Collective intelligence and social ontology. Bridging the divide between human and animal collective cognition through stigmergy and Peircean semiotics

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§1. Introduction

THE MAIN AIM OF THIS PAPER is to underline a few limits of the classic intentionalist approach to cognitive interaction and social ontology, widely applied both in cognitive science and social theory. In particular, I shall try to offer a new paradigm for the concept of *collective intentionality* (Searle 1995; 2006; 2010) to account for the socio–cognitive interactions taking place in a group of agents, focusing with particular attention on the concepts of *cooperation* and *competition*.

Now, collective intentionality has always been presented as a kind of default feature of human brains; although its origin and the way it works have never been clearly explained by its supporters, it appears to be, after all, a kind of 'synchrony in achievements' which entails some preliminary requirements like a *conscious subject* and the consciousness he has of his actions as *part of* a wider 'project', in which the actions of the other agents he comes in contact with can fit. In this context it is taken for granted that agents' actions take place in a background of shared rules which make it possible to understand the behaviour of the others and to act consequently. So the main problem of this approach is, in my opinion, that collective intentionality, as it has been conceived by its supporters, implies a *previous deal* sealed by the agents and a 'common project' to which everyone *knows* he is contributing to, as well as a direct cognitive relation among the agents and a conscious construction of the rules, like it happens in the choreography of a ballet.

Instead, what I am going to suggest in the next pages is that collective

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intelligence phenomena can be explained, in many cases, by means of structures of *emergent rules*, 'byproduct' of the behaviour of those agents who pursue their individual and more limited objectives: it is not necessary to establish in advance all the rules of the game to get the development of cooperation or competition dynamics in a group (Heylighen 2016a; 2016b). But, how do they emerge? The mechanism I am going to propose here is based on the dynamics of exchange of information in a multi–agent system (Parunak 2006; Ricci *et alii* 2007), where the agents/nodes *indirectly* communicate among them through the continuous modification of the medium/environment they act in, by means of sign manipulation. It is called *stigmergy*. So, one of the main original contributions of this article is, therefore, to apply the concept of stigmergy (which has already got a large history in biology and theory of systems) into the discussion about collective intentionality in human groups, in order to naturalize (at least some of) its features. A stigmergy based approach permits to bypass the difficulty of a conscious planning of rules and the intentionality postulate it entails. This is because the action (*ergon*) mediated by signs (*stigma*) is the mechanism that make the manipulation of information possible through an *indirect* cognitive relation among the agents, mediated by the space where they act. Stigmergy is characterized by two different types of sign manipulation: the first one, based on a *sematectonic* stimulation (Wilson 1975), that is the physical modification of the environment which provokes a specific behavioural response; the second one, based on markers dropped off in the environment, indicating what to do to the agents which 'read' them. To describe and to explain this sign–manipulation dynamics, I am going to propose here a semiotic approach: some authors have already noted that, in Peircean terms, the first type of stigmergy can be defined as an *index*, while markers corresponds to what Peirce defines as a *symbol* (Heylighen 2016b). So the second novelty proposed in this work will be a development of this intuition, to criticize the rationalist classic approach to collective intentionality (e.g. brentanian tradition; John Searle etc.) by means of Peircean semiotics, bridging the divide between human group behaviour and the rest of social animals.

§2. The problem of a rationalist approach to intentionality

Let's imagine a group of people, who don't know each other, sitting on the grass in a park. Some of them are having a picnic, others are playing soccer, someone else is lying on the grass enjoying the spring sun. Even though they don't know each other, when suddenly the sky clouds over and it starts raining, everybody rushes, in the *same* way, looking for a shelter under the *same* canopy.

Let's consider the same group of people, now, lying on the same lawn. But, when it starts raining, following a *precise choreography*, everyone gets up and does the *same* calculated movements, rehearsed a lot, and finally reaches the *same* canopy, getting a shelter from the sudden rain.

What does separate these two behaviours, considering that both the movements of the agents and the final result are identical? John Searle's answer is that in the latter case we see a coordination phenomenon which entails a form of collective intentionality and which produces a genuine social fact, while in the former case 'coordination' is just accidental, illusory.

Following the traditional definition used by Franz Brentano and his disciples, Searle defines intentionality as the feature of the mind representing objects or states of the world, the capability to have beliefs, desires, aims *about* something and, consequently, he calls *collective intentionality* that emergent feature of the consciousness which makes possible for a group of agents to share the same beliefs, the same desires and purposes about the same object. If the actors, getting up for the rain, rush in a coordinated way under the same canopy, they do it because those movements form part of a prearranged plan, of a *choreography* everyone knows: they all share the same beliefs and the same goal, in their action; all of them are aware of being part of a single *project*. However, also the subjects protagonists of the former case, gather under the same canopy — it is obvious! — for the same reason: they all think "it's raining, I don't want to get wet, so I'll go under the canopy". They all have the same belief about the same object, but, following Searle, we cannot define this as an example of collective intentionality just because each of them has just for him, *individually*, that kind of belief; none of them is wondering what the others could believe, no one is wondering "What the others will do? Will they get under the canopy too?". Their action, although coordinated, is not led by collective intentionality, hence it does not yield a genuine social fact.

Searle's perspective is taken here as representative of the intentionalist approach to social ontology. I am using in this paragraph the label 'rationalist' to define this kind of approach because it is based on *postulates* which support social ontology. In Searle's terms our social ontology rests on three *primitives*: collective intentionality (which is the most interesting for the present analysis); function assignment; constitutive rules (Searle 2006, p. 16).

Starting from the traditional definition of intentionality, this is what Searle says about collective intentionality:

> 'Intentionality' is the word philosophers use to describe that feature of minds by which mental states are *directed at* or *about* objects and states of affairs in the world. Thus, for example, if I have a belief it must be a belief that such and such is the case; if I have a desire it must be a desire that such and such should be the case. Intentionality, in this technical sense, includes not only intending in the ordinary sense, in which I might intend to go to the movies, but also beliefs, hopes, desires, emotions, perceptions, and lots of others. In addition to individual intentionality, which is described in the first–person singular forms such as 'I desire', 'I believe', 'I intend', there is also collective intentionality, which is described in the form, 'we believe', 'we desire', 'we intend'. (Searle 2006, p. 16)

In his view, collective intentionality is the default feature of our minds which enables us to collectively assign peculiar functions to any object in our environment and to create constitutive rules of social facts (X counts as Y in the context C, "This piece of paper count as money in our market") recognized and accepted by any agent of the group: we all *knows* the rules of our social reality and we follow them *presupposing* that all the other agents will do the same. This is why «Collective intentionality is the psychological presupposition of all social reality» (Searle 2006, p. 16). In this context, if we want to say that we are collectively achieving a goal, it is necessary to presuppose that we are acting in a well–defined scheme of rules, such as a group of people playing soccer: if I am crossing the ball to my teammate who is attacking on the other wing of the field, this is because I know our objective is to score a goal and that if I make him an assist he will kick the ball and score it. Anyway not everything we collectively do follows the dynamics of a soccer match. Do we really need to presuppose «all social reality» to act socially? What I would argue for, in this case, is that no matter what you intend to do when you do X, I could find appropriate to do Y as a response to your stimulus X and the final output of this chain of actions could yield a good solution to our problem: we would have *collectively* found that solution with no need for explicit planning. If John and Jack are both generic workers whose work consist in storing various construction materials in the warehouse of the company they work for, they do not need to talk at all to put in the correct place bricks, nails, screws and all that stuff: if Jack started taking the bricks John would take the screws, storing everything efficiently as a result of their collective work.

What I am suggesting here is that a lot of our collective behaviours could be explained by means of our responses to implicit stimuli in our environment (including those produced by other agents), with no need for explicit planning. In these cases we do not need any «we intend» at all, we do not need to *feel* as a part of any 'project'. This is why the main problem I see in Searle's perspective is this need each agent has to *represent* for himself all the 'project' he fits in to contribute to a collective scope, in order to make part of that «we intend».

Resuming what I said, collective intentionality, as Searle conceives it, needs as a precondition a subject who is aware of his actions as part of a wider 'project', shared with other subjects. Their actions take place in a background of shared rules (Searle 1995) which makes it possible to understand the others and to act consequently. For this reason, I think that the main problem we get when we try to interpret group intelligence in terms of collective intentionality, is that this perspective implies a *previous deal* among the agents, and a 'common project' in which everyone *knows* is playing a part, also a *direct* cognitive relation among the agents and, finally, a *conscious* construction of the rules — negotiated *ab origine* — which every agent will have to follow, exactly like in the choreography of a ballet. Instead, I would suggest that many collective intelligence phenomena can be explained by means of emergent structures of rules, 'byproduct' of the collective behaviour of a group of agents which pursue their own individual and limited aims: actually, it is not necessary to establish in advance all the rules of the game to get the development of socially relevant cooperation dynamics in a group. In this sense, I am convinced that a stigmergy based approach could bypass the difficulty of a *conscious and negotiated planning* of the rules and the rationalist postulates it entails.

§3. Human stigmergy

3.1. The concept of stigmergy: a case of distributed cognition

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» (Heylighen 2016a, p. 6). Derivative of *stigma* (stimulus/sign) and *ergon* (work), it is originally a technical term developed in a specific branch of biology, by the entomologist Pierre–Paul Grassé (Grassé 1959). Maybe for this originally technical and specialized character, it sounded from the beginning quite an obscure notion, difficult to transpose in different contexts. Grassé moulded it as an answer to the 'paradox of coordination' characterizing the cooperative behaviour of social insects (Bonabeau et al. 1997, 1999), that is: how is possible that individuals whose intelligence is extremely limited, who have no global idea of what is happening all around them, can yield cognitively complex responses? He found a solution observing the behaviour of a termite colony: every time an agent completed a task, he produced changes in the *structure of the workspace* shared with other agents; that is, he was changing the *affordances* (Gibson 1979) of the work environment, its practical meanings. A different structure of the environment produced therefore a different perceptual stimulus, a *cue* for the other agents

which modified their behaviour, moulding their behavioural algorithms in terms of evolutional efficiency of their responses. This is, actually, an attempt to «redesign their environment» (Kirsh 1996, p. 416) a group of agent do to *adapt the workspace* to their needs in the evolutional challenge:

> To change the task environment requires executing an action that lies outside the normal algorithm for the task. This makes creating a better task environment resemble selecting a better habitat. The similarity is only superficial. 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* [my emphasis]. Thus, in habitat selection, the environment is assumed to have its task characteristics independently of the creature, whereas in active redesign, the environment has been forcibly changed and may be expected to return gradually to its original state on the creatures death. (Kirsh 1996, p. 428)

In this sense, the workspace shared by all the agents has to be understood as the *niche* they live in, the ecological space they collectively build offloading in it a lot of implicit pieces of information. Stigmergy can, therefore, be defined as the basic dynamics of any niche construction theory, considering that «The niche–construction perspective […] contrasts with the conventional perspective by placing emphasis on the capacity of organisms to modify environmental states. […] In so doing, *organisms co–direct their own evolution* [my emphasis], 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» (Laland & O'Brien 2012a, p. 191)[1].

So, resuming, the fundamental principle of stigmergy maintains that the work produced by an *agent* in a *medium* leaves a *trace* which stimulates a subsequent activity by the same agent or a different one sharing the same medium. This entails a feedback cycle between *stimulus/sign* 🔄 *work*; a condition implies an action which modifies that very condition yielding, eventually, a new action (condition → action → condition[1] → action[1]…). Following this principle, it is natural to describe stigmergy as a kind of situated and distributed cognition

[1] Niche Construction Theory includes works 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 featuring that «Evolution entails networks of causation and feedback in which previously selected organisms drive environmental changes, and organism–modified environments subsequently select for changes in organisms» (Kendal, Tehrani & Odling–Smee 2011, p. 785).

(Sutton 2006): communication among the agents is mediated by the environment, namely the *medium*. In this sense it is important to note that a trace *stimulates* the action, it does not *determine* it, it makes a response more likely to happen, but not necessary. The stronger and the more evident a trace is, the more likely a correspondent response is. To make this mechanism yield an effective coordination, the medium has to be accessible, and then *modifiable*, for each one of the implicated agents.

The components of the stigmergic dynamics are, then, an *agent* (or more than one), a *medium*, a start *condition* of that medium, a consequent action which produces a *trace* and triggers a feedback cycle. The image we get is that of a massive parallel system for distributed cognition: each agent carries out individual computations which yield an effect in the medium while he is trying to reach his local aim, a *trace* which, as a side effect, is a *cue* for the agents who are sharing that medium, making possible in this way an indirect communication among them. So, the trace is a consequence of an action and therefore contains information about it, which can be made explicit through an *abduction*: the trace is, in the individual view of the agent, an obstacle, a *cognitive challenge* he has to overcome to reach his local goal.

In this context, we need to note that there are two fundamental types of stigmergy which we can distinguish in terms of the kind of sign used to communicate: one is called *sematectonic* stigmergy (Wilson 1975), while the other is a *marker based* stigmergy (Parunak 2006). The first one refers to meaning transmission through the 'structures' moulded in the *medium*: for example, opening a foraging path indicates a track to follow, while a heap indicates a deposit point; on the other side, marker based stigmergy is characterized by a more punctual and precise information which reveals 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 (Wilson & Hölldobler 2009) 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 Heylighen (Heylighen 2016a) 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 in 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.

3.2. Examples of stigmergy in human contexts

I have been using, so far, the prototypical ant based stigmergic model as a reference to explain the emergence of coordination, mediated by environmental stimuli. That is a model characterized by agents whose cognitive behaviour is limited to simple algorithms, but easy to be synthetically explained in its fundamental principles. Although, once understood the general mechanism governing the stigmergic coordination (namely, indirect communication based on cues in the agents' common workspace), is possible for me to focus quite more easily on the central topic of this paper, that is human coordination, making abstraction from this basic framework to consider now the concept of *cognitive stigmergy*.

Alessandro Ricci and colleagues (Ricci *et alii* 2007) remarked how distributed cognition ant based systems, though they offer a theoretically useful prototypical framework, are anyway limited in considering *non rational*, simple and homogeneous agents, which don't show relevant cognitive capabilities, because of the reduced number of algorithms through which is possible to explain all their possible behavioural responses. So, even on one hand it represents a useful and clear framework which make easier for us to detect the main features of the stigmergic mechanism, on the other hand it forces us with two prejudices: namely that the model of agent we consider has to be very simple (ant–like) and that the considered environment has to be extremely basic (like pheromones). Making abstraction from this framework we can, anyway, imagine more complex cognitive agents interacting in a much more complex medium: for instance human agents sharing a workspace characterized by complex structures such as *manipulable artefacts*. In this kind of space is possible to detect the same dynamics of both sematectonic and marker based stigmergy: if on the desk we are sharing there are a hammer and a screwdriver and I take the hammer, I am implicitly telling you to take the screwdriver and I am doing it just modifying the structure of the workspace, limiting your options; at the same time leaving a note about a task to be done, available in a workspace shared by many agents (for instance a Post It on a pile of documents saying "please photocopy!") means I am leaving a symbolic marker which mediates an indirect communication among different agents through a modification of the common space. The stronger the marker is, the more likely is to get a response to it. In this sense, Ricci and colleagues too

argue in favour of a *medium*, which is not a mere passive container, but the space where continuous feedback processes stimulate the emergence of both local and global coordinated behaviours. In this way I want to remark that, in each stigmergic system, traces left by the agents have to be considered as *signs* which, when have been created, persist independently from their author (because information is distributed in the environment) and remain available for other agents: *they have not a predefined recipient*.

Therefore, those socially relevant collective coordination phenomena of human agents which can be explained (at least partially) in terms of stigmergic dynamics, appear to be quite diffused: quite common examples are the workspace coordination through artefacts of the *dashboard* kind, like a control panel (Heylighen 2016a, b; Susi 2016), or cooperative production of contents in Wiki environments (such as Wikipedia entries), or collective open source software development, where the medium consists in the *codebase* and the communication among independent developers is implicit (sematectonic) when it directly lies on code variations, or explicit when it is based on markers like annotations (Bolici, Howison & Crowston 2016). But, maybe, the most representative human example of self–organization through stigmergic coordination, is the classic one of the stock market: mutually independent agents, buyers and sellers, who pursue selfish, personal and limited objectives, each one unaware of the plans of the others, modify the state of the market (medium) through their continuous and gradual action, influencing the prices (traces or markers) buying or selling any good; different prices induce new transactions which will modify those prices. Actually:

> Adam Smith's ''invisible hand'' metaphor (Smith 1776/1904) used to denote the unintended emergent consequences of a multiplicity of individuals' actions, is stigmergic in all but name — *it's a theory of collaboration via self–interest*. Leaving aside Smith's theological speculations, the invisible hand metaphor runs on the twofold idea that (a) *there need not be any intentional cooperation* [my emphasis]; and (b) actors need not even know of each other's existence. (Marsh & Onof 2008, p. 140)

Also human competition dynamics, such as those characterising the continuous struggle between policemen and smugglers along a national boundary, could be explained in terms of a stigmergic activity and tactics improvement:

> Because of the nature of the border as a stigmergic switch, borderlines affect but do not contain the criminal behaviors. The actions of criminal agents adapt to the environmental rules depending on the kinds of risk they perceive through stigmergic signals. When transborder networks encounter a border switch, the stimulus indicates to the agents that

> system rules are transitioning. Some of those transitions are evident. For example, the purchasing power north of Rio Grande/Bravo is higher, drug users are more affluent and willing to pay more, forensic science is more developed, border infrastructure and border patrol agents present an opposing force, and second amendment rights provide easier legal access to weapons, to cite just a few. Therefore, the risks associated with each territory are also different. Adversarial stigmergy makes of these geopolitical border switches, not a deterrent in the way the homeland security authorities of the United States would like them to be but an attractor around which the adaptive system self–organizes over time to manage risk. (Nieto–Gómez 2016, p. 35).

So, summarizing what I said, an approach to collective intelligence based on stigmergy implies a kind of externalism typical of situated and distributed cognition: the environment or *medium* works as a *distributed and shared memory* of the system, while between the agent and the medium a cybernetic feedback cycle develops. There are two different kinds of sign characterizing stigmergy: the sematectonic kind, that is *indexes* containing a straight information in a physical state of the medium; then the markers, namely symbols whose conventional meaning gradually stabilised because of a continuous use in agents' activity (an acquired habit).

Finally, a note on an interesting concept to understand the collective development of cultural structure in human groups in terms of stigmergy and environment manipulation: the *exogram* (Donald 1998, 2007, 2010; Sutton 2010). Exograms are all the manipulable artefacts which compose our cultural environment we offload our memory in:

> 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, p. 71).

Exograms are, therefore, informational structure which redesign our cultural niche each time we offload new pieces of information in them: they are our external collective memory scaffold[2]. Let's consider, for instance, the iconic value of an image accessible to every agent of the group: it constitutes a sign which produce a perceptual stimulus for any agent who bumps into it[3].

[2] «These abilities allow us to create and support cognitive profiles quite unlike those of creatures restricted to the brain's biological memories or engrams alone. […] our skilled use of such crafted aids changes both the locus of memory in general and the role of our biological memory within the new larger systems» (Sutton 2010, p. 189–190).

[3] Contemporary cognitive semiotics argues that the object of semiosis in not just a *terminus ad quem*, but

§4. Peircean semiotics: a common scheme in stigmergy

Why should we look for a common scheme in stigmergy? The obvious reason is that, to some of the possible readers, it could appear counterintuitive to compare all those different cases of stigmergy I outlined in § 3 without appealing for any concrete *trait d'union*. Considering that stigmergy is actually an ingenious label to define any dynamics where an action is stimulated by a sign and any response is, more or less, other–directed by external information distributed in the environment, the main feature of a stigmergic system appears to be just the role of signs in agents' distributed cognition.

As Francis Heylighen already observed e*n passant* (Heylighen 2016a), we could use a Peircean terminology to distinguish between a sematectonic stigmergy and a marker based one (see *supra*, § 3.1), respectively through *indexes* and *symbols*. So, what I am going to do in this last paragraph is trying to develop a little more this intuition: I am going to propose using Peircean semiotics to bridge the divide between human and not–human stigmergy.

In his semiotic writings Peirce describes a *sign* as a trace we can logically connect with its material cause through an *abduction* (cause ← effect). There are three fundamental kinds of sign: *icons*, *indexes* and *symbols*. An icon is a sign which represents its object because of a similarity feature; it is completely independent from any interpreter because its semiotic value is due only to its likeness to the referent, like the image — the visual information — contained in a picture (an hypoicon). An index is an effect directly related to its material cause, 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 from its material cause. Finally, a symbol is a kind of sign which mediates a semiotic relation between the referent and the interpreter, by reason of a stable association between the symbol and the referent, based in an acquired habit of the interpreter.

Once considered this context, it is easy to understand in what sense in the case of an ant–like stigmergic case opening a foraging path indicates a track to follow, while a heap indicates a deposit point; at the same time closing a street with a gate indicates that trespassing is forbidden. It is exactly what David Kirsh refers to with the words «redesigning the environment» (see *supra*, § 3.1). This is not different at all from what we normally do in our social niche: in the stock market the price of a good is a marker which symbolize the demand/offer ratio of that good. It mediates amongst all the different interest of the selfish agents

mainly a *terminus a quo*. That is: it is a *stimulus for* the semiotic process (Eco 1997).

acting in that medium and the economic order emerging from all these individual actions is a collective macro–phenomenon which is unpredictable in its structure and in the development of its rules. In the same way, the collective designing of an entry in Wikipedia can be explained as a continuous semiotic mediation among all the contributors participating in the endeavour: each of them have his particular idea of how the *Dante* entry should be structured and they act each one following his particular idea (how to organize biography or comments on his literary works, which reference to use, etc.), but eventually an homogeneous entry emerges[4].

Also an iconic sign (an hypoicon) is an exogram (cfr. *supra*, § 3.2) which influence the redesigning of a cultural niche. We could consider, for instance, the way in which an iconic information is gradually modified by the agents' collective manipulation of it: a certain iconography emerges through continuous gradual contingent contributions from each agent, it is not planned *ab ovo*.

§5. Conclusions

Firstly, I have focused in § 2 on a central problem of the classic rationalist approach to collective intentionality, namely the postulate of a previous deal among the agents of a group which they (are supposed to) feel being part of. I tried, referring to Searle as well–representing the rationalist approach, to outline how presupposing social reality is a fundamental feature of the rationalist perspective as well the requirement that each agent has, for himself, a representation of the system he is part of.

Secondly, I have detailed in § 3 what stigmergy is and why, in so far as a form of distributed cognition, it could offer the base for a new paradigm of collective intentionality. I have been explaining that a multi–agent system can develop a lot of collective dynamics just by means of the individual local manipulations of the environment each agent carries on, with no need for previous planning nor for presupposing the structure of the system.

Finally, I have remarked in § 4 that Peircean semiotics represents a common scheme in stigmergic systems. I noted how it can help us to bridge the divide between human and not–human stigmergy. Also I suggested that even our cultural niche is collectively built through a stigmergic redesigning of exograms.

[4] «A human example can be found in the Wikipedia encyclopaedia on the web. Readers are stimulated to improve existing pages either directly, by reading the text and noticing its shortcomings, or indirectly, by reading comments that summarize the tasks that still need to be done—such as adding references, clarifying ambiguous sections, or checking facts» (Heylighen 2016a, p. 52)

In this new paradigm collective intentionality should be seen as a high–level group feature, emerging from the continuous semiotic exchange among the agents in a shared environment.*

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Collective intelligence and social ontology. Bridging the divide between human and animal collective cognition through stigmergy and Peircean semiotics

My aim is to underline a few limits of an intentionalist approach to cognitive interaction and social ontology, typical of classic cognitive science and social theory. In particular, I shall try to offer a good alternative to the concept of *collective intentionality* to account for the socio–cognitive interactions taking place in a group of agents, focusing with particular attention on the concepts of *cooperation* and *competition*.

I claim that collective intelligence phenomena can be explained by means of structures of emergent rules, 'byproduct' of the behaviour of agents who pursue their individual and more limited objectives: it is not necessary to establish in advance all the rules of the game to get the development of cooperation or competition dynamics in a group. A stigmergy based approach permits to bypass the difficulty of a conscious planning of rules and the intentionality postulate it entails.

Keywords: Collective Intentionality · Group Intelligence · Stigmergy · Peirce · Semiotics.

Inteligencia colectiva y ontología social. Reducir la brecha entre la cognición colectiva humana y animal a través de la estigmergia y la semiótica peirciana

Mi objetivo es el de evidenciar algunos límites de un enfoque intencionalista a la interacción cognitiva y a la ontología social, típicos de las ciencias cognitivas clásicas y de la teoría social. En particular, trataré de ofrecer una buena alternativa al concepto de *intencionalidad colectiva* para dar cuenta de las interacciones socio–cognitivas que se producen en un grupo de agentes, con un foco particular sobre los conceptos de *cooperación* y *competición*.

Defiendo que el fenómeno de la inteligencia colectiva puede explicarse por medio de estructuras de reglas emergentes, productos 'colaterales' de la conducta de agentes que persiguen sus objetivos individuales y limitados: no es necesario establecer con antelación todas las reglas del juego para obtener el desarrollo de unas dinámicas de cooperación o competición en un grupo. Un enfoque basado en la estigmergia permite soslayar la dificultad de la planificación consciente de las reglas y el postulado de la intencionalidad que ella implica.

Palabras Clave: Intencionalidad colectiva · Inteligencia de grupo · Estigmergia · Peirce · Semiótica.

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