura. Dalla complessità all'impoverimento*. Roma–Bari: Laterza.

Sterelny, Kim (2007). «Social intelligence, human intelligence and niche construction»: *Phil. Trans. R. Soc. B* 362: pp. 719–730. Doi: doi: 10.1098/rstb.2006.2006

Sterelny, Kim (2010). «Minds: extended or scaffolded?». *Phenom Cogn Sci* 9: pp. 465–481. doi: 10.1007/s11097-010-9174-y

Sutton, John (2006). «Distributed Cognition. Domain and dimensions». *Pragmatics & Cognition* 14/2: pp. 234–247.

Sutton, John (2010). «Exograms and Interdisciplinarity: History, the Extended Mind, and the Civilizing Process», in Menary, R. (ed.) *The Extended Mind*, Cambridge: MIT Press, pp. 189–226. doi: 10.7551/mitpress/9780262014038.003.0009

Turing, Alan M. (1950). «Computing Machinery and Intelligence». *Mind* 49: pp. 433–460. doi: 10.1093/mind/LIX.236.433

Wilson, Edward Osborne (1975). *Sociobiology: The new synthesis*. Cambridge, MA: Harvard University Press.