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Spontaneous Generations Volume 11, Issue 1 (Spring/Summer 2023)

doi.org/10.4245/spongen.v11i1.19966

https://spontaneousgenerations.com

Editorial Offices

Institute for the History and Philosophy of Science and Technology

Room 316 Victoria College, University of Toronto

91 Charles Street West, Toronto, Ontario, Canada

M5S1K7

Founded in 2006, Spontaneous Generations is an online academic journal published by the Institute for the History and Philosophy of Science and Technology, University of Toronto. There is no subscription or membership fee. Spontaneous Generations provides immediate open access to its content on the principle that making research freely available to the public supports a greater global exchange of knowledge.

Agency, Inventiveness, and Animal Play: Novel Insights into the Active Role of Organisms in Evolution

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Abstract

Agency is a central concept in the organisational approach to organisms, which accounts for their internal purposiveness. Recent recognition of the active role played by organisms in evolution has led researchers to use this concept in an evolutionary approach. Agency is then considered in terms of 'unintentional' choice: agents choose from a given repertoire the behaviour most appropriate to their goal, with this choice influencing evolutionary pathways. This view, while allowing for the evolutionary role of the activity of organisms, presents two pitfalls. First, it restricts organisms' agency by confining their choice within the bounds of a behavioural repertoire, and assuming their goals are dictated by natural selection. Second, this view, while claiming to eliminate the idea of intentionality, retains its structure: organisms are portrayed as rational entities, persistently pursuing specific goals. This leads us back to a teleological thinking, whose use in evolutionary theory has already been heavily criticised. This paper proposes a conception of biological agency which does not assume goal-directedness but considers agency as inventiveness. An organism will be said to be an agent if it is the triggering cause of behaviours falling outside the known repertoire and whose form can only be explained by the unique relationship between the organism and the environment. If these behaviours have implications in evolution, the agent will be considered an evolutionary agent. The merit of this approach is further validated by evidencing the significant role behavioural innovations play in evolution. Finally, the last section delves into the process of invention by examining animal play.

Key Words

Agency; teleology; invention; innovation; Baldwin effect; animal play

In evolutionary biology, a certain form of *agential thinking* characterised by a teleological approach (Godfrey-Smith, 2009) plays an important role in explanations, at least by way of metaphor. It is used both to describe the action of natural selection as the vehicle by which nature is striving to produce the most adapted traits possible (Dennett, 1995; Dawkins, 1996), and to refer to the role played by certain biological entities. In this second sense, the entities might be genes with their own selfish interests (Dawkins, 2006) or, more typically, organisms, which are then ascribed intentions and/or goals. For instance, host birds will be said to kill alien eggs in their nest because they realise it is a stranger egg, and don't want to waste energy and resources feeding offspring that are not their own. This use of teleology has been the subject of much criticism (Okasha, 2021; Tahar, 2021): in one case (the eleology of natural selection) it is misleading, in the other (the teleology of intentionality) it obscures the processes underlying this appearance of intentionality – genetics (Mayr, 1988) and natural selection (Lennox, 1993).

Nonetheless, organisms are active in the struggle for existence, and what they do does impact evolution. Thus, while rejecting the anthropomorphism of the agential thinking described above, which grants organisms intentions, we must nevertheless attempt to account for the biological agency of living beings, in other words the active role they play in shaping their conditions of existence and in contributing to evolutionary change. The role of organisms in evolution is increasingly recognised and explored, notably through the important work of Denis Walsh (see Walsh, 2015, p. 164). Yet, their agency is generally considered in terms of choice within a repertoire: it consists merely in choosing, from a fixed set of behaviours, the most appropriate one to achieve their goals (Walsh, 2015; Margulis & Sagan, 1995, p. 180; Diogo, 2017, p. 42-50, 187-8). This conception is faithful to a tradition of continental philosophy which considers that some non-human living beings (animals) may be able to choose their actions from a repertoire that reflects their (limited) set of possible relations to the world (Uexküll, 2010). But, because of its teleological anchorage, it is scientifically problematic. Indeed, this view presents two pitfalls: the narrowing of agency and the retention of an anthropomorphic paradigm.

First, the role of organisms is doubly restricted. Not only are their options limited by the behavioural repertoire, but moreover they do not choose their goals. Goals are imposed on them by 'nature': they can be referred to the imperatives of the struggle for existence (to reproduce; to eat, to protect the offspring, etc.).

Second, this view does not seem to escape the anthropomorphism of conceiving organisms as rational agents. Indeed, although Walsh eliminates the idea of intentionality, the agency he describes nonetheless seems to retain its structure, and organisms can be described as rational agents choosing the most appropriate action according to their given goals. The hypothesis of my article is that these pitfalls can be overcome by abandoning the identification of agency with goal-directedness.

My aim is to underline the active role that organisms play in evolutionary dynamics, without making the metaphysical assumption that they are purposive and make choices based on certain goals. To do so, I will study agency as visible in the behaviour of organisms, when they display truly novel (non-typical) behaviours. Their evolutionary agency can thus be assessed by examining the impact of their novel behaviours on ecological conditions and selective pressures. This approach has fewer metaphysical presuppositions than the previous one, since it assumes that agency is observable in behaviour. But it proposes a conception of agency that is stronger than the traditional one, since agents are not considered as systems that choose among behaviours pre-set within a behavioural repertoire, but as capable of creating new behaviours.

First, this paper introduces various concepts of biological agency to pinpoint the challenges in understanding organisms' agency in evolution. Following that, I will establish a definition of organisms' agency, that does not assume organisms are goal-directed. This definition will frame agency as inventiveness. Some elements will be added to the definition in order to distinguish what constitutes an evolutionary agent. The third section will justify this definition through examples of behavioural innovations in animals and by demonstrating how these innovations can play an evolutionary role. Finally, I will delve into the process of invention by examining animal play. By analysing the reasons behind the exclusion of non-human organisms from the realm of inventiveness in continental philosophy, I will identify the necessary conditions of invention. Through a study of animal play, I will demonstrate that at least some non-human animals fulfil these conditions. This examination of animal play will shed light on the process of invention itself and will also provide some leads regarding the relationship between play, inventiveness and the active role played by organisms in evolution.

Agency in Evolution

Agency, Organisation, and Natural Selection

In biology, agency has played an important role in our conception of biological systems. It is used to provide an understanding of the specificity of organisms and of their relationships with their environment, as opposed to other systems incapable of self-maintenance and self-generation. Accordingly, the concept holds an important position in so-called 'organisational approaches' (Weber & Varela, 2002; Mossio & Moreno, 2009). Barandiaran and colleagues encapsulate the characteristics of agency in three foundational conditions: individuality (the system is an individual), asymmetrical interaction (the system is the active source of the interaction), and normativity (Barandiaran et al., 2009). Normativity is a teleological concept: it refers to the fact that agents are guided by norms or goals that are not externally imposed. This agentive conception of organisation makes it possible to describe the role that organisms play in their own constitution and maintenance. But it does not imply that all agents are the result of natural selection, nor that they play a role in evolution. The relevant entities are not necessarily biological: indeed, agency is a concept also widely used to study artificial intelligence (Russell & Norvig, 1995).

What the concept of agency helps capture is the functioning and organisation of a system that is capable of self-maintenance and self-generation, i.e., that is autonomous. Agency is then considered as a property of organisms describable from their activities, without making assumptions about its origin or its evolutionary implications. This limitation to the functional description of the organism guarantees the heuristic strength of the concept of agency for understanding organisation, but also results in potential confusion. It implies that organisms define their goals by themselves, without examining the genealogy of this goal-directedness. But from the point of view of evolutionary biology, agency appears to be a result of natural selection (Okasha, 2018). Thus, agency could be nothing more than a useful metaphor which enables us to treat organisms as rational agents for the purposes of explanation; but in the end organisms should be seen as the results of evolution, not as true agents in evolution. Indeed, in evolutionary biology, the dominant view considers that organisms represent compromises between genetic determinism and the selective pressures of the environment (Dennett, 1995; Dawkins, 2006).

Hence, biological agency seems to reach a theoretical impasse. Either it is considered a genuine property of organisms but whose origin cannot be questioned, or it is referred to the action of natural selection, but this reference ends up cancelling out agency itself.

Agency in Evolution: a Chicken-and-Egg Situation?

The vision of the organism as the result of the interaction of two efficient causal chains belongs to a vision of evolution that leaves no room for living beings: it explains the evolution of biodiversity entirely via the natural selection of genetic variations available in an environment. This conception has recently encountered considerable criticism. Increasing numbers of researchers now embrace a new vision of causality that is better suited to the complexity of biology and that would avoid the pitfalls of this deterministic view. Gould, and more recently, Montévil and Mossio (Gould, 2002; Montévil & Mossio, 2015) have developed a theory of biological constraints to enable researchers to think beyond efficient causality in biology. Using this concept, they seek to explain both the stabilisation of biological processes and the unpredictability inherent to biology. In a previous paper, I have suggested that such constraints derive their evolutionary power through internalisation by living beings in practices and behaviour (Tahar, 2022). The basis for this suggestion, as Darwin already emphasized, is that the causality of natural selection resides in the actual lives of living beings, their struggle for existence (Darwin, 1859). For a genetically based variation to be selected, it must prove useful for the organism: the adaptive value of a variation does not exist without the organism's practice that will make it valuable. This is not a mere addendum to the theory, because it is in the organisms' original actions and interactions that the unpredictability of evolution lies.

In this perspective, organisms are not mere proximate causes of their activities and relationships with the environment – evolution being the ultimate cause (See Mayr, 1961). On the contrary, organisms should be considered as ultimate causes (or ultimate sources, see Walsh, 2015, p. 234) of evolutionary change. These new insights on causality in evolution invite us to consider afresh the active role played by organisms in evolution. Walsh (2015) was one of the first to propose such a theory of biological agents in evolution. He views organisms as true agents because they are purposive, and because they experience ecological conditions as meaningful in relation to their purposes. This allows Walsh to envision how ecological conditions and, more generally, biological constraints can take on an evolutionary meaning: interaction with agents constitutes the constraints as *affordances*, to which agents can respond based on their *adaptive repertoire*, and according to their *purposes*. Agency is therefore based on the organism's ability to choose its response – similar considerations are found in Margulis and Sagan (1995) – and this ability to choose is seen as present at all levels of organisation: in plants (Gilroy & Trewavas, 2001), in unicellular organisms (Beekman & Latty, 2015), and even in prokaryotes (Koshland 1977).

However, it could be argued that if organisms are purposive, or goal-directed, it is because of natural selection, which has given them a *unity-of-purpose* (Okasha, 2018). But, for natural selection to operate, there had to be organisms that struggled for their existence, and therefore these organisms must have been purposive agents. The risk here is to end up with an infinite regress, a chicken-and-egg situation, depending on whether one puts natural selection or biological agents first.

This may be a false problem. Indeed, it seems that its premises are misleading in at least two respects: (A) it is based on a confused conception of the relationship between proximate and ultimate causes; (B) it emerges from a first badly posed problem, which consists in treating goal-directedness as an *explanandum* whose *explanans* are the activities of organisms, forgetting that goal-directedness is only the metaphysical concept by which we approximate these activities.

On the one hand, it is based on two distinct understandings of the relationship between proximate and ultimate causes, one that assumes their radical distinction, the other that proposes their identification. In the 'natural selection first' view, the proximate cause of organisms' goals is the organism, and the ultimate cause is natural selection. In the 'organisms first' view, the proximate cause is also the ultimate one: the activity of the organism. In reality, it is probably necessary to maintain the distinction between the levels of causality, while also considering their entanglement. This is what Ramsey and Aaby propose, by substituting to the proximate/ultimate couple the triggering/structuring one (Ramsey & Aaby, 2022): organisms can then be considered as both triggering causes of their behaviour and structuring causes of evolutionary outcomes. This implies that the competing views are in fact both correct (albeit only partially).

On the other hand, this chicken-and-egg problem arises when investigating the rationale for the goal-directedness of organisms. But what are we investigating here? Goal-directedness is neither an observable adaptation nor an identifiable behaviour. It is a feature that we attribute to the organism, but which is more a matter of metaphysical presupposition than of scientific observation. Instead of describing the activities of the organism and trying to explain them, we first posit the goal-directedness (or purposiveness) of the organism (which is invisible) and try to explain it by its activities (which leads us to the chicken-and-egg problem). But this is backwards reasoning: the *explanandum* are the actual activities of the organisms, not goal-directedness, which is merely a metaphysical property that we project onto the beings performing these activities.

Thus, the research is biased from the start and ends up facing an unsolvable problem, i.e., a chicken-and-egg situation.

Agency as Inventiveness?

In contrast, by not assuming that organisms are goal-directed, we can understand the active role played by organisms in evolution without falling into the pitfall of infinite regress highlighted above. It is necessary to decorrelate agency and goal-directedness because this very decorrelation allows us to disclose the agency of organisms as constituted in their unique relationship with their environment, rather than as a property potentially resulting from natural selection (whether or not this evolutionary origin is made explicit). In fact, agency emerges precisely in those cases where the behaviour of organisms does not seem to be fully explainable by natural selection, i.e., when it is not the typical behaviour used by the organism to achieve the 'natural' goals. In other words: agency manifests itself when behaviour cannot be understood as included in a fixed space of genetic and behavioural possibilities (the repertoire of adaptive responses, according to natural goals). Agency unfolds in invention.

This potential for organisms to invent new relationships with the world, i.e., new behaviours not initially included in their behavioural repertoire, is only touched upon in Walsh's seminal work, which does not manage to escape the pitfalls of teleological thinking. Nevertheless, the ethological literature provides numerous examples of behavioural inventions (see Reader & Laland, 2003; Ramsey et al., 2007). In animals, especially vertebrates, there is abundant evidence of inventions and innovations. These data converge towards the idea that at least some animals could be inventive. They could initiate behaviour that is not dictated either by the environment or by their behavioural repertoire, or even by the interaction of both. This capacity suggests that the active role of organisms should be thought of in a very different, and yet much more powerful sense, than that of a choice or a decision: organisms as agents capable of inventing the new relations they have with their surroundings.

Definition of Agency

Agency and Evolution

Traditionally, in philosophy, agency is used to designate the capacity of certain entities or individuals to both cause an action and be its *raison d'être*: the action would not have been the same or would not have even occurred had the agent been different (see Schlosser, 2015). To borrow Ramsey and Aaby's (2022) distinction, agents are both triggering causes and structuring causes of the action. And this agency is echoed in the consequences of the action: agents are indeed the causes, albeit indirect, of their actions' outcomes. How does this play out on an evolutionary scale? On what condition can organisms be agents in evolution?

To begin with, we need to establish the minimum conditions under which organisms can be qualified as *agents*. An organism can be said to be an agent if, and only if, it exhibits behaviours:

(1) [*triggering cause*] whose triggering cause is the organism itself (the cause of the behaviour is internal to the organism), and not the environment. For instance, a deer falling into a hunter's trap is not the cause of its fall, whereas the same deer running is the cause of its different movements.

(2) [*content*] that are characterised by their *originality*: they are not typical responses to environmental stimuli. In other words:

> a. *[the behaviour's form]* the organism is capable of exhibiting behaviours that fall outside the known behavioural repertoire,
>
> b. *[the behaviour's structuring cause]* and whose form can be explained neither by genetics alone, nor by the interaction of genetics and environmental conditions. The original form of the behaviour must therefore be related to the specificity of the organism and its unique relationship with the environment.

These criteria are not, however, enough to consider the organism in question as an evolutionary agent. An organism can only be an agent in evolution if it not only displays behaviours fulfilling these two criteria, but also if these same behaviours:

(3) [*consequence*] have implications for ecological dynamics and selective pressures, i.e., have implications in evolution.

Only (1) and (2)a-b are required for the organism to be an agent, i.e., for it to be the full cause of its behaviour. But if all its behaviours meet only conditions (1) and (2), then the organism is not an *evolutionary agent*. Nor is condition (3) alone sufficient for the organism to be regarded as an agent in evolution. If it performs behaviour that impacts evolution, but for which the organism is not the triggering cause (the behaviour is entirely explained by the environment or genetics), then the organism cannot be considered an evolutionary agent. Only an organism that displays behaviours meeting all three criteria at the same time can be said to be an evolutionary agent: it is involved in the structuring causes of evolutionary dynamics.

In contrast to other approaches of biological agency (see Weber & Valera, 2002; Mossio & Moreno, 2009; Walsh, 2015), this definition has the merit of not presupposing that organisms are purposive or goal-oriented. Nor does it rely on the questionable comparison according to which organisms behave like rational agents. As a result, this definition requires fewer metaphysical and epistemological assumptions than the conception of agency as an ability to choose according to goals. However, it conveys a stronger understanding of agency: agency is not the outcome of the mere capacity to choose between predetermined behaviours, but it relies on the ability for some organisms to invent new behaviours (this inventiveness results from the combination of (1) and (2)a-b).

Consequently, this definition is more restrictive than those that link agency to goal-directedness.

Because goal-directedness is invisible, it could theoretically apply to all organisms. On the contrary, by attributing agency only to those organisms we know are capable of inventing (their inventions are visible behaviours, identifiable by objective criteria), we narrow the concept's extension – at least de facto to animals, perhaps even to vertebrates, maybe only to some vertebrates (the question remains open as to whether, de jure, this agency should be extended to all organisms).

This definition of agency leads us to conceive of agency in terms of inventiveness. Organisms are agents if they can demonstrate inventiveness.

And to ascribe them a role in evolution, it is necessary to add condition (3) to this agency, i.e., that their inventions can become innovations.

Lexical Clarification

By inventiveness I refer to the living being's ability to display behaviours that were truly unpredictable given the behavioural repertoire (of the individual and of its group) and the conditions of the environment. Following Bateson and Martin (2013; see also Perry et al., 2021), I therefore distinguish inventions from innovations.

A behaviour is an *invention* if it has never been (i) displayed before, either by the individual or the group under study, or (ii) observed in a particular context (the behaviour is typical, but the situation is novel). On the contrary, a behaviour already present in the group and/or simply manifesting the normal development of a juvenile is not an invention, according to this definition. But it may be considered an invention if the behaviour exists in another group of the population, as it is likely not socially learned. This is a minimal definition that does not make any presuppositions about the cognitive capacities of inventive animals and allows a study of inventions through observation. According to this definition, inventions can become, but are not necessarily, innovations.

By *innovation* I mean a 'successful' invention: one that has spread in the population (Tebbich et al., 2016) and changes the way things are done (Bateson & Martin, 2013). It is innovations that are important for the study of the organisms' *evolutionary agency*: organisms can only be agents in evolution if their inventions can spread, and thus play a role in ecological and thus selective conditions.

Behaviours can thus be regarded as inventions or innovations according to objective criteria which a researcher can observe in the field and/or deduce from available data. For, if inventiveness, as a faculty, is not visible in itself, its outputs are. The organism will be said to be an agent when it manifests the products of inventiveness.

Avoiding the Chicken-and-Egg Problem

This understanding of agency allows us to overcome the infinite regress underlined above, by avoiding the confusions caused by premises (A) and (B).

Inventions, unlike goals, are neither arcane nor invisible. Invention is an observable behaviour, characterised by not being directly induced by the environment and never having been recorded before, either in the individual or in the group under study – therefore, it is unlikely to be the mere result of genetics or of the typical development of the individual. Obviously, this implies that an invention can only be detected in the context of long-term monitoring where the group's typical behaviours have been identified. But, notwithstanding the constraints of the investigation of inventions, they can be objectively assessed. Consequently, by being defined through inventiveness, agency is given objective criteria. It is no longer a mere metaphysical property to be explained by the activities of organisms, but an observable property deduced from these activities. This avoids the pitfalls of premise (B).

Inventiveness can certainly be seen as a product of natural selection (this would result in a chicken-and-egg situation concerning the origin of inventiveness). But it remains that once inventiveness has evolved, inventions cannot be the result of natural selection by definition, since they are characterised by being at odds with the behavioural repertoire of the group under study. This means that when an organism invents a new behaviour, the cause of the invention cannot be traced back to natural selection, and the organism should be regarded as the full (triggering and structuring) cause of its invention. This allows us to surmount the difficulties of premise (A).

One might argue that the same holds for goal-directedness: natural selection fashions natural goals and a behavioural repertoire, but the way behaviours are deployed to pursue these goals depends on the organism, and how it experiences and constitutes affordances. A distinction could thus be made between the general patterns of goals (shaped by natural selection), the means, i.e., the behaviours available to achieve them (*idem*), and the modalities of their realisation (for which the organism would be the full cause). And just as this distinction was not enough to get out of the chicken-and-egg problem for goal-directedness, so it would fail to avoid the infinite regress regarding the conception of agency as inventiveness.

Yet, the conception of agency developed in this paper avoids this pitfall because of two fundamental epistemological differences with the approach of agency as goal-directedness.

Firstly, it assumes a *dynamic* understanding of the behavioural repertoire: the repertoire is not the static result of natural selection, nor even of developmental constraints, but a complex that can be transformed, i.e., new behaviours can be invented. Thus, biological agents can be structuring causes of the behaviours themselves, in their patterns, and not just of the modalities of their realisation.

Secondly, because I dismiss the idea of goal-directedness, I do not presume that the behaviour produced follows a direction constituted by natural selection (although I do not rule out that it does). If the organism is not merely an agent but an evolutionary agent, i.e., if an invention becomes an innovation, and can play a role in selective pressures, it is certainly because the invention helps the organism to survive and reproduce. However, we do not (and need not) speculate that it was in order to survive and reproduce that the organism invented the behaviour, and that it was ultimately the goals imposed by natural selection that drove the organism to invent the behaviour. Instead, even if the new behaviour has not been performed as a means to a 'natural' end, the organism will nevertheless be considered an agent of that invention. Therefore, in this view, the organism that is an agent is both the triggering and structuring cause of the behaviour it invents, and natural selection need not be invoked to fully explain the behaviour. Understanding agency as inventiveness prevents the pitfall of infinite regress.

Now that I have defined the criteria for biological agency, I will show that some non-human organisms do meet these criteria. In addition, to support this conception of evolutionary agency, I will explain how and by what processes innovations can impact evolution.

The Evolutionary Role of Behavioural Innovations

Behavioural Innovations

It is of course innovations that are primarily relevant for studying the active role of organisms in evolution, for they can change evolutionary trajectories. Corning illustrates this theoretically by formulating the following hypothesis on the evolution of Lamarck's giraffes (*Giraffa camelopardalis*). If the neck of giraffes has evolved to become so long, it would be because a giraffe would have displayed, at a given moment, a new behaviour: eating *Acacia* leaves. The behaviour would have spread (Corning does not specify how), i.e., the invention would have become an innovation. And finally, this innovation would have led to variations already appearing spontaneously in the population (a slightly longer neck) taking on an adaptive meaning and being selected (Corning, 2014).

For this kind of hypothesis to be viable, it must be proved that non-human organisms are capable of innovation. In fact, there is a lot of actual data on animal innovations (human and non-human). Without making an exhaustive list of the cases reported in the literature, several examples of innovations by non-human animals are worth mentioning.[1]

One of the first innovations to be identified, and therefore also one of the most celebrated, is that of British tits and milk bottles, in the south of England (Fisher & Hinde, 1949). In the 1920s, milk bottles were often delivered to people's front doors, but it was not uncommon for the bottles to be found with the lids pierced. This was because birds would open the waxed cardboard lids and drink the cream on top. This innovation, first observed at one site in 1921, was recorded at over 30 sites twenty years later (Lefebvre, 1975). The ways in which the behaviour has spread are still being debated (Aplin et al., 2013).

Another well-known example of innovation is the potato washing behaviour exhibited by Japanese macaques, *Macaca fuscata*, on the island of Koshima (Kawamura, 1959; Kawai, 1965; Schofield et al., 2018). The island was under observation since 1948. To get the macaques out to observe them, the researchers left sweet potatoes on the beach. Macaques would remove the sand and directly eat the sweet potato. But in 1953, an 18-month-old female named Imo (which means 'sweet potato' in Japanese) was observed washing her sweet potatoes in the river. Imo taught her siblings the behaviour, and then the behaviour spread to the community and most of the macaques adopted Imo's behaviour. It went even further, since Imo started dipping the potatoes in the ocean (for the salty taste?), transforming her first invention.

Less well known, yet notable examples include the green heron (*Butorides striatus*) and its lures. Indeed, a new fishing technique has been observed in a group of green herons. Some individuals started dropping objects on the surface of the water which appear to operate as lures: the fish move towards the object, i.e., towards the surface where the heron can more easily catch it (Lefebvre et al., 2002).

Although it is impossible to list all animal innovations, it should be noted that inventors are not only found among birds or primates. In fact, cetaceans have been known to exhibit innovative behaviours as well (Patterson & Mann, 2015). One famous case is that of the killer whale and the dead salmon, observed in Puget Sound in 1987: a female killer whale was seen carrying a dead salmon on top of her head. The behaviour quickly spread to several neighbouring pods, although it eventually disappeared from the community (Baird, 2000; Whitehead et al., 2004).

Thus, in animals, and particularly in vertebrates, many examples of inventions and even innovations have been recorded, even if their modes of transmission are still being debated. At least in some non-human organisms, inventiveness is visible through its products.

Behavioural Innovations, Ecology, and Evolution

Although they are widespread, innovations have only very recently been investigated for their evolutionary impact. While the influence of human innovations on the environment and biodiversity has long been investigated, few systematic studies assess the role played by animal innovations in ecological and evolutionary dynamics (Sol, 2003).

However, several lines of inquiry suggest the importance of innovations in ecological dynamics and thus in evolution. It seems that behavioural innovation plays a significant part in the invasion of new niches (Sol et al., 2002) and in the adaptation to new conditions: food (Estes et al., 1998), and predators (Berger et al., 2001). In some situations, it can prevent extinction. This is what happened with the Mauritius kestrel (*Falco punctatus*), which was severely endangered after the introduction of long-tailed macaques (*Macaca fascicularis*) in Mauritius (Acrese et al., 1997). Kestrels nested in tree-holes, but the arrival of the macaques led to a significant increase in nest failure. After a few years, there were only two pairs of kestrels left. But one day, one of the pairs did something new and nested on a cliff, enabling them to nest without risk. Since then, many other kestrels have nested on cliffs, leading to a partial restoration of the population. Behavioural innovation has thus saved them from extinction.

Finally, it has been suggested that behavioural innovations may affect the rate of evolutionary divergence by shifting selective pressures, or even by channelling selective pressures in a given direction. This is what Simpson (1953) called (to debunk it) the "Baldwin effect" (Baldwin, 1896), and which was actually formulated more precisely by Lloyd Morgan (1896). The Baldwin effect explains how an acquired trait can become genetically heritable. The rationale is as follows (Bateson, 2004). If a group of organisms is exposed to new conditions, those able to change their behaviour adequately will survive, while the others will die. The behavioural modification will occur generation after generation in this changed environment but will not be inherited genetically. However, its acquisition has a cost for the individual (e.g., to be able to consume new types of nuts, the squirrel has to learn how to open them). However, this cost can be reduced by genetic variations facilitating the production of this behaviour. Consequently, these variations – if they appear in the population – will be selected for. The new behaviour first achieved through what Bateson (2004) calls *behavioural plasticity* becomes a driver in evolutionary change: it can induce and orient this

Baldwin effect helps explain the genetic evolution of complex behaviours that would be unlikely to arise otherwise if they were the result of simultaneous mutations.

What started as a behavioural innovation becomes a 'model' for natural selection, thereby explaining the gradual accumulation of variations in the same direction. Each mutation substituting an inherited (genetic) disposition for a step in learning the new behaviour will reduce the cost of learning for the individual and thus be selected for, even if the other steps remain accessible only by learning.

Alongside the extensive data collected by ethologists on the form and context of non-human innovations, we are thus beginning to glimpse the driving role they may play in evolution. These innovations and their evolutionary impact reveal the importance of conceiving the agency of organisms, or at least of some organisms, as inventiveness. Yet little is known about the inventions that are at the root of these innovations, and even less about the process itself that generated them (Perry et al., 2021).

Both biological and philosophical research have largely ignored the process of animal invention – with a few notable exceptions (Dufourcq 2022; Gigliotti, 2022). In the following section, I will refer to the continental tradition, and its perspective on non-human animals, in order to elucidate the reasons of this oversight. This will allow me to suggest directions for reflecting on the still little-known process of animal invention.

Play as the Laboratory of Inventiveness?

Conditions for the Possibility of Animal Inventiveness

In philosophy, the invention of non-human organisms is generally ignored because the philosophical tradition grants the privilege of creativity only to human beings. This privilege is based on humans' ability to take distance from what surrounds them, and to fiddle with the elements of their environment.

Indeed, inventiveness presupposes, by definition, a distancing from the imperatives of the environment. Invention occurs when there is a gap between perception and action, i.e., perception does not immediately cause action, or the organism fails to immediately produce the standard response. Invention is only possible if typical behaviours are not automatically triggered by the environment. This non-immediacy allows for a time of invention, during which the usual relationship with the environment can be diverted, thus opening up the horizon of possibilities for the organism.

It is indeed this ability to distance oneself that is generally not granted to non-human organisms. The philosophical tradition holds that, even in cases where living beings, and in particular animals, are considered as meaning-maker agents, they are distinguished from humans by the *limitation* of their significations (Buytendijk, 1965; Merleau-Ponty, 1967; Canguilhem, 1975; Uexküll, 2010) and thus of their possible relationships with the environment. Animals are seen as able to relate meaningfully to the environment but not to create meanings. Whereas humans are seen as having a world (*monde*) with an indefinite number of meanings (their world is *ambiguous*, see Buytendijk, 1965), animals have only an unambiguous environment (*milieu*), a limited set of stimuli likely to produce meaning for them. This meaning is predetermined and prescribes the animal's behaviour (Uexküll, 2010). According to this view, animals have an environment devoid of virtuality: they move in an unequivocal space, always in the present of their action. This conception of animality emphasises the privilege of humans: their ability to relate to virtuality, and thus to invent new relations to their surroundings.

While animals are riveted to the actuality of present action, human existence is that which opens up virtual possibilities. This understanding of human distinctiveness is at the heart of Merleau-Ponty's analysis of Schneider's case. Indeed, when he analyses the pathological case of Schneider, wounded by a shell, with which Merleau-Ponty contrasts the main characteristics of our consciousness, he indicates that Schneider's main loss is the ability to place himself into virtuality.[2] Thereby, Merleau-Ponty adds, he lost the existential sense of consciousness. This loss is manifested by "the fact that he is incapable of play-acting":

> "To act is to place oneself for a moment in an imaginary situation, to find satisfaction in changing one's 'setting' [*millieu*]. The

patient, on the other hand, cannot enter into a fictitious situation without converting it into a real one […note:] In the same way there are for him no double meanings or puns because words can have only one meaning at a time, and because the actual is entirely without any horizon of possibilities." (Merleau-Ponty, 2005, p. 135)

Schneider is seen as having passed from the world to an environment without virtuality: he could therefore no longer play. According to this conception, animals, which live in an environment devoid of virtuality, cannot play either. And yet we observe that some animals do play. And just as the absence of play is evidence that Schneider can no longer project himself into the virtual, into the possible, so the play of animals shows that at least some animals can divert their usual relationship with the environment and thus open up the horizon of possibilities. The presence of play in certain animals obliterates the traditional distinction between animal environments and the human world. But more crucial for the present subject, animal play offers a phenomenology of the gap between perception and action, i.e., of the diverted relationship to reality which is the precondition for agency as inventiveness.

Thus, animal play reveals that at least some non-human organisms fulfil the conditions of invention, which were thought to be the privilege of human beings. Through the study of play, we may enhance our understanding of the inventive process that allows certain organisms to become agents, and possibly even evolutionary agents.

Definition of Play

Play is a motor activity that appears (i) to have no obvious short-term benefits (Martin & Bateson, 1985), (ii) in which motor patterns from other contexts may be used in (iiia) modified forms and (iiib) altered temporal sequencing (Bekoff & Byers, 1981). Given its uselessness, it (iv) occurs mainly in unstressful situations when animals feel safe.

Concrete Virtuality

The absence of immediate function (i) and the deviation from typical behaviour (ii) relate to the distance that play establishes with reality. Play is based on pretence. It entails the stance of *se déprendre* (disengagement), a phrase Fagen borrows from Lévi-Strauss (1995, p. 497), meaning a non-use-oriented relationship with the environment which requires both a detachment from immediate purposes and a distancing from the imperatives of the environment.[3] Another way of putting it is to say that play reveals a "power to look up" (Bailly, 2007, p. 36). Play introduces a relationship with the world that is uncorrelated with immediate reality. Playful behaviour does not take place in the animal's real environment. In play, objects and situations are concrete opportunities to display *virtuality*. When a cat plays with a ball or even with its own tail, it acts as if the ball or tail were a mouse. When hyenas play fight, the fighting situation is a pure image of real combat. The virtuality here is in the object, the body, or the interaction: it is a *concrete virtuality*. It is important to emphasise that these situations do not stem from an error of judgement on the part of animals. When the cat finally grabs its tail and bites it, it most probably feels that it is biting its own body, but the game does not end. It resumes as if there had been no break: the tail continues to be a virtual prey. Likewise with the hyenas: strong codes ensure that the fictional fight never becomes an actual fight: hyenas can emit meta-communication signals that tell their partner the situation is merely fictional (Nolfo et al., 2021), as can dogs with their play bows (Bekoff & Allen, 1998).

It is because the situation is fictional, that play also displays inventiveness. In play, not only is the behaviour diverted from its function, but it is highly flexible, in its form (iiia) and/or in its temporality (iiib). Playful behaviours are thus often unpredictable (Bekoff & Byers, 1981; Bateson & Martin, 2013). So, for us (observers), play is a laboratory of inventiveness. It allows us to observe a distancing from the imperatives of the environment, which is both the prerequisite for possibility and the first stage of invention. Without making any assumptions about the cognitive faculties that enable play, or about the animals' experience of virtuality (does it imply a primary form of representation?), it can be argued that play provides us with a phenomenology of inventiveness in non-human animals, by exhibiting a virtuality within the animals' behaviour.

Playful Agency: Play as a Training for Inventiveness?

Because of the particular context (iv) in which playful activities occur, play may also be a laboratory of inventiveness for animal players. The real situation is sufficiently secure for the animal to feel relaxed and to indulge in play; and the playful situation is only fictitious. This is why, in play, animals can afford to vary their behavioural patterns and even test new patterns without running great risks. Hence, play may allow the organism to increase its behavioural flexibility through anatomical and chemical changes (Fedigan, 1972; Fagen, 1981; 1982), and to train itself to respond inventively to unpredictable situations (Spinka et al., 2001).

Without going so far as to say that play has evolved for this function (see Smith, 1982; Fagen & Fagen, 2004; Burtsev et al., 2022), it is at least probable that it enhances adaptability (Bateson & Martin, 2017) by training inventiveness (Burghardt, 2015). Play could enable behavioural innovations that might not otherwise have been developed. Bateson (2014) and Burghardt (2015) offer numerous cases, in several different species, that may highlight a link between play and behavioural innovation. For instance, many cetaceans use bubbles in play (Paulos et al., 2010; Jones & Kuczaj, 2014; Kuczaj & Eskelinen, 2014), but humpback whales (*Megaptera novaeangliae*) use these bubbles in group predatory tactics. Both Bateson and Burghardt, referring to the work of Wiley and colleagues (Wiley et al., 2011), hypothesise that this predatory behaviour could have been invented during playful activities. If the hypothesis were to prove true, and if other correlations of this type could be put forward, this would mean that play could facilitate the appearance of new (functional) behaviours in new conditions. Thus, the most playful individuals (and/or species) would also be the most likely to construct new niches.

Inventiveness-agency thus leads us to consider playful agents. By observing animal play, we may catch a glimpse of how inventiveness develops in (at least some) animals. While play does not fully elucidate the inventive process, it does provide rare and valuable phenomenological insight. Moreover, some of the above leads suggest that the study of play could also bridge the gap between the process of invention, behavioural innovations, and the evolutionary impact of the latter. Thus, play might be pivotal for our understanding of non-human agency because it suggests a potential continuity between biological agency (which fulfils conditions (1) and (2)a-b) and evolutionary agency (which additionally meets condition (3)). If we could empirically ground the connection between inventions, innovations, and their evolutionary impact for at least some animals and given the important data already available on transmission processes (Rogers, 2003; Lehmann et al., 2013), we would be able to obtain a relatively complete view of agency as inventiveness, including its evolutionary implications. Therefore, the distinction we advanced between agency and evolutionary agency may need to be qualified. Given the continuity of the process from invention to its evolutionary effects suggested by the study of play, it is likely that if an organism meets *de facto* criteria (1) and (2), it can at least *de jure* meet criterion (3).

Conclusion

The definition of biological agency as inventiveness, i.e., as the faculty for an organism to be (1) the cause of a behaviour which (2) is characterised by its originality, and which can (3) have an evolutionary impact (it is then an evolutionary agency) offers several advantages over the traditional goal-directed approach.

Firstly, it avoids the problematic teleological implications of the traditional view, and the resulting chicken-and-egg dilemma. It also fosters a more nuanced and elaborate understanding of related concepts by redefining them. The behavioural or adaptive repertoire is no longer viewed as a static set but as a dynamic, changing complex. Similarly, the relationship of agents with their environment is no longer seen as occurring through the filter of affordances constrained by the goals imposed by natural selection; rather, it is characterised by its equivocity. Thus, inventive agency offers a more comprehensive and complex view of how organisms shape their modes of existence and interactions with the environment, while requiring fewer metaphysical and epistemologically problematic assumptions than the traditional conception.

In addition to these theoretical advantages, this definition also has the benefit of being operational for scientists by making agency an observable and measurable property. First, agency is observable, and I provided objective criteria for its identification. In the context of long-term field research, in which typical behaviour of individuals is known, observing an organism exhibiting non-typical behaviour that it fully causes can identify it as an agent. Second, by being observable, agency is also measurable. One could envisage measuring the agency of an individual or a group based on the frequency of its inventions. Furthermore, it is possible to evaluate an organism's evolutionary agency retrospectively, by analysing the rate of transmission of its inventions and their ecological and evolutionary impacts.

Hence, because this definition of agency has fewer metaphysical presuppositions than the traditional approach that grounds agency in goal-directedness, it may be more amenable to use by scientists. However, what is gained in clarity and objectivity is lost in extension. Indeed, according to my definition, agency and *a fortiori* evolutionary agency can only be confidently attributed to a limited number of organisms, mostly vertebrate animals. To extend the application of the concept, it is essential to investigate the process of invention that underlies agency. Unfortunately, as indicated, little research has been carried out so far on the subject. Through my examination of animal play, I wanted to pave the way for such research.

The study of play also revealed a possible continuity between agency and evolutionary agency, which would imply that an organism that is an agent is, in principle, also a potential evolutionary agent. However, the limited evidence presented so far is insufficient to confirm this continuity. To investigate further, experiments could assess the link between playful invention and functional innovation, in order to answer questions such as: are the animals that play the most quantitatively (in terms of play time) the most likely to produce inventions in functional situations? are the animals whose behaviour varies the most in play the most likely to invent in real situations? does playful inventiveness consists in producing and testing behavioural inventions that would then be reproduced identically in a functional context (invention of form), or is it a behavioural flexibility that play can bring about and which would facilitate functional inventions? Such research would help to complete the definition of inventiveness-agency and to better appreciate its implications.

I also recognise that some more properly philosophical and epistemological questions remain unanswered at this point and should be address in future research. Especially, it is necessary to consider whether an organism's agency is transitive to its species. In other words, if we define an individual as an agent by reference to an observed invention, are we entitled to attribute agency to all other members of its species, at least in principle (even if this agency is not actually apparent)? Furthermore, given that some organisms display inventiveness, should we infer all organisms are agents *de jure*, even in those cases where *de facto* there is no evidence (yet?) of their capacity for invention? One way of addressing these issues would be to investigate the possible connection between inventiveness-agency and "adaptive improvisation" as outlined by Soen and colleagues (Soen et al., 2015). Adaptive improvisation may indeed be understood as an incipient form of inventiveness at the physiological level underpinning behavioural agency. If continuity between adaptive improvisation and inventive agency exists, then agency could be considered a ubiquitous property of all organisms manifested in various forms and degrees (adaptive improvisation, spontaneity, choice, inventiveness, inventiveness through conceptual representation,…). Furthermore, this would challenge us to rethink the link between organisational and evolutionary approaches to agency.

In the end, although many issues still need to be examined, I believe that this definition of agency holds significant value by circumventing numerous metaphysical and epistemological complexities. Most importantly, by providing objective criteria, it enables further research into the agency of organisms in a way that successfully connects science and philosophy.

Notes

1. From now on I will use 'animals' to refer to non-human animals. This is not to say that the elements I will propose to conceive of animal agency are not relevant to human agency at all. But given the cognitive capacities of human beings, and the sophistication of their representational faculties, this theorisation of animal inventiveness-agency is likely to be reductive and insufficient to account for human agency.

2. I warmly thank Garance Champlois, who brought this important text to my attention in her 2019 article (cited below).

3. I got this from my discussions with Robert Fagen. His findings on this subject will be developed in a book he is currently writing, to be called *Animal Play*.

Bibliography

Aplin, L. M., Sheldon, B. C., & Morand-Ferron, J. Milk bottles revisited: Social learning and individual variation in the blue tit, Cyanistes caeruleus. *Animal Behaviour, 85*, 1225-1232. https://doi.org/10.1016/j.anbehav.2013.03.009

Arcese, P., Keller, L. F., & Cary, J. R. (1997). Why hire a behaviorist into a conservation and management team. In Clemmons, J. R., & Buchholz, R. (Eds.), *Behavioral approaches to conservation in the wild*, , 48-71. Cambridge University Press.

Bailly, J. C. (2007). *Le versant animal*. Bayard.

Baird, R. W. (2000). The killer whale. In Mann, J. R., Connor, R. C., Tyack, P. L., & Whitehead, H. (Eds.), *Cetacean societies, field studies of dolphins and whales*. The University of Chicago Press.

Baldwin, J. M. (1896). A new factor in evolution. *American Naturalist, 30,* 441-451, 536-553.

Barandiaran, X. E., Di Paolo, E., & Rohde, M. (2009). Defining agency: Individuality, normativity, asymmetry, and spatio-temporality in action. *International Society for Adaptive Behavior, 17*(5), 367-386. https://doi.org/10.1177/1059712309343819

Bateson, P. (2004). The active role of behaviour in evolution. *Biology and Philosophy, 19*, 283-298. https://doi.org/10.1023/B:BIPH.0000024468.12161.83

Bateson, P. (2014). Play, playfulness, creativity and innovation. *Animal Behavior and Cognition, 1*(2), 99-112. https://doi.org/10.12966/abc.05.02.2014

Bateson, P. (2017). *Behaviour, development and evolution*. Open Book Publishers.

Bateson, P., & Martin, P. (2013). *Play, playfulness, creativity and innovation*. Cambridge University Press.

Beekman, M., & Latty, T. (2015) Brainless but multi-headed: Decision making by the acellular slime mould physarum polycephalum. *Journal of Molecular Biology, 427*(23), 3734-3743. https://doi.org/10.1016/j.jmb.2015.07.007

Bekoff, M., & Allen, C. (1998). Intentional communication and social play: how and why animals negotiate and agree to play. In Bekoff, M., & Byers, J. A (Eds.), *Animal play: Evolutionary, comparative and ecological perspectives*. Cambridge University Press.

Bekoff, M., & Byers, J. A. (1981). A critical reanalysis of the ontogeny of mammalian social and locomotor play: An ethological hornet's nest. In Barlow, G. W., Petrinovich, L., & Main, M. (Eds.), *Behavioural development: The bielefeld interdisciplinary project*, edited by Klaus Immelmann, George W. Barlow, Lewis Petrinovich, and Mary Main. Cambridge University Press.

Berger, J., Swenson, J. E., & Persson, I. (2001). Recolonizing carnivores and naïve prey: Conservation lessons from pleistocene extinctions. *Science, 291*(5506), 1036-1039. https://doi.org/ 10.1126/science.1056466

Burghardt, G. M. (2015). Creativity, play and the pace of evolution. In Kaufman, A. B., & Kaufman, J. C. (Eds.), *Animal creativity and innovation*. Elsevier.

Burtsev, M., Anokhin, K., & Bateson, P. (2022). Plasticity facilitates rapid evolution. *BioRxiv 2022.05.04.490584*. https://doi.org/10.1101/2022.05.04.490584

Buytendijk, F. J. J. (1965). *L'homme et l'animal: Essai de psychologie comparée*. Gallimard.

Canguilhem, G. (1975). *La connaissance de la vie*. Vrin.

Champlois, G. (2019). Le jeu et la vie animale: la distinction du monde et du milieu au regard d'un comportement limite. *Revue de Métaphysique et de Morale, 101*(1), 53-64. https://doi.org/10.3917/rmm.191.0053

Corning, P. A. (2014). Evolution 'on purpose': How behaviour has shaped the evolutionary process. *Biological Journal of the Linnean Society, 112*, 242-260. https://doi.org/10.1111/bij.12061

Darwin, C. R. (1859). *On the origin of species by means of natural selection, or the preservation of favoured races in the struggle for life*. John Murray.

Dawkins, R. (1996). *The blind watchmaker: Why the evidence of evolution reveals a universe without Design*. Norton & Company.

Dawkins, R. (2006). *The selfish gene*. Oxford University Press.

Dennett, D. C. (1995). *Darwin's dangerous idea: Evolution and the meanings of life*. Penguin.

Diogo, R. (2017). *Evolution driven by organismal behavior: A unifying view of life, function, form, mismatches and trends*. Springer.

Dufourcq, A. (2002). *The imaginary of animals*. Routledge.

Estes, J. A., Tinker, M. T., Williams, T. M., & Doak, D. F. (1998). Killer whale predation on sea otters linking oceanic and nearshore ecosystems. *Science, 282*, 473-476. https://doi.org/10.1126/science.282.5388.473

Fagen, R. (1981). *Animal play behavior*. Oxford University Press.

Fagen, R. (1982). Evolutionary issues in development of behavioral flexibility. In Bateson, P. P. G., Klopfer, P. H. (Eds.), *Perspectives in ethology* (vol. 5 'Ontogeny'). Plenum Press.

Fagen, R., & Fagen, J. (2004). Juvenile survival and benefits of play behaviour in brown bears, Ursus arctos. *Evolutionary Ecology Research, 6*(89).

Fedigan, L. (1972). Social and solitary play in a colony of vervet monkeys (Cercopithecus aethiops). *Primates, 13*, 346-374. https://doi.org/10.1007/BF01793655

Fisher, J., & Hinde, R. A. (1949). The opening of milk bottles by birds. *British Birds, 42,* 347-357.

Gigliotti, C. (2022). *The creative lives of animals*. New York University Press.

Gilroy, S., & Trewavas, A. (2001). Signal processing and transduction in plant cells: The end and the beginning. *Nature Reviews (Molecular Cell Biology), 2*, 307-314. https://doi.org/10.1038/35067109

Godfrey-Smith, P. (2009). *Darwinian populations and natural selection*. Oxford University Press.

Gould, S. J. (2002). *The structure of evolutionary theory*. Harvard University Press.

Jones, B. L., & Kuczaj, S. A., II. (2014). Beluga (Delphinapterus leucas) novel bubble helix play behavior. *Animal Behavior and Cognition, 1*(2), 206-214. https://doi.org/10.12966/abc.05.10.2014

Kawai, M. (1965). Newly-acquired pre-cultural behavior of the natural troop of Japanese monkeys on Koshima islet. *Primates, 6*(1), 1-30. https://doi.org/10.1007/BF017934457

Kawamura, S. (1959). The process of sub-culture propagation among Japanese macaques. *Primates, 2*, 43-60. https://doi.org/10.1007/BF01666110

Koshland, D. E. (1977). A response regulator model in a simple sensory system. *Science, 196*(4294), 1055- 1063. https://doi.org/10.1007/BF870969

Kuczaj, S. A., II, & Eskelinen, H. C. (2014). Why do dolphins play?. *Animal Behavior and Cognition, 1*(2), 113-127. https://doi.org/10.12966/abc.05.03.2014

Lefebvre, L. (1975). The opening of milk bottles by birds: evidence for accelerating learning rates, but against the wave-of-advance model of cultural transmission. *Behavioural Processes, 34*, 43-53. https://doi.org/10.1016/0376-6357(94)0051-h

Lefebvre, L., Nicolakakis, N., & Boire, D. (2002). Tools and brains in birds. *Behaviour, 139*, 939-973. https://doi.org/10.1163/156853902320387918

Lehmann, L., Wakano, Y. J., & Aoki, K. (2013). On optimal learning schedules and the marginal value of cumulative cultural evolution: cumulative culture and life history. *Evolution, 67*, 1435-1445. https://doi.org/10.1111/evo.12040

Lévi-Strauss, C. (1995). *Tristes tropiques*. Librairie Plon.

Lennox, J. (1993). Darwin was a teleologist. *Biology and Philosophy, 8*(4), 409-421. https://doi.org/10.1007/BF00857687

Morgan, C. L. (1896). On modification and variation. *Science, 4*, 733-740. https://doi.org/10.1126/science.4.99.733

Margulis, L., & Sagan, D. (1995). *What is life*. Simon and Shuster.

Martin, P., & Bateson, P. (1985). The ontogeny of locomotor play behaviour in the domestic cat. *Animal Behaviour, 33*, 502-510. https://doi.org/10.1016/S0003-3472(85)80073-7

Mayr, E. (1961). Cause and effect in biology. *Science, 134*, 1501-1506. https://doi.org/10.1126/science.134.3489.1501

Mayr, E. (1988). *Toward a new philosophy of biology*. Harvard University Press.

Merleau-Ponty, M. (1967). *Structure of behaviour* (L. Alden Trans.). Beacon Press. (Original work published 1942)

Merleau-Ponty, M. *Phenomenology of perception* (C. Smith Trans.). Routledge, 2005. (Original work published 1945)

Montévil, M., & Mossio, M. (2015). Biological organisation as closure of constraints. *Journal of Theoretical Biology, 372*, 179-191. https://doi.org/10.1016/j.jtbi.2015.02.029

Mossio, M., Saborido, C., & Moreno, A. (2009). An organizational account of biological functions. *The British Journal for the Philosophy of Science, 60*(4), 813-841. https://doi.org/10.1093/bjps/axp036

Nolfo, A. P., Casetta, G., & Palagi, E. (2021). Visual communication in social play of a hierarchical carnivore species: the case of wild spotted hyenas. *Current Zoology*, *68*(4), 1-11. https://doi.org/10.1093/cz/zoab076

Okasha, S. (2018). *Agents and goals in evolution*. Oxford University Press.

Patterson, E. M., & Mann, J. (2015). Cetacean innovation. In Kaufman, A. B., & Kaufman, J. C. (Eds.), *Animal creativity and innovation*, Elsevier.

Paulos, R. D., Trone, M., & Kuczaj II, S. A. (2010). Play in wild and captive cetaceans. *International Journal of Comparative Psychology, 23*(701). https://doi.org/10.46867/ijcp.2010.23.04.06

Perry, S., Carter, A., Smolla, M., Akçay, E., Nöbel, S., Foster, J. G., & Healy, S. D. (2021). Not by transmission alone: the role of invention in cultural evolution. *Philosophical Transactions of the Royal Society B, 376*(1828). https://doi.org/10.1098/rstb.2020.0049

Ramsey, G., & Aaby, B. H. (2022). The proximate-ultimate distinction and the active role of the organism in evolution. *Biology & Philosophy, 37*, 31. https://doi.org/10.1007/s10539-022-09863-0

Ramsey, G., Bastian, M. L., & van Schaik, C. (2007). Animal innovation defined and operationalized. *Behavioral and Brain Science, 30*, 393-407. https://doi.org/10.1017/S0140525X07002373

Reader, S. M., & Laland, K. N. (2003). *Animal innovation*. Oxford University Press.

Rogers, E. *Diffusion of innovations*. Free Press, 2003.

Russell, S. J., & Norvig, P. (1995). *Artificial intelligence: A modern approach*. Prentice Hall.

Schlosser, M. Agency. (2015). In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy*. Stanford University Press. https://plato.stanford.edu/entries/agency.

Schofield, D. P., McGrew, W. C., Takahashi, A., & Hirata, S. (2018). Cumulative culture in nonhumans: overlooked findings from Japanese monkeys?. *Primates, 59*, 113-122. https://doi.org/10.1007/s10329-017-0642-7

Simpson, G. G. (1953). The Baldwin Effect. *Evolution, 7*, 110-117.

Smith, P. K. (1982). Does play matter? Functional and evolutionary aspects of animal and human play. *The Behavioral and Brain Sciences, 5,* 139-184. https://doi.org/10.1017/S0140525X0001092X

Soen, Y., Knafo, M., & Elgart, M. (2015). A principle of organization which facilitates broad Lamarckian-like adaptations by improvisation. *Biology Direct, 10*, art. 68. https://doi.org/10.1186/s13062-015-0097-y

Sol, D. (2003). Behavioural innovation: A neglected issue in the ecological and evolutionary literature. In Reader, S. M., & Laland, K. N. (Eds.), *Animal Innovation*. Oxford University Press.

Sol, D., Timmermans, S., & Lefebvre, L. (2002). Behavioural flexibility and invasion success in birds. *Animal Behaviour, 63,* 495-502. https://doi.org/10.1006/anbe.2001.1953

Spinka, M., Newberry, R. S., & Bekoff, M. (2001). Mammalian play: Training for the unexpected. *The Quarterly Review of Biology, 76*(2), 141-168. https://doi.org/10.1086/393866

Tahar, M. (2021) The historicity of biodiversity: A Bergsonian look at the theory of evolution. *Thaumazein Rivista di Filosofia, 8*, 89-106. https://doi.org/10.13136/thau.v8i1.113

Tahar, M. (2002). Biological constraints as norms in evolution. *History and Philosophy of the Life Sciences, 44*(1), art. 9. https://doi.org/10.1007/s40656-022-00483-1

Tebbich, S., Griffin, A. S., Peschl, M. F., & Sterelny, K. (2016). From mechanisms to function: an integrated framework of animal innovation. *Philosophical Transactions of the Royal Society B., 371*(1690). https://doi.org/10.1098/rstb.2015.0195

Uexküll, J. (2010). *A foray into the worlds of animals and humans with a theory of meaning* (J. D. O'Neil Trans.). University of Minnesota Press. (Original work published 1934)

Walsh, D. L. (2015). *Organisms, agency, and evolution*. Cambridge University Press.

Weber, A., & Varela, F. J. (2002). Life after Kant: Natural purposes and the autopoietic foundations of biological individuality. *Phenomenology and the Cognitive Sciences, 1*, 97-125. https://doi.org/10.1023/A:1020368120174

Whitehead, H., Rendell, L. E., Osborne, R. W., & Würsig, B. (2004). Culture and conservation of non-humans with reference to whales and dolphins: Review and new directions. *Biological Conservation, 120*, 427-437. https://doi.org/10.1016/j.biocon.2004.03.017

Wiley, D., Ware, C., Bocconcelli, A., Cholewiak, D., Friedlaender, A., Thompson, M., & Weinrich, M. (2011) Underwater components of humpback whale bubble-net feeding behaviour. *Behaviour*, 148(5-6), 575-602. https://doi.org/10.1163/000579511X570893

Acknowledgement

I am deeply grateful to Robert Fagen for reading and commenting on this article so thoroughly. Most importantly, the generosity of his exchanges, his intellectual curiosity, and his great capacity to se déprendre were very important for the maturation of this article. I also wish to express my appreciation to Alecia Carter for our inspiring discussions, during which some of her insightful comments proved to be pivotal for this work. Additionally, I wish to acknowledge Emily Herring for her diligent proofreading and her valuable help in enhancing the clarity of my manuscript. Finally, I would like to extend my thanks to the anonymous reviewers whose constructive feedback and relevant references have greatly contributed to the improvement of this article.