This is the Author's [accepted] manuscript version of the following contribution:

Lorini, Giuseppe, Donato A. Grasso, Andrea Loi, Are ants not only 'social insects', but also 'nomic insects'? In search of clues of normativity in the ant world. Behaviour, vol. 161, no. 5, 2024, pp. 331-352.

The publisher's version is available at: **https://doi.org/10.1163/1568539X-bja10265**

When citing, please refer to the published version.

Are Ants not only 'Social Insects', but also 'Nomic Insects'? In Search of Clues of Normativity in the Ant World

Giuseppe Lorini, Donato A. Grasso, Andrea Loi

1. Introduction

Since the middle of the last century, various philosophers have spoken of humans as 'rule-following animals' (Peters, 1958; von Hayek, 1967a, 1967b; Sellars, 1980; Searle, 1995; Nozick, 2001). These philosophers introduced a new image of human beings alongside the traditional images of humans as social/political animals, symbolic animals and rational/teleological animals: humans as 'nomic animals'.

By the expression ‘nomic animal’, from the Greek νόμος ‘*nómos*’ meaning ‘norm’, we mean an animal that is capable of acting in the light of norms and performing nomic/normative behaviour.

But is it true that humans are the only nomic animals? Recently, various studies by philosophers and ethologists have appeared where it is argued or hypothesised that there are non-human animals that are capable of nomic behaviour (de Waal 2014a; Andrews, 2015, 2020; Lorini, 2017, 2022; Okrent, 2018; Vincent et al., 2018; Danón, 2019; Roughley & Bayertz, 2019; Fitzpatrick, 2020). For example, Frans de Waal (2014a, p. 187) supports the thesis according to which “that animal behaviour is not free of normativity [...] is hardly in need of argument”.

There is still an open debate on this issue, with scholars arguing the opposite thesis of the uniqueness of humans as nomic animals, according to which humans are the only animals truly capable of normative action and whose behaviour can be guided by norms (Fletcher, 2003; Searle, 2010; Riedl et al., 2012; Jensen et al., 2014; Tomasello, 2021).

It is important to note that the investigation of animal normativity so far has mainly focused on mammals and, in particular, non-human primates and cetaceans. This work aims, on the other hand, to extend this research to the world of invertebrates and, more specifically, to investigate the world of insects. In particular, for an ethological study of norms and normativity, it would be particularly interesting to investigate whether there are traces of normativity (or proto-normativity) in the lives of those insects that live in complex societies such as ants, termites, bees and wasps, those insects that have been called ‘social insects’ for over a century (e.g. Wheeler, 1911, 1923 and 1928).

Social insects are animals that live in communities or colonies characterised by a strong ‘social order’. These insects form highly integrated, cooperative and self-organised societies characterised by, among other things, complex forms of communication and an efficient division of labour and task allocation (Hölldobler &Wilson, 2009; Gordon, 2019).

Developments in the cognitive ethology of social insects show that these animals are endowed with important cognitive capacities raising a large and interesting debate on the topic and its possible implications on insect and more in general on animal cognition and sociobiology (Perry et al., 2017; Chittka & Rossi, 2022; Poissonnier et al., 2023; Traniello & Avarguès-Weber, 2023; Lucon-Xiccato et al., 2024). Social insects possess complex learning and information-processing abilities and in some cases possibly even 'conceptual capabilities' (e.g. Millikan, 2000; Giurfa et al., 2001; Carruthers, 2009; Avarguès-Weber & Giurfa, 2013; Giurfa & Menzel, 2013; Giurfa, 2019; Bortot et al., 2021; D'Ettorre et al., 2021; Chittka, 2022; Czaczkes, 2022).

The concept of the 'social insect' is particularly important for the investigation of normativity in the invertebrate world, as it has generally been argued for the human world that if there is a society and a particular social order, there must necessarily also be a normative system (a system of norms) that makes them possible. Specific to animal societies, this thesis has been formulated, for instance, by Friedrich A. von Hayek and Rodolfo Sacco. Indeed, both seem to suggest that social animals (animals living in communities or colonies) are by their very nature necessarily 'nomic animals' insofar as they observe the same rules. For example, Hayek (1967b, p. 279) writes: "A society of animals or men is always a number of individuals observing such common rules of conduct as, in the circumstances in which they live, will produce an order of actions" (see Moroni, 2014).

According to Sacco, where there is a society there is a normative system (for Sacco it would even be a 'legal system' in its own right).

"*Law provides a means to prevent and solve conflicts throughout society. Wherever we find a society, we find law. This holds true in human societies as well as in advanced animal societies. Lions, wild dogs and many other carnivorous mammals 'mark' their territory and obtain from their counterparts, i.e., from other members of their species, observance of their exclusive rights*" (Sacco, 1995, p. 459).

But is this really the case? Does what Hayek and Sacco claim also apply to insects? We can then ask ourselves: is there room for norms and normativity in the world of social insects? In other words, are there 'nomic insects' whose behaviour is guided by norms?

For the purposes of investigating whether there are traces of normativity in the world of social insects, in this essay we will focus our attention on a particular group: the hymenopterans of the family Formicidae – ants. We will specifically question whether the behaviour of ants can be 'nomic behaviour', i.e., rule-guided behaviour; in other words, whether ants can 'follow rules' or, more generally, whether they have some sort of 'nomic capacity', albeit a basic one (Lorini, 2022).

Ants are animals that live in colonies characterised by a strong social order. This social order, also characterised by a certain degree of flexibility, manifests itself in the 'order of actions' (to use a term from Hayek (1948, 1967a)) that ants perform and in the behavioural regularities found in ant colony life. Two significant examples, as we shall see, can be found in the order of actions found in the construction of complex architectural structures and in the order of actions that characterises the efficient movements of ants that make foraging possible (Hölldobler & Wilson, 1990, 2009).

Of ants, myrmecologists have extensively studied the many aspects of their social life, the complex forms of collaboration, the different kinds and strategies of communication (in particular, chemo-communication) and also the architecture of the nest (see for example

Hölldobler & Wilson, 1990, 2009; Hansell, 2007; Arndt & Tautz, 2013; Leonhardt et al., 2016; Reznikova, 2016; Moffett et al., 2021; Tschinkel, 2021). On the other hand, the question of whether there are norms regulating their behaviour and social life has been almost completely left out.

This question has attracted the attention of a philosopher, Martin Kusch, and a primatologist, Frans de Waal, who, however, have differing views on the normativity of ant behaviour.

Kusch denies that there is any room for normativity in the social world of ants. According to Kusch (2006, p. 194), ants cannot be regarded as nomic, rule-following animals:

> "*We would not regard the ants as rule-followers possessing a sense of correct and incorrect, although they may well be guided by something external to themselves (i.e., the odour marks). We would not regard the ants as rule-followers, since we have no idea of how ants could acquire concepts such as 'correct' and 'incorrect'. We know how we acquire these concepts and where they figure: in discursive practices of teaching and training and in justifications and negotiations with others. Put differently, in order for us to think of someone as a rule-follower, we must be able to think of "correctness" and "incorrectness" (or their analogues) as concepts that they possess (as actors' categories)*".

De Waal (2014a, p. 187) instead seems to be open to the possibility that ants are nomic animals when he writes:

> "*Disturbing an ant nest or termite hill leads to immediate repair as does damage to a beaver dam or bird nest. Nature is full of physical structures built by animals guided by a template of how the structure ought to look. This template motivates repair or adjustment as soon as the structure deviates from the ideal. In other words, animals treat these structures in a normative fashion*".

Recently, Rachel Powell also investigated normativity in superorganisms. According to Powell (2023, p. 12), “several types of norms are ostensibly policed in insect societies”. Powell recognises a form of social normativity in policing behaviours adopted in different contexts (egg laying, caste-fate, social status), in which “subordinates use biochemical cues and context-sensitive fixed patterns of action to coordinate efforts to prevent individuals of any rank or caste from performing behaviour that threatens to derail group performance”.

While it is true that myrmecologists do not address this issue directly, it is certain that myrmecologists in some cases use the term ‘rule’ (and deontic categories) to describe the social behaviour of ants: for example, they speak of ‘ant traffic rules’ with regard to the collective movements of ants that display a high level of social order (Fourcassié et al., 2010; Strömbom and Dussutour, 2018), or they speak of ‘internal rules of ant societies’ (Stroeymeyt & Keller, 2014) and in the case of internal conflicts within the society (especially regarding reproduction) they speak of policing or even ‘punishment’ aimed at regulating and managing them. In this context there are also further parallels with human society, since insect policing relies on both detection and prevention, and individuals sometimes attempt to evade policing (Ratnieks and Wenseleers, 2005; Hölldobler & Wilson, 2009; Smith et al., 2012; Wenseleers et al., 2020; Moffett et al., 2021). Moreover, as we shall see in § 2., myrmecologists, in some cases, do not limit themselves to describing ant behaviour in terms of ‘rules’, but even give a linguistic formulation of the rules that ants would follow.

The question is, however, whether behind the term ‘rule’ used by scientists to describe ant behaviour and the linguistic formulation of rules that, according to some myrmecologists, ants would follow in certain contexts, there are full-fledged norms that condition ant behaviour. By ‘full-fledged norms’ we mean what de Waal calls ‘prescriptive rules’, meaning those rules to which members of a species conform and that are characterised by the “crucial ‘ought’ quality” (de Waal, 1996, p. 90). From these prescriptive rules de Waal distinguishes descriptive rules, which are formulated by scholars to capture mere behavioural regularities, which are 'typical responses to specific situations' (de Waal, 1991, 1996). Unlike prescriptive rules, descriptive rules do not have a normative nature, as they merely describe the behaviour of the subjects they refer to, without in any way conditioning their behaviour. While a prescriptive rule can be infringed upon, it makes no sense to speak of violation of a descriptive rule.

In light of this distinction between prescriptive rules and descriptive rules, then, the problem we pose to investigate is whether ant behaviour is really conditioned by prescriptive norms and is not merely susceptible to an *a posteriori* description in terms of descriptive rules that capture mere behavioural regularities.

We shall therefore speak of full-fledged norms in order to refer not only to a behavioural regularity, but to a pattern of action endowed with what the German sociologist Theodor Geiger (1947) calls 'normative stigma', in other words, a pattern of action endowed with compulsory force (Durkheim, 1895) that 'influences conduct' by exerting 'normative pressure' (von Wright, 1963).

In this context, it is also important to underline that the ants, like other social insects (and sometimes even at a higher level), are not mere stimuli-response machines but possess particularly sophisticated cognitive abilities. They have remarkable individual as well as social learning capacities (D'Ettorre, 2013; Alem et al., 2016; Chittka et al., 2022; Czaczkes, 2022; Dong et al., 2023; Glaser & Grüter, 2023), manifest personality traits (individual and social) and even self-control abilities (e.g. D'Ettorre, 2013; Wendt & Czaczkes, 2017; Wright et al., 2019; Maák et al., 2020; Czaczkes, 2022). Moreover, individuals and colonies often exhibit sophisticated information-processing systems, have a 'sense of number' and cognitively process 'identity' and 'difference' relations between sensory stimuli (e.g. Carruthers, 2009;

Reznikova & Ryabko, 2011; Beugnon & Macquart 2016; Bortot et al., 2021; D'Ettorre et al., 2021; Czaczkes, 2022).

The scope of this paper is to show the soundness of the working hypothesis that ants are nomic animals, i.e. animals endowed with a nomic capacity, and to present clues to the hypothetical nomic behaviour of ants.

The essay is divided into three parts. In § 2. we will search for clues of normativity (or proto-normativity) in the world of these social insects, examining some contexts where myrmecologists seem to characterise the behaviour of ants as a 'rule-guided behaviour'. In § 3., through the introduction of two conceptual paradigms, we will distinguish three possible answers to the question of whether ant behaviour can be nomic behaviour, i.e., normatively conditioned behaviour. Finally, in § 4. we will present four contributions to the ethology of normativity that come from the attempt to investigate the nomic behaviour of ants.

2. Four hypothetical contexts of ants' rule-guided behaviour

Let us now examine four different contexts in the social world of ants studied by myrmecologists in which glimpses or clues of normativity (and more precisely, clues of rule-guided behaviour) appear: (i) ant traffic, (ii) living structures composed of a large number of ants, (iii) nest construction, and (iv) the temporal allocation of tasks in the colony.

For the description and explanation of ant activity in these specific contexts, myrmecologists use the term 'rule' and, in some cases, even codify in linguistic formulations the 'rules' that would guide ant behaviour.

2.1. Ant traffic rules

A first hypothetical context of rule-guided behaviour of ants is the regulation of traffic, i.e., the regulation of movement flows along paths. While the vast majority of animal 'traffic' takes place in migration contexts where all animals follow the same direction of movement, in the case of ants often a two-way flow emerges: outbound flow of individuals towards destinations outside the nest generally consisting of food sources and inbound flow of individuals returning back to the nest. To avoid clashes and slowdowns and to make the foraging activity fluid and effective, it is therefore necessary to maintain high levels of order of action. How is this possible? Ethologists, in explaining the order of this two-way traffic, speak of rules and specifically of 'simple rules of traffic regulation' (Fourcassié et al., 2010; Hoenicke et al., 2015):

> "*Whereas human traffic is regulated by a series of strict rules designed by some legislation, we hypothesise ants to have simple rules of traffic regulation as well, shaped by natural selection. Indeed, we expect self-organised mechanisms to be prime drivers, since many complex patterns in ant societies are driven as emergent properties of a few, very simple rules*" (Hoenicke et al., 2015).

There would thus be 'rules' that, followed at the individual level, make it possible to avoid overcrowding and traffic jams, through a 'temporal organisation' of the flow that takes place by alternating between ants moving outwards from the nest and ants returning to it. Daniel Strömbom and Audrey Dussutour (2018) therefore hypothesised the existence of certain 'local priority rules' governing the behaviour of ants of the species *Atta colombica* and proposed a model simplifying the individuals as self-propelled particles possibly valid also for other ants. For example, in a narrow trail the 'particles' will adopt the following rules:

(i) "An unladen particle does not attempt to pass a laden particle ahead of it. Instead, it stops and waits until the laden ant has moved forward enough for it to take another step".

(ii) “An outbound particle stops and gives way to a laden particle, and potentially a number of unladen particles following the laden particle”.

(iii) “An unladen particle stops and gives way to an outbound particle, unless the outbound particle is waiting following an interaction with a laden particle”.

These rules would only intervene at particular times, i.e., when the narrowness of the passageway creates a risk of congestion and consequent slowing down or blocking of traffic. This shows how the ants’ behaviour is flexible and context-sensitive: leaf-cutting ants, in the same way as *Lasius niger*, avoid crowding on recruitment trails by changing the temporal organisation of the flows of inbound and outbound individuals. In particular, on a narrow path where crowding is more probable, alternating groups of inbound and outbound ants were observed, whereas on wider paths the sequence of outbound and inbound ants was not different from random (Dussutour et al., 2009).

2.2. Rules of ant behaviour in ‘living structures’

A second hypothetical context of rule-guided behaviour of ants is represented by special forms of coordination during the construction of complex living structures, such as real ‘living bridges’ needed to overcome obstacles or ground cavities. For example, “using simple interaction rules, *Eciton* army ants construct complex bridges from their own bodies to span forest-floor gaps” (Reid et al., 2015, p. 15113). One of the most interesting phenomena of living structures has been studied with reference to ants of the genus *Solenopsis*. In the original ranges of *Solenopsis invicta*, for example, it often happens that rainfall causes flooding of the nest. These ants have developed the ability to save themselves by forming living structures in the form of rafts, which allow them to float and survive. The ants form this structure by intertwining their bodies when they sense an increase in the water level in the nest. On the first layer of individuals, others are formed on which the queen and other workers with part of their offspring take their place (Adams et al., 2011; Carlesso & Chris, 2023).

Researchers, by combining experimental and theoretical studies (see Mlot et al., 2011, 2012), identified in detail the possible 'rules' that are 'followed' by ants in the construction of these rafts summarised by Phonekeo et al. (2017):

> "*We found ants followed three rules, which yielded accurate predictions for raft growth rate. These rules are as follows:*
>
> *(i) Do not move if ants are on top of you.*
>
> *(ii) If atop other ants, repeatedly move a short distance in a random direction.*
>
> *(iii) Upon reaching available space adjacent to non-moving ants, stop and link with them*"

It is of great interest to point out, moreover, that authors themselves propose the idea that these 'rules' can explain numerous problems of collective behavioural coordination and that, applied under different environmental conditions, they give rise to various ordered structures.

One example is identified in the ability of *Solenopsis* ants to build living structures that are different from rafts, but equally complex and highly functional: they can form living towers consisting of several thousand individuals (Phonekeo et al., 2017; Carlesso & Chris, 2023). This recent scientific literature also suggests the opportunity to investigate the relationships between the rules identified in the construction of living structures and the rules identified in the regulation of traffic or the rules of swarm formations (recurring in other animal species, such as bees or fish):

> "*According to our hypothesis, the tower results from fire ants following the same set of rules that we previously used to accurately predict the shape and growth rate of a different structure, the ant raft. [...] Work is also needed to link these proposed rules to*

those found for traffic flows in ants, or to swarm behaviours in other ant species and in organisms such as fish and bees" (Phonekeo et al., 2017).

2.3. Rules of ant stigmergic behaviour

A third hypothetical context of rule-guided behaviour of ants relates to the ability to construct complex architectural structures. Underlying this capacity would be the process of 'stigmergy' (inducement to work) defined and extensively studied in termites by Pier-Paul Grassé (1959), but also applied to the description of self-organisation in ants' and other social insects' nest-building (Hölldobler & Wilson, 2009). Stigmergy would, in fact, be based on the application of simple 'rules' based on the acquisition of local information by individuals.

In the construction phase, individuals do not necessarily have to interact with each other, but can influence each other through the products of their activity. The ants seem here to follow rules such as 'If you find a small hole in the ground, enlarge it', thus producing environmental changes (e.g. the removal or placement of a piece of soil in a particular spot) which in turn become a source of new stimuli that trigger specific actions by the other workers (such as the addition or removal of more soil). It is thus the work already done that acts as a stimulus that drives the nestmates to new tasks based on specific 'rules' (often also called 'decision-making algorithms' by ethologists).

The process shows a certain elasticity due to the influence of social (e.g., the addition of specific pheromones to the building material) and environmental (e.g., the presence and abundance of offspring) information, which ensure functional effectiveness of the construction (Khuong et al., 2016).

In addition to nest construction, other contexts in which stigmergic coordination is thought to act are the network of foraging tracks, the setting up of 'cemeteries' in which dead individuals are deposited, and waste storage areas (Ireland & Garnier, 2018).

2.4. Rules of task allocation in ant colonies

A fourth hypothetical context of rule-guided behaviour of ants concerns the arrangement of the work and worker force of a colony. Indeed, ethological research points to the existence of rules that coordinate the temporal subdivision of activities in order to change work allocation according to the changing needs of the colony (Gordon, 1996, 2010, 2019; Chittka & Muller 2009). In this context, Deborah Gordon (2003) points out that "ants do not tell each other what to do when they meet, but the pattern of interaction each ant experiences influences the probability it will perform a task. Each ant uses a set of rules such as, 'I'm a forager and if I meet a returning patroller every so often, I remain likely to go out'. Evidence for such a rule is that if the forager does not meet a returning patroller, the probability it will go out decreases".

Ants are thus capable of making clear behavioural changes by switching from one activity to another, according to a 'rule' made possible by the cognitive ability to perceive the number of a certain kind of individuals encountered in certain situations.

3. Three hypotheses on the normativity of ant behaviour: *anomic* behaviour, *nomic nomotropic* behaviour, *nomic non-nomotropic* behaviour

In § 2. above, we examined four possible contexts in which clues of normativity emerge in the social world of ants. These are contexts in which ants appear as possible insects capable of following rules. Moreover, as we have also seen in § 2., various scholars have even tried to reconstruct the rules that ants in various contexts would follow and have given them a linguistic and, in particular, *propositional* formulation.

In this section, however, starting from the previous investigation of hypothetical rule-guided behaviours, we will reconstruct possible answers to the question of whether ant behaviour can be nomic behaviour, i.e., normatively conditioned behaviour, and distinguish three hypotheses by proceeding through two different divisions (*diaíreses*).

Firstly (first *diaíresis*), given the question of whether ant behaviour is nomic behaviour we can distinguish two possibilities:

(i) ant behaviour is always *anomic* (not nomic), i.e. it is a behaviour that can never be normatively conditioned;

(ii) ant behaviour can be *nomic*, i.e. it is a behaviour that can be normatively conditioned.

Secondly (second *diaíresis*), in the case where the ants' behaviour can be nomic behaviour, we can distinguish two further possibilities:

(i) ant behaviour can be nomic and also *nomotropic* behaviour;

(ii) ant behaviour can be nomic but *not nomotropic* behaviour.

We take the adjective 'nomotropic' from Amedeo Giovanni Conte's philosophical lexicon. Studying rule-following behaviour, Conte (2000) uses the term 'nomotropism' to designate the phenomenon of 'acting in light of norms'. The origin of the term is rather transparent. The term is built on the example of the terms ‘heliotropism’ and ‘phototropism’: the expression ‘nomotropism’ derives from the ancient Greek *νόμος* ‘*nómos*’, ‘norm’, and the Greek verb *τρέπω* ‘*trépo*’, ‘to turn’, ‘to direct’. Just as in the case of phototropism the sunflower orients itself according to the light of the Sun, in the case of nomotropism the agent orients itself according to norms.

This second *diaíresis* arises from the distinction of two different types of nomic behaviour: (i) nomic *nomotropic* behaviour and (ii) nomic *non-nomotropic* behaviour. These are two types of behaviour that are both normatively conditioned, i.e. behaviours that are engaged in because they are conditioned by an ‘ought’, a normative model that guides action. The difference between these two types of nomic behaviour consists in the fact that while nomic *nomotropic* behaviour is behaviour conditioned by full-fledged norms (examples of this type of behaviour are the hypothetical nomic behaviour of ants in the four contexts that we have examined and reconstructed in § 2., obviously on the assumption that the rules identified by the researchers are full-fledged prescriptive rules); the *non-nomotropic* nomic behaviour is conditioned by deontic structures that do guide action and are characterised by 'oughtness', but which cannot be properly defined as ‘full-fledged norms’ since they are cognitively simpler structures than the norms themselves (an example of this type of behaviour, as we shall see better later, is that of the spider that acts according to a template of how the spiderweb ought to look).

This distinction could also be reformulated in terms of ‘proposition-like entity’ or ‘proposition-like structure’ (McGrath & Frank 2023). In the case of *nomotropic* nomic behaviour, one could say that the agent acts according to a ‘proposition-like deontic structure’, i.e. a deontic structure with a *propositional form* (e.g. in the case of an ant acting according to the norm ‘If you find a small hole in the ground, enlarge it’), whereas in the case of nomic *non-nomotropic* behaviour, the agent acts according to a ‘non-proposition-like deontic structure’, a deontic structure with no *propositional form* (on animal non-propositional thought, see Bermudéz, 2003a, 2003b, 2007; Aguilera, 2018; Danón, 2022; Lorini, 2022). In the case of nomic *non-nomotropic* behaviour, therefore, more basic cognitive skills are required than in nomic nomotropic behaviour.

This distinction between nomic *nomotropic* behaviour and nomic *non-nomotropic* behaviour is important as it shows that the set of *nomic* behaviours is broader than the set of *nomotropic* behaviours. In other words, nomic capacity is not exhausted in the ability to act in the light of full-fledged norms: it is, in fact, also possible to act nomically in the light of deontic structures that guide behaviour without being able to be called 'norms' in their own right as in the case of the spider that acts in the light of normative templates described by de Waal. The distinction of these two types of nomic behaviour has an interest and value that is not confined to the sphere of mere myrmecological research and more generally to the investigation of eusocial insects but concerns the investigation of normativity *tout court*.

Now, combining the two previous *diaíreses*, we obtain three distinct hypotheses on the normative nature of ant behaviour:

(i) first hypothesis: ant behaviour can only be *anomic* behaviour;

(ii) second hypothesis: ant behaviour can be, in some contexts, *nomic nomotropic* behaviour;

(iii) third hypothesis: ant behaviour can be, in some contexts, *nomic non-nomotropic* behaviour, but not a full-fledged nomotropic behaviour.

Let us now analyse these three hypotheses, which together exhaust the scope of possible answers to the question of the normativity of ant behaviour.

According to a first hypothesis, ants would not be able to follow rules, nor would they have any form of sensitivity or ability to perceive deviations from a normative pattern. In this case, contrary to what de Waal claims (2014a, p. 200), ants would not be able to correct "or trying to correct, deviations from an ideal state."

According to this hypothesis, ants would be mere 'anomic animals', not endowed with any nomic capacity or nomic sensitivity. This is, for example, the hypothesis proposed by Kusch (2006), according to which ants could be guided by something external to themselves (i.e., the odour marks), but would not be nomic animals as they would not be able to act in terms of 'correctness' and 'incorrectness'. This, however, is the hypothesis, which seems to be generally taken for granted.

According to a second hypothesis, an ant would be able to follow full-fledged norms such as 'If you find a small hole in the ground, enlarge it', or 'If atop other ants, repeatedly move a short distance in a random direction'. As we saw in § 2., myrmecologists and other researchers talk extensively about rules to describe and explain ant behaviour and in some cases even codify these rules, which would condition the ants' lives in various contexts, providing a linguistic formulation having a propositional form of them.

In this regard, it is suggestive of what Wilson (2020) writes with a hint of irony about the ants' hypothetical language, Formic, when reflecting on the ants' ability to communicate syntactically complex messages to express different information. Wilson writes that "from one pheromone, the harvester ant has fashioned the equivalent of three words". Furthermore, he adds that "ants can put together pheromones with other odours to create 'proto-sentences'".

According to this hypothesis, ants would not only be 'nomic animals', i.e., animals sensitive to normativity, but would even be 'nomotropic animals', i.e., animals capable of orienting their behaviour according to full-fledged norms.

Should this second hypothesis prove to be true, it would then open up further research into the origin of ant norms. For example, it might be interesting to investigate whether or not full-fledged ant norms can be shaped through social learning and thus investigate their degree of flexibility.

A third hypothesis would allow us to attribute to ants a nomic capacity without real 'nomotropic capacity', i.e. the capacity to act in light of full-fledged norms. In this different perspective, a more basic form of nomic capacity consists in acting in the light of a simpler deontic structure than the full-fledged norms of the second hypothesis.

As we have already seen, an example of this hypothesis is de Waal's (2014a, p. 187) idea that ants are animals sensitive to deviation from normative 'standards', 'ideals' or 'template'. These standards, ideals or templates do not represent how things *are*, rather they depict how things *ought to be*.

To explain this basic form of normativity, de Waal starts with the example of a spider reacting to a damaged web. If the damage is extensive, the spider will abandon the web but in many cases it will repair the web to its previous state by weaving. The same happens, according to de Waal, when ants are confronted with a damaged anthill. They work to repair it. In these cases, spiders and ants are guided "by a template of how the structure ought to look". It is in the light of this template that they rebuild the structure that deviates from the ideal. According to de Waal, these "animals treat these structures in a normative fashion".

De Waal's examples suggest that a spider or an ant may be capable of a basic form of normative cognition that consists in the perception of deviation from an ideal template. This model does not represent reality as it is, but rather as it should be. The nomic action would consist here in the restoration of the physical structure (the web or nest structure) corresponding to the normative model.

According to de Waal, even animals with a very simple cognitive structure (invertebrates such as spiders or ants) could be endowed with the ability to see reality through 'lenses' that allow them to act normatively. This is an interesting perspective that harks back to the idea of a proto-normativity with distant evolutionary roots and perhaps to the idea of basic forms of (non-propositional) ought-thoughts (Rudolf von Rohr et al., 2011; Vincent et al., 2018; Danón, 2019; Andrews, 2020).

It is interesting to note, however, that the case of ants appears significantly different from that of the spider. As Hölldobler and Wilson (2009) effectively stated, the individual ant does not possess a mental model of the architecture of the whole nest nor of the other complex properties emerging from low-level social interaction. We could then hypothesise that the individual ant is only sensitive to local and circumstantial information that is capable of provoking the perception of a mismatch with respect to micro-models of the environment. For example, the fact that the ant perceives a depression in the ground and is consequently motivated to fill it could reveal the operation of cognitive phenomena very similar to those through which de Waal explains the spider's reparative behaviour.

A similar example of non-nomotropic nomic behaviour can be found in Andrews and Westra (2021), who extend to invertebrate behaviour a hypothesis recently developed in relation to the evolution of human normative capacities (see Birch 2021 and Sterelny 2021). More specifically, Andrews and Westra hypothesise that social insects use 'cognitive maps' to orient themselves in the environment. Although the scientific debate on cognitive maps in insects is still open and alternative explanations have been proposed (Cruse and Wehner, 2011; Dhein, 2023), we can see in it a good example of how auroral forms of normative cognition might manifest themselves in the mind of a bee or an ant. According to this hypothesis, the insect's ability to perceive and correct a path error seems to require that cognitive maps play the role of normative models from whose deviation a perception of error would emerge. As Andrews and Westra

(2021, p. 213) write, “cognition, plus a type of sentience that permits feelings of wrongness in the face of mismatches, should together be sufficient for having a normative psychology”. The idea of the perception of a deviation from a standard, and thus of error/mismatch corrective behaviour, is also central here: “corrections are by definition normative: they reflect how animals feel things ought to be” (de Waal, 2014b, p. 227).

A similar insight is also found in the French philosopher Étienne Souriau (1965) regarding another species of hymenoptera but with a solitary habitus: the potter wasp (*Sceliphron spirifex*). He hypothesised that these insects, in the construction of their pedotrophic nests, are sensitive to imperfections in their work, as they are capable of retouching their nest when some event compromises its structure. According to Souriau, potter wasps would reveal through this corrective behaviour a real sensitivity to symmetry and proportion. (For details on nest features, techniques and rules used by mud-dauber wasps in nest building see for example Polidori et al., 2005; Chatenoud et al., 2012; Ertürk et al., 2019; Park & Alqrinawi, 2023).

All these reflections illuminate a more primitive form of normative sensibility than the capacity to act in the light of full-fledged norms and show that the investigation of animal normativity should not be exhausted in the study of the mere ‘rule-guided behaviour’.

The concept of nomic non-nomotropic behaviour suggests that an ant can act nomically by virtue of a simpler capacity to perceive the ‘wrongness’ of a state of affairs, and thus to act in order to match the ‘correct’ state of affairs. In this case the cognitive capacity to understand complex proposition-like deontic structures is not involved. The nomic capacity here takes the form of a sensitivity to deviation from ‘non-propositional normative models/templates’, and thus appears much more primitive than the nomic capacity required to act in the light of full-fledged norms.

4. Conclusion

In this essay we have raised the question of whether ants, in addition to being social insects, are also 'nomic insects', i.e., insects capable of performing nomic behaviour and having a nomic sensitivity. This question has the merit of extending the field of research into animal normativity, hitherto almost entirely confined to mammals and focused mainly on primates and cetaceans, to the realm of invertebrates as well. The hypothesis of nomic behaviour for social insects clearly does not imply that normative patterns are socially learned and culturally transmitted and thus opens up new research perspectives on the aetiology of normativity.

The investigation of normativity of ant behaviour has revolutionary theoretical consequences for the investigation of the sociality and normativity of humans and other non-human animals, regardless of what the answer to the question "Are ants nomic animals?" is.

If it is argued that ant behaviour *can be* nomic, this would extend the scope of normativity beyond the boundaries of the human and mammalian worlds. This would also force us to rethink the image we have of human normativity, and also the image of the cognitive assumptions of normativity.

If, on the other hand, it is argued that ant behaviour *cannot be* considered nomic behaviour, we would then be faced, in the case of ants and by extension other social insects with similar habitus, with an 'anomic' spontaneous social order, i.e., a spontaneous social order in the absence of norms/rules. Furthermore, in the light of this hypothesis, two types of spontaneous social orders could be distinguished: (i) a *nomic spontaneous social order* (i.e., a norm-dependent social order) and (ii) an *anomic spontaneous social order* (i.e., a norm-independent social order).

References

Adams, B.J., Hooper-Bùi, L.M., Strecker, R.M. & O'Brien D.M. (2011). Raft formation by the red imported fire ant, *Solenopsis invicta*. – Journal of Insect Science 11:71.

Aguilera, M. (2018). Why the content of animal thought cannot be propositional. – Análisis Filosófico 38(2): 183-207.

Alem, S., Perry, C.J., Zhu, X., Loukola, O.J., Ingraham, T., Søvik, E, Chittka, L. (2016) Associative Mechanisms Allow for Social Learning and Cultural Transmission of String Pulling in an Insect. – PLOS Biology 14(10): e1002564.

Andrews, K. (2020). Naïve normativity: the social foundation of moral cognition. – Journal of the American Philosophical Association 6(1): 36–56.

Andrews, K. (2015). The folk psychological spiral: explanation, regulation, and language. – The Southern Journal of Philosophy 53(S1): 50-67.

Andrews, K. & Westra, E. (2021). If skill is normative, then norms are everywhere. – Analyse & Kritik 43(1): 203–218.

Arndt I., Tautz J. (2013). Animal Architecture. – Abrams, New York.

Avarguès-Weber A, Giurfa M. (2013). Conceptual learning by miniature brains. Proceedings of the Royal Society B. – 280 (1772): 20131907.

Bermúdez, J.L. (2003a). Ascribing Thoughts to Non-Linguistic Creatures. – Facta Philosophica 5: 313–34.

Bermúdez, J.L. (2003b). Thinking Without Words. – Oxford University Press, Oxford.

Bermúdez, J.L. (2007). Thinking Without Words: An Overview for Animal Ethics. – Journal of Ethics 11: 319–35.

Beugnon, G. & Macquart, D. (2016). Sequential learning of relative size by the Neotropical ant *Gigantiops destructor*. – Journal of Comparative Physiology A 202: 287-296.

Birch, J. (2021). Toolmaking and the evolution of normative cognition. – Biology & Philosophy, 36(1).

Bortot M., Regolin L., Vallortigara G. (2021). A sense of number in invertebrates. – Biochemical and Biophysical Research Communications, 564: 37-42.

Carlesso, D. & Chris, R.R. (2023). How to become one: the proximate mechanisms of self-assembly behaviour in social insects (*Hymenoptera: Formicidae, Apidae*). – Myrmecological News 33: 149-168.

Carruthers, P. (2009). Invertebrate concepts confront the generality constraint (and win). – In: The Philosophy of Animal Minds (Lurz, R.W., ed.). Cambridge University Press, Cambridge, p. 89-107.

Chatenoud, L., Polidori, C., Federici, M., Licciardi, V. & Andrietti, F. (2012). Mud-ball construction by *Sceliphron* mud-dauber wasps (Hymenoptera: Sphecidae): A comparative ethological study. – Zoological Studies 51(7): 937–945.

Chittka L., Muller H. (2009). Learning, specialization, efficiency and task allocation in social insects. – Communicative & Integrative Biology, 2: 151-154.

Chittka L. (2022). The mind of a bee. – Princeton University Press, Princeton, New Jersey.

Chittka, L. & Rossi, N. (2022). Social cognition in insects. – Trends in Cognitive Sciences 26(7): 578–592.

Conte, A.G. (2000). Nomotropismo: agire in funzione di regole. – Sociologia del diritto 27(1): 1–27.

Cruse, H. & Wehner, R. (2011). No need for a cognitive map: decentralized memory for insect navigation. – PLOS Computational Biology 7: e1002009.

Czaczkes, T.J. 2022. Advanced cognition in ants. – Myrmecological News 32: 51-64.

D'Ettorre, P. (2013). Learning and recognition of identity in ants. – In: Invertebrate Learning and Memory (Menzel, R. & Benjamin, P., eds.). Academic Press, Amsterdam, p. 503-513.

D'Ettorre, P., Meunier, P., Simonelli, P. & Call, J. (2021). Quantitative cognition in carpenter ants. – Behavioral Ecology and Sociobiology 75.

Danón, L. (2019). Animal normativity. – Phenomenology and Mind 17: 176–187.

Danón, L. (2022). Modest Propositional Contents in Non-Human Animals. – Philosophies 7(5).

de Waal, F.B.M. (1991). The Chimpanzee's Sense of Social Regularity and Its Relation to the Human Sense of Justice. – American Behavioral Scientist 34: 335–349.

de Waal, F.B.M. (1996). Good Natured: The Origins of Right and Wrong in Humans and the Other Animals. – Harvard University Press, Cambridge.

de Waal, F.B.M. (2014a). Natural normativity: the 'is' and 'ought' of animal behavior. – Behaviour 151(2-3): 185–204.

de Waal, F.B.M. (2014b). The Bonobo and the Atheist: In Search of Humanism Among the Primates. – W. W. Norton & Company, New York.

Dhein, K. (2023). The cognitive map debate in insects: a historical perspective on what is at stake. – Studies in History and Philosophy of Science 98: 62-79.

Durkheim, É. (1895). Les règles de la méthode sociologique. – F. Alcan, Paris.

Dussutour, A., Beshers, S.N., Deneubourg, J.L. & Fourcassié, V. (2009). Priority rules govern the organization of traffic on foraging trails under crowding conditions in the leaf-cutting ant *Atta colombica*. – Journal of Experimental Biology 212(4): 499–505.

Ertürk, Ö., Taş, B., Şahin, H. & Çaldaş, A. (2019). Determination of some structural features of the dud nest materials of *Sceliphron curvatum* (Smith, 1870), (Hymenoptera: Sphecidae) in Turkey. – Journal of the Entomological Research Society 21(2): 157–166.

Fitzpatrick, S. (2020). Chimpanzee normativity: evidence and objections. – Biology and Philosophy 35(4): 1–28.

Fletcher, G.P. (2003). Law. – In: John Searle (Smith, B., ed.). Cambridge University Press, Cambridge, p. 85-101.

Fourcassié, V., Dussutour, A. & Deneubourg, J.L. (2010). Ant traffic rules. – Journal of Experimental Biology 213(14): 2357–2363.

Geiger, T. (1947). Vorstudien zu einer Soziologie des Rechts. – Munksgaard, Copenhagen.

Giurfa, M., Zhang, S., Jenett, A., Menzel, R. & Srinivasan, M. V. (2001). The concept of 'sameness' and 'difference' in an insect. – Nature 410: 930–933.

Giurfa, M. & Menzel, R. (2013). Cognitive components of insect behavior. – In: Invertebrate Learning and Memory (Menzel, R. & Benjamin, P., eds.). Academic Press, Amsterdam, p. 14-25.

Giurfa, M. (2019). An insect's sense of number. – Trends in Cognitive Sciences 23(9): 720–722.

Glaser S.M. & Grüter, C. (2023). Social and individual learners use different pathways to success in an ant minisociety. – Animal Behaviour 198: 1-9.

Gordon, D.M. (1996). The organization of work in social insect colonies. – Nature 380: 121–124.

Gordon, D.M. (2003). The organization of work in social insect colonies. – Complexity, 8: 43-46.

Gordon, D.M. (2010). Ant Encounters. Interaction Networks and Colony Behavior. – Princeton University Press, Princeton.

Gordon, D.M. (2019). The ecology of collective behavior in ants. Annual Review of Entomology 64:35–50.

Grassé, P. (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: 41–80.

Hansell, M. (2007). Built by Animals: The natural history of animal architecture. – Oxford University Press, Oxford.

Hayek, F.A. (1948). Individualism and Economic Order. – University of Chicago Press, Chicago.

Hayek, F.A. (1967a). Notes on the evolution of systems of rules of conduct. – In: Studies in Philosophy, Politics and Economics (Hayek, F.A., ed.). Routledge & Kegan Paul, London, p. 66-81.

Hayek, F.A. (1967b). Studies in Philosophy, Politics and Economics. – Routledge, London.

Hoenicke, C., Bliss, P.J. & Moritz, R. (2015). Effect of density on traffic and velocity on trunk trails of *Formica pratensis*. – The Science of Nature 102: 1–9.

Hölldobler B., Wilson, E.O. (1990). The Ants. – Harvard University Press.

Hölldobler B., Wilson, E.O. (2009). The Superorganism. – W. W. Norton & Company.

Ireland, T. & Garnier, S. (2018). Architecture, space and information in constructions built by humans and social insects: a conceptual review. – Philosophical Transactions of the Royal Society B: Biological Sciences 373(1753).

Jensen, K., Vaish, A. & Schmidt, M.F. (2014). The emergence of human prosociality: aligning with others through feelings, concerns, and norms. – Frontiers in Psychology 5.

Khuong, A., Gautrais, J., Perna, A., Sbaï, C., Combe, M., Kuntz, P., Jost, C. & Theraulaz, G. (2016). Stigmergic construction and topochemical information shape ant nest architecture. – Proceedings of the National Academy of Sciences 113(5): 1303–1308.

Kusch, M. (2006). Sceptical Guide to Meaning and Rules: Defending Kripke's Wittgenstein. – Routledge, Abingdon-on-Thames.

Leonhardt, S.D., Menzel, F., Nehring, V., Schmitt, T. (2016). Ecology and Evolution of Communication in Social Insects. – Cell 164 (6): 1277-1287.

Lorini, G. (2017). Il comportamento nomico degli animali non-umani. Verso un'etologia della normatività. – Sociologia del diritto 44 (3): 77-105.

Lorini, G. (2022). Animal Norms: An Investigation of Normativity in the Non-Human Social World. – Law, Culture and the Humanities 18 (3): 652–673.

Lucon-Xiccato, T., Carere, C. & Baracchi, D. (2024). Intraspecific variation in invertebrate cognition: a review - Behavioral Ecology and Sociobiology 78, 1.

Maák, I.E., Roelandt, G. & d'Ettorre, P. (2020). A small number of workers with specific personality traits perform tool use in ants. – eLife 9: e61298.

McGrath, M. & Frank, D. (2023). Propositions. – The Stanford Encyclopedia of Philosophy, Edward N. Zalta & Uri Nodelman (eds.), https://plato.stanford.edu/archives/win2023/entries/propositions/

Millikan, R.G. (2000). On Clear and Confused Ideas: An Essay about Substance Concepts. – Cambridge University Press, Cambridge.

Mlot, N.J., Tovey, C.A. & Hu, D.L. (2011). Fire ants self-assemble into waterproof rafts to survive floods. – Proceedings of the National Academy of Sciences of the United States of America 108, 7669–7673.

Mlot, N.J., Tovey, C.A. & Hu, D.L. (2012). Dynamics and shape of large fire ant rafts. – Communicative & Integrative Biology 5(6): 590–597.

Moffett, M.W., Garnier, S., Eisenhardt, K.M., Furr, N.R., Warglien, M., Sartoris, C., Ocasio, W., Knudsen, T., Bach, L.A., & Offenberg, J. (2021). Ant colonies: building complex organizations with minuscule brains and no leaders. – Journal of Organization Design, 10: 55-74.

Moroni, S. (2014). Two different theories of two distinct spontaneous phenomena: orders of actions and evolution of institutions in Hayek. – Cosmos and Taxis 9: 9-23.

Nozick, R. (2001). Invariances: The Structure of the Objective World. – Harvard University Press, Cambridge.

Okrent, M. (2018). Nature and Normativity: Biology, Teleology, and Meaning. – Routledge, London.

Park, J.S., Lin, H. & Alqrinawi, H. (2023). Mechanical and thermal properties of mud-dauber nests under atmospheric drying. – Scientific Reports 13: 12627.

Perry, C.J., Barron, A.B. & Chittka, L. (2017). The frontiers of insect cognition. – Current Opinion in Behavioral Sciences 16: 111–118.

Peters, R.S. (1958). The Concept of Motivation. – Routledge and Kegan Paul, London & Boston.

Phonekeo, S., Mlot, N.J., Monaenkova, D., Hu, D.L. & Tovey, C.A. (2017). Fire ants perpetually rebuild sinking towers. – Royal Society Open Science 4(7).

Poissonnier, L.-A., Tait, C. & Lihoreau, M. (2023). What is really social about social insect cognition? – Frontiers in Ecology and Evolution 10.

Polidori, C., Trombino, L., Fumagalli, C. & Andrietti, F. (2005). The nest of the mud-dauber wasp, *Sceliphron spirifex* (Hymenoptera, Sphecidae): Application of geological methods to structure and brood cell contents analysis. – Italian Journal of Zoology 72(2): 153–159.

Powell, R. (2023). Social norms and superorganisms. – Biology & Philosophy, 38(3).

Ratnieks, F.L.W. & Wenseleers, T. (2005). Policing insect societies. – Science 307(5706): 54-56.

Reid, C.R., Lutz, M.J., Powell, S., Kao, A.B., Couzin, I.D. & Garnier, S. (2015). Army ants dynamically adjust living bridges in response to a cost–benefit trade-off. – Proceedings of the National Academy of Sciences 112(49): 15113–15118.

Reznikova, Z. & Ryabko, B.Y. (2011). Numerical competence in animals, with an insight from ants. – Behaviour 148(4): 405-434.

Reznikova, Z. (2016). Studying Animal Languages Without Translation: An Insight from Ants. – Springer, Berlin.

Riedl, K., Jensen, K., Call, J. & Tomasello, M. (2012). No third-party punishment in chimpanzees. – Proceedings of the National Academy of Sciences 109(37): 14824–14829.

Roughley, N., Bayertz, K., eds. (2019). The Normative Animal? On the Anthropological Significance of Social, Moral, and Linguistic Norms. – Oxford University Press, Oxford.

Sacco, R. (1995). Mute law. – The American Journal of Comparative Law 43(3): 455–467.

Searle, J.R. (1995). The Construction of Social Reality. – Free Press, New York.

Searle, J.R. (2010). Making the Social World: The Structure of Human Civilization. – Oxford University Press, Oxford.

Sellars, W. (1980). Language, rules and behavior. – In: Pure Pragmatics and Possible Worlds. The Early Essays of Wilfrid Sellars (Sicha, J.F., ed.). Ridgeview, Atascadero, p. 289-315.

Smith, A.A., Hölldobler, B. & Liebig, J. (2012). Queen-specific signals and worker punishment in the ant Aphaenogaster cockerelli: the role of the Dufour's gland. – Animal Behaviour 83(3): 587–593.

Souriau, E. (1965). Le Sens Artistique des Animaux. – Hachette, Paris.

Sterelny, K. (2021). The Skill Hypothesis: A Variant. – Analyse & Kritik, 43(1): 225–234.

Stroeymeyt, N. & Keller, L. (2014). Editorial overview: social insects: the internal rules of ant societies. – Current Opinion in Insect Science 5: iv-v.

Strömbom, D. & Dussutour, A. (2018). Self-organized traffic via priority rules in leaf-cutting ants. – PLoS Computational Biology 14(10): e1006523.

Tomasello, M. (2021). Norms require not just technical skill and social learning, but real cooperation. – Analyse & Kritik 43(1): 219–224.

Traniello, J.F. & Avarguès-Weber, A. (2023). Individual and collective cognition in social insects: What's in a name? – Behavioral Ecology and Sociobiology 77: 119.

Tschinkel, W.R. (2021). Ant Architecture: The Wonder, Beauty, and Science of Underground Nests. – Princeton University Press, Princeton.

Vincent, S., Ring, R. & Andrews, K. (2018). Normative practices of other animals. – In: The Routledge Handbook of Moral Epistemology (Zimmerman, A., Jones, K. & Timmons, M., eds.). Routledge, London, p. 57-83.

Rudolf von Rohr, C., Burkart, J. M & van Schaik, C.P. (2011). Evolutionary precursors of social norms in chimpanzees: A new approach. – Biology and Philosophy, 26 (1): 1–30.

Wendt, S. & Czaczkes, T.J. (2017). Individual ant workers show self-control. – Biology Letters 13(10).

Wenseleers, T., Oi, C.A., & Caliari Oliveira, R. (2020). Worker Policing. – In: Encyclopedia of Social Insects (Starr, C., ed.). Springer, Cham, p. 1–8.

Wheeler, W.M. (1911). The ant-colony as an organism. – Journal of Morphology 22(2): 307-325.

Wheeler, William Morton (1923). Social Life Among the Insects. – Harcourt Brace and Company.

Wheeler, William Morton (1928). The Social Insects: Their Origin and Evolution. – Harcourt, New York; Kegan Paul, Trench, Trubner & Co.

Wilson, E.O. (2020). Tales from the Ant World. – Liveright, New York.

Wright, C.M., Lichtenstein, J.L.L., Doering, G.N., Pretorius, J., Meunier, J., Jonathan & N. Pruitt, J.N. (2019). Collective personalities: present knowledge and new frontiers. – Behavioral Ecology and Sociobiology 73(3): 1–23.

Wright, G.H. von (1963). Norm and Action: A Logical Enquiry. – Routledge and Kegan Paul, London.