PRINCIPIA 24(1): 89–119 (2020) doi: 10.5007/1808-1711.2020v24n1p89
Published by NEL — Epistemology and Logic Research Group, Federal University of Santa Catarina (UFSC), Brazil.

# A CONTEXTUALIST APPROACH TO EMERGENCE

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**Abstract.** What is exactly the emergence relation? In which sense is irreducibility associated with it besides being assumed by definition? Although in many cases the explanatory role of emergent states does not exceed the explanatory role of more basic states, this does not speak against the fact that, for some relevant explanatory contexts, emergent states are irreducible. On this basis, an epistemic concept of the emergence relation that does not depend strictly on irreducibility is here offered.

**Keywords:** Emergent properties • contextualism • irreducibility • physicalism • reductionism

RECEIVED: 10/05/2019 ACCEPTED: 03/09/2019

## 1. Emergence, supervenience and reduction

According to a traditional notion, particularly one based on the work developed by the group of the British emergentists, an emergent property is a characteristic of a high-level phenomenon that is independent and distinct from the characteristics corresponding to lower-level phenomena (cf. Mill 1843; Broad 1925). Also, emergent properties are considered to be completely novel qualities and are in some sense unpredictable on the basis of low-level states and laws (cf. Alexander 1927).

A more actual characterization of an emergent property is the following (cf. El-Hani and Pereira 2000):

The property $P$ of a system $S$ is an emergent property just in case it arose as a result of the increasing complexity of $S$.

A complex system can be understood, roughly, as a system with a great number of parts that interact in a great number of ways (cf. Holland 2014). The greater the number of parts and types of interactions involved in a system, the more complex it is. Thus, we may reformulate the characterization of an emergent property as follows:

The property $P$ of a system $S$ is an emergent property just in case it arose as a result of the increasing number of parts and interactions involved in $S$.

Here, the notion of complexity is needed in order to understand emergence. But emergent properties have not always been understood in this way. Jaegwon Kim

(2006; see also Kim 1999) argues that only supervenience and irreducibility are necessary features of a notion of emergence compatible with the classical ideas proposed by the British emergentists.[1] If $P$ is an emergent property of a system $S$, then $P$ supervenes on some set of properties of $S$, but cannot be reduced to them. Kim (2006, p.550) puts supervenience as follows:

*Supervenience/determination*. Property $M$ supervenes on, or is determined by $N_1, \ldots,$ $N_n$ in the sense that whenever anything has $N_1, \ldots, N_n$, it necessarily has $M$.

With regard to reduction, we may distinguish two main notions, each of which grounds a distinct concept of irreducibility. Consider first *derivational reduction* (cf. Nagel 1961):

*Derivational reduction*. A sentence $P$ is reduced to another sentence $Q$ just in case $P$ is derivable from $Q$ under certain conditions and according to a set of bridge laws.

Bridge laws state logical connections that allow to establish an identity between the meanings of relevant terms involved in $P$ and $Q$. Usually, they establish identities between the relevant predicates of the reduced sentence and the relevant predicates of the reducing sentence. Suppose, for the sake of illustration, that we are able to reduce the sentence "Mental states of type $M_1$ cause mental states of type $M_2$" to the sentence "Neural states of type $N_1$ cause neural states of type $N_2$". In this case, appropriate bridge laws may establish identity or strong relation between $M_1$ states and $N_1$ states, as well as between $M_2$ states and $N_2$ states.[2]

As Kim argues, derivational reduction does not seem to be relevant for a characterization of emergence, if we want to be faithful to the traditional notion. For the bridge laws, which serve as additional conditions in a case of reduction, are precisely what need to be explained. According to emergentism, a bridge law such as "$M$ states are nothing but $N$ states" is not so simple to establish, because $M$ states are supposed to be irreducible to $N$ states. More precisely, bridge laws are easy to establish inductively or by observation, but they are hard (maybe impossible) to establish in a deductive form. Considering this, Kim turns to another kind of reduction, functional reduction, and characterizes an emergent property as follows (2006, p.555):

*Emergent property as functionally irreducible*. Property $M$ is emergent from a set of properties, $N_1, \ldots, N_n$, only if $M$ is not functionally reducible with the set of the $N$s as its realizer.

For a state $s$ to be functionally reducible, it must be functionally interpretable. That is, one must be able to define it in terms of what it causes and of what is caused by it. It must be definable, for instance, as a state that is typically caused by events of a class $C$ and that typically causes events of a class $E$. Now, when there is a realizer $b$ that plays that same causal role, one could say that $s$ is reducible to $b$. The realizer *b* must not be a single state, it can be a set of states, set of processes or types thereof. The key point is that by carrying out a functional reduction, one does not establish any identity between relevant states involved in the reduced sentence and relevant states involved in the reducing sentence. One just claims that the considered states play the same causal role.

Here is a simple example of a biological emergent property:

*Skin formation*. Skin formation in vertebrates involves different complex processes that result in different forms, textures and structures (cf. Olivera-Martinez et al. 2004). These processes involve a great number of interactions between skin cells that can lead, in different layers and phases, to the formation of a variety of structures such as ectoderm, dermis, epidermis, nails or wings.

Suppose that a sentence, $s$, describes the density of an individual's specific portion of skin and that another sentence, $r$, describes the relevant cellular processes involved in that individual's body until the portion of skin mentioned in $s$ was formed. It may seem plausible to claim that the particular skin density mentioned in $s$ is an emergent property, a property that is novel regarding the considered organism and that arose from the complex interactions between processes described in $r$. Now, according to the notion of an emergent property considered above, if the particular skin density, which we may symbolize as $D$, is a property emergent from a set of processes $P$ described in $r$, then $D$ would have to be considered to be supervenient on and functionally irreducible to $P$.

The idea that only supervenience and irreducibility are necessary conditions for emergence, following a classical notion, might be put in doubt. I will propose a way to understand the idea of emergence, having in mind the traditional notion, its essential features and the problems that it may confront. To do this, apart from supervenience and irreducibility, I will take novelty as an important condition in order to characterize the idea that emergent states *arise* from their constituents and are frequently surprising. The notion of complexity, which does not have to be included in a traditionalist view of emergence either, is closely linked to novelty, as shown later.

Note that derivational reduction is a relation between sentences and supervenience, as considered, is a relation between properties. We may say that while such a notion of supervenience is a metaphysical notion, derivational reduction is an epistemic one. Functional reduction, as just characterized, is a relation between properties and, thus, is understood as a metaphysical notion.[3] Although emergence has traditionally been considered to be a metaphysical notion, I think that the problems related to the attempts of defining it can be appropriately tackled on the basis of an epistemic account. The concept of emergence, I conjecture, is a sign of our epistemic limitations. Thus, I will avoid confusing metaphysical notions with epistemic ones.

In the following section, two issues that any account of emergence should face are presented and briefly explained. First, the notion of emergence should be clear and informative, not just based on negative features. Second, it should be clear in which sense emergent states are causally irreducible, i.e. in which sense downward causation is possible. The third section is on a criticism against irreducibility that could be seen as an obstacle in the way of trying to tackle the mentioned issues. A response to this criticism will be offered in the sixth section, after introducing some terminology in sections four and five. In the seventh section, an epistemic notion of emergence will be proposed, which supports the preceding arguments and, thus, the irreducibility of emergent states. Finally, some possible objections to the proposed definition will be considered.

## 2. Two issues regarding the notion of emergence

Even if the considered characterization of an emergent property may be clear enough to be associated with some examples, such as the one just shown, it is far from providing a solid basis for an account of emergence. As Kim (2006) argues, an appropriate account of emergence must be able to tackle two main issues. First, it must be able to characterize the relation of emergence positively. We may claim that if a property $M$ is emergent from a set $N$ of low-level properties, then $M$ is irreducible to $N$. But irreducibility is a negative feature. One could try to focus on supervenience and claim that the covariation implied in it may be considered to be a positive feature, but it is far from clear why emergent properties covary with the constituent elements of the system in which they arise. We could conceive the demand imposed by this problem in the following way:

*First demand*. If property $M$ is emergent from a set $N$ of lower-level states, then a characterization of emergence should be based on a clear, positive feature or relation that links $M$ and $N$.

The second problem is related to the causal efficacy of emergent states. If emergent states are supposed to be functionally irreducible to any set of low-level states, it should be clear which is the causal role played by them (Kim 2006). This problem can be stated as follows:

*Second demand*. If property $M$ is emergent from a set $N$ of lower-level states, then $M$ is irreducible to $N$, that is, for some causal relevant role played by $M$, there is no realizer of that role within $N$. Thus, one should be able to describe that causal role without appealing to $N$.

In sum, a clarifying definition of the notion of emergence should, according to Kim, provide positive conditions and also explain how emergent states have causal powers that are distinct from the causal powers of the states that constitute them.[4]

Particularly, an appropriate account should explain why emergent states are irreducible to the constituent elements of the system in which they emerge, even if the former supervene on the latter (Kim 2006, p.557).

## 3. A case against irreducibility

As a problem for the second demand related to a proper characterization of emergence, I am going to consider Alex Rosenberg's criticism of antireductionism. He focuses, in particular, on physicalist antireductionism, a thesis that, expressed on the basis of the relation between molecular and non-molecular biology, can be characterized by the two following principles (Rosenberg 1997, p.446; cf. Rosenberg and Kaplan 2005):

*Principle of autonomous reality*. Highlevel, non-molecular, biological states are considered to be irreducible because they provide objective explanatory generalizations that are autonomous from the explanations provided by molecular biology.
*Principle of explanatory primacy*. Non-molecular processes may sometimes provide the best explanation for molecular processes.

As an example for the principle of the autonomous reality of non-molecular biological states, Rosenberg mentions the fact that Mendel's laws are not reducible to molecular laws. Take for instance, the law of segregation. Roughly put, according to it, alleles corresponding to an organism's trait are separated in gamete formation, such that gametes will have only one allele corresponding to each gene. This can be explained in terms of what occurs in the cell without considering molecular processes. Thus, the phenomenon of segregation is autonomous from the underlying molecular states. Furthermore, as an example of explanatory primacy, the right level of explanation regarding segregation is the domain of cellular physiology and not the molecular level, which means that segregation involves non-molecular processes that may provide the best sort of explanations for molecular processes (Rosenberg 1997). In this case, one may consider the resultant phases of meiosis as the molecular processes explained.

Rosenberg presents a case that should work to criticize both the principle of autonomous reality of non-molecular states and the principle of explanatory primacy. It goes like this. The activation of the gene called Eyeless is a necessary and sufficient condition to trigger a set of proteins that form the eyes of the fruit fly. It is present in every cell of the species and activating it may result in the generation of eyes in different parts of the fly's body, such as the wings or the antennae (Halder, Callaerts and Gehring 1995; Rosenberg 1997). Even more interestingly, a homologous gene present in mice has the same effects when it is introduced and activated in cells of the fruit fly.

As Rosenberg explains (1997, p.454), these results suggest that there is a molecular mechanism responsible for a non-molecular process that occurs in different species. That is, the non-molecular process is not autonomous regarding the explanation of eye formation. More importantly, no special cellular structure seems to be particularly relevant in the mentioned cases of eye morphogenesis or, at least, cellular structure does not seem to be more important than the genetic machinery. No cellular description involved in such developmental processes play a crucial role in explaining the resulting states. As Rosenberg argues, cellular descriptions of such developmental phenomena either refer to unexplained functional regularities or to cellular structures that only come to existence thanks to preceding molecular processes. Thus, non-molecular processes do not have explanatory primacy with regard to the relevant molecular processes. They never provide the best explanation for molecular processes in these cases.

In the remaining of this article, I will try to show that there is a notion of irreducibility that is not affected negatively by Rosenberg's argument. Before introducing such a notion, it will be necessary to reformulate some features of emergent states.

## 4. Characterizing features of emergent states

In this section, I will put forward and defend a thesis that should clarify some issues regarding the notion of emergence, implying neither a strong emergentism nor a strong reductionism. The idea is the following:[5]

*Contribution of emergent states*. Let $M$ be the description of an emergent state $m$ and $N$ be a description of the lower-level constituents of $m$. Let $E$ be the description of a state that is appropriately considered as a causal effect of both $m$ and $m$. Call that effect $e$. The expectability of the occurrence of $e$, given $M$ and $N$, might be higher than its expectability, given only $M$ or only $N$. That is, $M$ can contribute in the explanation of $E$, even if $N$ is taken into account.

According to the spirit of the contribution thesis, it will not be enough to say that emergent states play distinct, independent causal roles with regard to the causal roles of their constituents.[6] In order to provide an appropriate account of emergence, we have to show in which sense information about emergent states can say *something more* about the effects of their constituents.

This thesis is clearly related to the problem about the possibility of overdetermination. Physicalists assume in general that overdetermination is not possible. For each event there is always a sufficient physical cause that explains its occurrence and sufficient physical causes exclude non-physical causes. So, in order to accept the contribution thesis, we have to accept that causality is not a relation that occurs only and strictly within the physical domain. Although this idea could be supported by different accounts of causation, I will focus on a characterization of causation based on probabilistic terms (cf. Reichenbach 1956, Suppes 1970, Cartwright 1989, Eells 1991), as follows:

*Causation*. Let $c$ and $e$ be two distinct phenomena, considered from the perspective of a particular epistemic context $K_\phi$. We say that $c$ is a cause of $e$, according to a distinct epistemic context $K_\theta$ just in case the following conditions hold:

(i) There is in $K_\theta$ a description $C$ of $c$ and a description $E$ of $e$.

(ii) $p(E|C) > p(E|\neg C)$ according to $K_\theta$.

Condition (ii) expresses that the expectability (or probability) of $e$ (i.e. *the expectability of E being true*) on the basis of $C$ is higher than on the basis of the absence of $C$.[7] Note that this characterization implies that our attributions of causation depend on what we know and how we describe the putative causal relata. It is an epistemic notion of causation.

We may also characterize explanation in a contextualist way.

*Explanation*. A description $E$ is explained by another description $C$ within a given context $K$ just in case, according to $K$, the expectability of $E$, given $C$, is higher than the expectability of $E$, given the non-occurrence of the facts described by $C$.[8]

Nothing is said about the metaphysical nature of $c$ and $e$. They are not events in any ontological sense. So, events are not understood as metaphysical instantiations of properties, but as epistemic attributions and distribution of properties. Thus, $c$ and $e$ must be considered as (types of ) phenomena, that is, as pieces of data or as parts thereof. Pieces of data are seen as such only within some epistemic context focused on observation or data collection. This may be called *observational context* (or data context) and is represented by context $K_\phi$ in the definition just given. Now, causal claims do not need to be included in $K_\phi$. Actually, they are better described within a distinct epistemic context, a context that can be conceptually and theoretically more elaborated than $K_\phi$. Such a context may be called *explanatory context* (or theoretical context) and is represented by $K_\theta$ above. The distinction between observational and explanatory contexts will be particularly important later (Section 6) in order to criticize Rosenberg's argument.

The notion of context is not easy to define, since, usually, a context is characterized negatively by mentioning first the things that we care about that are not part of the context. For example, the context of a conversation is something that is not the conversation as such, but that surrounds and determines it.[9] Here is an attempt of a characterization of the concept of an *epistemic context*, which is the type of context that is more relevant for the purposes of this work. An epistemic context is a set of background beliefs, assumptions, experiences, interests of different sorts and methodological criteria that may determine the sensitivity to different ways of reasoning or precision in the gathering of empirical evidence. They can be individuated mainly on the basis of the reference classes they imply. For instance, the interests that constitute a context could refer to certain epistemic states that a subject or scientific community may want to achieve.

An interesting work has been done by Peter Baumann (2016), who considers a set of parameters that may fix reference classes of epistemic contexts, such as topics, methods, temporal frames and spatial frames.[10] Thus, essentially, contexts are individuated by the things they are about. Considering this, contexts may be about other contexts. When a context $K$ is about another context $K'$, we say that $K'$ is *accessible from* $K$. Note that such a relation is not merely based on content. That $K'$ is accessible from $K$ does not mean that every true sentence in $K$ must also be true in $K'$. A sentence may be true according to $K$, but indeterminate or false according to $K'$.

Consider, for the sake of illustration, a context focused on criminal law. That context may be about contexts focused on how persons might be robbed. We could think of contexts of the second sort as accessible from contexts of the first sort. While the sentence "Robbery must be punished" could be true according to the context of criminal law, it could also have an indeterminate truth value according to a context that mainly describes a situation in which a person is being robbed.

A context's structure must also determine an order of relevance of the topics it is about. For each context $K$ and a pair of topics $A$ and $B$, if $A$ and $B$ are relevant in $K$, then either $A$ is more relevant than $B$, $B$ is more relevant than $A$ or both are equally relevant. Following the example just introduced, both a context of criminal law and a context focused on the study of violence may refer to contexts that describe how persons are robbed, but such contexts could be considered with a different degree of relevance in each case.

Contexts can be conceived as set of sentences, but they are more than that. A set of sentences can imply reference classes indirectly. For instance, a set of sentences about houses and their architectural design may not include any term referring to some of the materials needed to build them, but it may refer to those materials implicitly. This is why I prefer to assume that contexts are individuated by the reference classes they imply rather than by the sentences with which they are explicitly constructed.

Two contexts may describe the same phenomenon type using different concepts. Phenomenon types are items represented in observational contexts. Two contexts can be different even if they are focused in describing the same phenomenon type, if they use different concepts to do it, because different concepts imply different reference classes. And even if two contexts describe the same phenomenon type using the same terms, they might be different with regard to the reference classes associated with those terms in each case. A typical example is the case of the term "mass". It occurs in classical and in relativistic mechanics, but the concept of mass is different in each theory and, therefore, selects distinct reference classes.

Let us focus again on the distinction between theoretical or explanatory contexts and observational contexts. Perhaps one of the most crucial differences between both kinds of contexts is the fact that they are moved by different epistemic interests. While an observational context is mainly focused on the collection and order of the phenomena, a theoretical context is focused on their interpretation and explanation. This does not mean, of course, that neither interpretation nor explanation play any role in observational contexts. It neither means that in theoretical contexts there is no interest concerning the importance of data collection and organization. Considering the relevance structure mentioned above, we may say that the set of interests that corresponds to an observational context usually differs from the interests corresponding to a theoretical context either regarding their elements or regarding the order of their elements.

Consider now novelty, one of the main features of emergent properties. The novelty of an emergent state can be taken to be a second order property assigned to a phenomenon that can also be expressed by some description. We may view novelty as follows:

*Novelty*. Let $f$ and $g$ be two sets of observed phenomena, ordered in a sequence, such that $f$ is observed earlier than $g$. Let us further assume that the source of $f$ and $g$ is a single system $s$. If $P$ is a property that, from the perspective of a certain context $K$, one can observe in $g$ but one cannot observe in $f$, we call $P$ a novel property of $s$ in $K$.[11]

Let $F$ and $G$ be expressions that represent $f$ and $g$ within some data context $K_\phi$. Let $p_\phi$ be a probability function based on $K_\phi$, that may operate on expressions referring to observations. We may express in a very simple way that $g$ was unexpected given $f$, from the perspective of $K_\phi$, in this manner:

$$p_\phi(G|F) < p_\phi(\neg G|F).$$

Novelty may also be called *observational unexpectability*. As should be clear later, observational unexpectability differs from *explanatory unexpectability*. Emergent states involving novel properties can also be considered novel, if the appropriate focus is on that property.

Note that we could not have constructed the description $G$ before having observed $g$. Thus, in a certain sense, we are stating that we would not have expected to observe the property $P$ when we were observing $f$.

Of course, the fact that $P$ is a novel property according to $K_\phi$ does not preclude the possibility of explaining its appearance on the basis of $F$ from the perspective of a distinct context $K_\theta$, which may include the information needed to carry out such an explanation. Thus, given a function $p_\theta$ operating on propositions, it is perfectly possible that

$$p_\theta(G|F) > p_\theta(G|\neg F).$$

Furthermore, novelty is compatible with functional reduction of states, which can be characterized, in an epistemic sense, as follows:

*Functional reduction*. Let $e$ and $b$ be a pair of states described by $E$ and $B$ respectively. State $e$ is functionally reduced to $b$, according to $K_\theta$, if and only if the following holds for every $X$ in $K_\theta$.

(i) If $p_\theta(E|X) > p_\theta(E|\neg X)$, then $p_\theta(B|X) > p_\theta(B|\neg X)$.

(ii) If $p_\theta(X|E) > p_\theta(X|\neg E)$, then $p_\theta(X|B) > p_\theta(X|\neg B)$.

In other words, $e$ is functionally reducible to $b$ just in case the causal powers of $e$ are part of the causal powers of $b$.[12] Note that functional reducibility does not establish that the causal powers of $b$ must be part of the causal powers of $e$. The compatibility between the novelty and the functional reducibility of emergent states can be understood by noting that some emergent state $e$ could be novel on the basis of a set of observations that does not include any of the states causally related to IT. Again, the distinction between $K_\phi$ and $K_\theta$ is crucial. Many emergent processes such as economic crises and ecological changes may be novel and reducible in this sense. Furthermore, even although some state $e$ may turn out to be novel on the basis of a set of observations that include the causes of $e$, those causes may not be considered as such according to $K_\theta$.

I have mentioned earlier that novelty is closely related to complexity. But how close are they related? Roughly, it is very plausible to put it as follows. Suppose that $r$ and $s$ are two systems. The number of parts and interactions that constitute $r$ is higher than the number of parts and interactions that constitute $s$. Let us assume that this is enough to establish that $r$ is more complex than $s$. Then, it is more likely to find novel properties observing $r$ than observing $s$.

Another important feature of emergent properties is their unexpectability with regard to the constituent elements of the system in which they arise. This kind of unexpectability is not necessarily observational unexpectability, as the one that allows us to characterize the novelty of an emergent state. Rather, it may be better understood as explanatory unexpectability.

Let $K_\theta$ be an explanatory context. We may characterize the explanatory unexpectability of an emergent state as follows:

*Explanatory unexpectability*. According to $K_\theta$, $e$ is unexpected given $b$ just in case $p_\theta(E|B) < p_\theta(\neg E|B)$, where $E$ is the description of $e$ according to $K_\theta$ and $B$ the description of $b$ according to $K_\theta$.

Explanatory unexpectability expresses the fact that one cannot expect (or could not have expected) the occurrence of a certain emergent state within a system merely on the basis of a description of the physical constituents of that system. We may introduce two special types of explanatory unexpectability, causal unexpectability and unpredictability. Causal unexpectability can be characterized in the following way:

*Causal unexpectability*. According to $K_\theta$, $e$ is causally unexpected given $b$ just in case

(i) $E$ and $B$ describe the already observed phenomena $e$ and $b$, *respectively*, and
(ii) $e$ is explanatorily unexpected given $b$.

Unpredictability can be understood as follows:

*Unpredictability*. According to $K_\theta$, $e$ is unpredictable given $b$ just in case $e$ is explanatorily unexpected given $b$, where $E$ is the description of the not yet observed phenomenon type $e$ and $B$ the description of the observable phenomenon $b$.

This notion of unpredictability captures appropriately the way in which emergent states are usually considered to be unpredictable from mere descriptions of the physical constituents of the system in which they arise.

Now, let us consider again the *contribution thesis*. We may reformulate it as follows. Let $e$ be an emergent state described by $E$, $b$ be the set of the lower-level constituents of $e$ (described by $B$) and $K_\theta$ the theoretical context in which they are described. Let $F$ be the description of a state that is appropriately considered as a causal effect of both $e$ and $b$, such that, according to $K_\theta$,

(i) $p_\theta(F|E) > p_\theta(F|\neg E)$ and
(ii) $p_\theta(F|B) > p_\theta(F|\neg B)$.

Furthermore, the expectability of $f$'s occurrence (the effect described by $F$), given $E$ and $B$, is higher than its expectability, given only $E$ or only $B$.

(iii) $p_\theta(F|E\&B) > p_\theta(F|\neg E\&B)$ and
(iv) $p_\theta(F|E\&B) > p_\theta(F|E\&\neg B)$.

This set of inequalities shows in which sense emergent states can be explanatory relevant. Of course, this does not show that the explanatory power of $E$ is completely independent of the explanatory power of $B$. However, the irreducibility of $e$ cannot be discarded either. Note that the inequalities are not trivial. Strong reductionists try to show that $e$ and $b$ are identical, which implies the triviality of the first set of inequalities. And (iii) should be an equality according to reductionism, assuming that high-level descriptions are not necessary to explain effects that can already be explained on the basis of low-level descriptions. Reductionists cannot conceive (i) as an inequality either, if we assume that it is a way of expressing (iii), for instance, including $B$ in $K_\theta$.

Note that, since causation is a special case of explanation, as defined in Section 4, the contribution thesis implies the possibility of downward causation, under the appropriate assumptions. Such assumptions express, basically, that the explanantia and the explananda are referred to observable phenomena.

Although I am not focusing on the metaphysical aspects of downward causation, the notion of realization may provide a basis to do that. Sydney Shoemaker (2007) tackles the problem of downward causation in terms of property realization. Roughly, a property $Q$ is realized by a property $P$, if and only if $Q$'s causal powers are a subset of $P$'s causal powers (see also Wilson 2009). Thus, by assumption, high-level properties can have causal powers that are distinct from the causal powers of the low-level properties that realize them. On the basis of the present work, the interesting aspect of this is not related, I think, to whether realization is the key for developing an account of downward causation, but to the fact that realization may be considered as a metaphysical notion projected from functional reduction, together with appropriate, additional conditions, assumed within particular epistemic contexts. And, of course, metaphysical downward causation may be projected from epistemic downward causation.

## 5. Contextual irreducibility

We may consider now reduction on the basis of the concepts introduced in the preceding section. The reduction of one description to another can be understood as follows:

*Contextual reducibility*. A state $a$ is contextually reducible to another state $b$ just in case there is at least one relevant explanatory context $K_\theta$ according to which $a$ is functionally reduced to $b$.

In other words, $a$ is reducible to $b$ just in case there is a relevant context in which $A$ plays the same explanatory role as $B$. It is easy to see here, if one focuses on condition (ii), in which sense the reduction of a state $a$ to a state $b$ implies that $a$ is not explanatory primary according to $K_\theta$.

On the basis of this notion of reducibility, there is a relevant sense in which descriptions of emergent states are irreducible to descriptions of the constituent elements of the system in which they arise.

*Contextual irreducibility of emergent states*. Let $e$ be some emergent state of a system constituted by a set $b$ of basic elements and let $E$ and $B$ describe them, respectively.

The state $e$ is contextually irreducible to $b$, just in case there is at least one relevant explanatory context $K_\theta$, according to which the explanatory role of $E$ is not played by $B$ (i.e. is not functionally reducible to $B$).

Thus, the sense in which emergent states are irreducible is the following. Although there might be an explanatory context in which the causal role of the emergent states is also played by the constituent states, there might be a distinct relevant context in which they do not.[13] An emphasis should be made on the relevance notion, which I understand simply as epistemic relevance for the moment. I shall come back to this later.

## 6. A way to tackle Rosenberg's criticism

We may now reconsider Rosenberg's argument against physicalist antireductionism in the light of the notions characterized in the previous sections. Let $B$ be a set of molecular descriptions about a particular activation of the Eyeless gene in a fruit fly and $F$ be a set of non-molecular descriptions about the corresponding particular process of eye formation in that same fly. It seems plausible to claim that $F$ may be autonomous with regard to $B$ in some contexts. Thus, there is at least one context $K_\theta$ and a state $E$, such that, from the perspective of $K_\theta$, $E$ is explained by $F$ but not by $B$.

Roger Hardie and Kristian Franze (2012) studied the rapidity of the Drosophila's eye movements in cellular terms. One of their main results is the fact that the rapid opening of light sensitive channels in the fly's photoreceptors is explained on the basis of the membrane's contraction rather than by describing a molecular process. Light exposure causes contraction of the photoreceptor cells modulating their activity. Also, membrane stretch contributes to photoreceptor light responses, affecting the molecular activity of light-sensitive channels. Thus, main elements of the explanation are grounded on the mechanical changes of the membrane. This seems to be a good example of both the autonomy and the explanatory primacy of a non-molecular state.

Let $C$ be a description of the characteristics of the membrane associated with its rapid contraction. Suppose that the underlying molecular processes, including the developmental processes, are described by $B$. Let $N$ be a description of the non-molecular mechanism responsible for $C$. Now, the crucial point is the following. There does not seem to be any subset of $B$ that is, alone, more relevant for explaining $C$ than $N$. This shows the explanatory autonomy of $N$. Additionally, $N$ determines $C$ by affecting some subset of $B$. This shows the explanatory primacy of $N$.

The notion of emergence is particularly relevant here, allowing us to shed some light on the relations that hold between the considered descriptions. An event $e$, involving some characteristic described by $C$, could also be seen as an emergent state.

It is a state that arises as a result of the increasing complexity not only of the whole development of the organism, but also of the biological processes interacting with the environment. A fly's single rapid response to some particular visual stimulus can be considered a state that emerges from all those kinds of processes.

Let $E$ be the description of $e$ and let us consider the novelty of the ability described in $E$, that is, the ability to react extremely fast to visual stimuli. We cannot deny that $e$ arises, partly, from the complex, molecular processes involved in the fly's eye development described in $B$. However, from the perspective of an observational context $K_\theta$, $e$ might be novel (i.e. observationally unexpected) with regard to $B$:

$$p_\phi(E|B) < p_\phi(\neg E|B).$$

In other words, we would not have expected to observe the particular state described by $E$ just by observing the set of processes described by $B$. Furthermore, $e$ is causally unexpectable and unpredictable on the mere basis of $B$, according to some explanatory context $K_\theta$:

$$p_\theta(E|B) < p_\theta(\neg E|B).$$

Note that there may be a pair of contexts, one observational and the other one explanatory, such that $e$ is observationally unexpected but causally expected and predictable. Political crises and accidents of different sorts may provide good examples of such cases. Earthquakes, which may be considered to be part of another class of emergent states, are also especially interesting. According to our common scientific and ordinary contexts, earthquakes are observationally unexpected, unpredictable, but causally expectable, under certain conditions.

Considering again the case presented by Rosenberg, we can also claim that the non-molecular description of the fly's eye development, described by $F$, is irreducible to the underlying molecular processes, described by $B$: following the study of Hardie and Franze, there does not seem to be any relevant explanatory context, according to which both $F$ and $B$ are together necessary to explain $E$, the description of a fly's extremely rapid visual reaction. One of the main reasons is, again, the fact that $E$ is fundamentally explained in terms of cellular membrane contraction rather than in molecular terms. Furthermore, there is no context at all in which a purely molecular description could explain a fly's particular visual reaction. Of course, this does not preclude the fact that some part of $B$ may explain $F$ or even the contraction mechanism that causes $e$.

The argument just considered shows in which sense non-molecular descriptions can be autonomous and explanatory primary over molecular ones. Of course, there are kinds of states that are better (and perhaps only) explained in molecular terms, as Rosenberg shows. But this does not mean that the autonomy and primacy of non-molecular states cannot be expressed with regard to other kinds of states that are not reducible to molecular descriptions.

The importance of the notion of context is also emphasized by Manfred Laubichler and Günter Wagner in their response to Rosenberg's argument:

> Any identification of causally relevant parts (such as cells or molecules) is an active, informed decision by the researcher that ideally reflects the context-dependent selection of objects by the biological processes themselves. Hence, we have to justify in every instance whether a particular object, such as a specific molecule or gene, actually performs a useful role in a mechanistic explanation. In many instances molecules are the relevant entities, for instance in explanations of cellular metabolism, but to *a priori* assume that they always have to be the relevant level of description is to adopt a metaphysical position contrary to proper scientific conduct (Laubichler and Wagner 2001, p.60).

The construction of causal explanations depends on the decisions of researchers. In other words, it depends on particular epistemic contexts. A key idea pointed out by Laubichler and Wagner at this point is the fact that although explanations based on molecular mechanisms are acceptable in many contexts, there are contexts in which explanations that do not involve molecular terms may be relevant and acceptable.[14] It would be against proper scientific conduct to assume that explanations based on molecular terms are relevant for every context of investigation.

Let us now focus again on Rosenberg's criticism against physicalist antireductionism. The case of the Drosophila only suggests, as he admits, that non-molecular processes have little explanatory force in developmental biology (Rosenberg 1997, p.448). Of course, this does not threaten the explanatory primacy that non-molecular processes. For physicalist antireductionism does not promote absolute primacy. According to it, non-molecular processes are *sometimes* involved in the best explanations, that is, for some contexts. As I have tried to argue, this also holds for emergent states in general.

We should also avoid understanding the autonomy of non-molecular processes and of emergent states as an absolute feature. Emergent phenomena are considered to be autonomous for some explanations, for some contexts and according to some of their properties. The autonomy thesis should not establish that they are strongly autonomous, that is, autonomous in every aspect and in every context. Autonomy is not an exceptionless rule, but a possibility. And that possibility is enough to support anti-reductionism.

Rosenberg acknowledges that, in order to provide a solid criticism against physicalist antireductionism, one would have to show that the irreducibility of non-molecular processes is not absolute and that non-molecular processes never provide the best explanation for molecular processes (1997, p.463). As I tried to show, absolute irreducibility is not the best way of characterizing emergent states. But arguing for contextual irreducibility (and for contextual reducibility at the same time) should not affect antireductionism. Now, regarding explanatory primacy, it is hard to support the idea that there are no relevant epistemic contexts in which non-molecular processes provide appropriate explanations for molecular processes. I tried to show that there are such contexts.[15]

Rosenberg considers the possibility of treating explanation as a pragmatic process that may vary depending on particular belief systems and admits that if causation is just explanation, the causal efficacy of emergent states is plausible (1997, p.467). In some sense, I have explored such a possibility in this work. He criticizes this move claiming that although it allows for reconciliation between physicalism and downward causation, it does not suffice for antireductionism, because antireductionism must be interpreted in either a non-pragmatic way or according to a notion of explanation that depends on causation. It should be clear, on the basis of the proposed notion of contextual reducibility, that I do not think that this criticism is correct.

Rosenberg argues then that even if one accepted antireductionism in its pragmatic form, it would not be compatible with the physicalist fundamental idea that explanation depends on causation (1997, p.468). I would answer to this focusing on the plausible distinction between token physicalism and causal physicalism. On the one hand, according to token physicalism, every particular entity is a set of physical entities (cf. Fodor 1974; Papineau 1996). On the other hand, according to causal physicalism, every causal event must be characterized in terms of physical events or processes (cf. Dowe 2000). I admit that this distinction presupposes, somehow, that causation cannot be merely characterized in terms of physical processes. A causal physicalist might claim that, precisely because every particular process is a set of physical processes, the causal relation can be characterized as a physical relation. But we do not have to accept causal physicalism. And if one rejects causal physicalism, one may still be able to endorse some moderate form of token physicalism.[16] For instance, we might claim that not every process is a physical process, while claiming at the same time that every particular event is a set of physical events, or that processes are not particular entities, while still claiming that all particular entities are sets of physical entities. Thus, in principle, there is no conceptual incompatibility between pragmatic antireductionism and token physicalism. The latter does not imply that explanation depends on causation. Rosenberg's criticism can only mean that pragmatic antireductionism is incompatible with causal physicalism. But physicalist antireductionism does not have to be limited to causal physicalism. This means that Rosenberg's criticism fails to damage physicalist antireductionism (generally conceived) as well as the pragmatic notion on explanation.

The previous discussion may be considered as an answer to one of the issues pointed out by Jaegwon Kim about emergence. As he claims, an appropriate account of emergence should clarify in which sense the causal efficacy of emergent states is independent of the causal efficacy of its constituent parts. I tried to show that the study on the Drosophila's vision (Hardie and Franze 2012) provides a relevant basis for tackling Kim's demand about the clarification of causal efficacy. I will tackle his demand on the necessity of providing a positive characterization of emergence in the following section.

## 7. A positive aspect of emergence

I think that one cannot provide a completely positive notion of emergence. Nevertheless, we can include a positive element as a condition of its characterization. This is possible if we let a door open for reduction. Emergent states are reducible, in principle, to processes involving physical quantities and, in this sense, have a positive, scientific feature. Of course, irreducibility must have an open door too. It is important to emphasize that the notion of contextual irreducibility is an epistemic notion and not a metaphysical one, in the sense that whether a state (a metaphysical item) is irreducible depends on our descriptions about it (epistemic items). In what follows, I will propose a characterization of emergence based on that notion of irreducibility and, thus, the idea of emergence I will defend is an epistemic one as well. As I will try to make clear, this does not mean to defend a subjectivist notion of emergence. That emergence is context-dependent does not imply that all that matters are individual whims and opinions. Of course, it may be that, according to the context of one single person, some state is emergent, while for many others it is not. Giving an account that allows us to determine who is wrong and who is right in absolute terms would be too simplistic. Rather, we need an account that shows us why that state is emergent according to that single person and why it is not so for many others. Furthermore, we need an account that tells us which of those contexts is more appropriate, given certain research goals. I will do my best to pursue this challenge.

We can define the emergence relation as follows:

*Contextual Emergence*.[17] A set of states $e$ emerges from a set of states $b$, according to a theoretical context $K_\theta$, just in case the following conditions hold.

a) According to some observational context $K_\phi$, $e$ involves novel properties with regard to the properties involved in $b$.
b) According to some relevant context $K_1$, $e$ is functionally reduced to $b$.
c) According to $K_1$, the system involving $e$ has increased its complexity in a way that is correlated with the appearance of novel properties.
d) According to some relevant context $K_2$, $e$ is irreducible to $b$.
e) $K_\phi$, $K_1$ and $K_2$ are accessible and relevant from the perspective of $K_\theta$.

On this basis, we can define the notion of an emergent state, emergent property and emergent phenomenon. An *emergent property* is the relevant novel property observed in a set of states involved in some case of emergence. An *emergent state* is a state involving an emergent property. *Emergent phenomena* are emergent states, considered from a given observational context. Alternatively, Mark Bedau (2002) proposes to explain the notion of an emergent property first and then extend the notion to emergent phenomena and entities.

This notion of emergence should support the contribution thesis: Although it is possible to conceive a context in which the emergent state is reduced to its constituents, from the perspective of the more general epistemic context, the emergent state can provide additional information about its effects.

The notion is a positive and illuminating one in the sense that it is not merely based on negative and obscure conditions such as irreducibility and supervenience. Of course, it involves irreducibility and may imply supervenience somehow, which is appropriate, considering that, traditionally, they are understood as necessary conditions. However, the definition also involves observation and reduction as relevant features, which are associated with empirical and scientific virtues, such as confirmation, prediction and replication.

The characterization just proposed assumes that there can be different levels of epistemic contexts. Attributions of emergence do not occur on the level on which states can be rendered as reduced or irreducible, but on a higher contextual level. Contexts of a low contextual level can be considered (i.e. can be referred to) from contexts of a higher level. Usually, contexts of a high hierarchy are theoretical contexts, such as contexts according to which we compare scientific theories. Here, "theoretical" is not opposed to "practical" or "normative", but to "observational". Thus, theoretical contexts may involve descriptions of normative principles, interests and goals.[18] A simple way to order contexts is based on the notion of *aboutness*. In this sense, one context $K$ is accessible from another context $K'$ just in case $K'$ involves descriptions that refer to or are about $K$. Usually, observational contexts can also refer to other contexts, but their hierarchy is generally not as high as the hierarchy of many theoretical contexts. For any two contexts $K$ and $K'$, the hierarchy of $K'$ is higher than the hierarchy of $K$, if $K'$ refers to $K$ but $K$ does not refer to $K'$.

It is also important to emphasize that although irreducibility is assumed as a necessary condition for emergence, it is not absolute, but contextual irreducibility.[19] Actually, the irreducibility of emergent states is as crucial as their reducibility. A state is emergent precisely because there is a context in which the constituents of the system in which it arises are relevant for its considered causal role. An absolutely, in principle irreducible high-level state would not count as an emergent process. Some religious notions of a soul could be good examples of this. On the other hand, an absolutely reducible state cannot count as emergent either. This may be the case of the notion of temperature understood in terms of molecular kinetic energy.

Recall that the relation between a context and the contexts that are accessible to it is an aboutness relation and not a relation that mainly depends on content. If it were a content-dependent relation, to describe emergent states in terms of the definition just given would always imply a contradiction: State *e* would have to be both irreducible and reducible according to $K_\theta$. Alternatively, one may claim that, since $K_1$ is accessible from $K_\theta$, the definition implies that a state *e* is emergent only if *e* is reducible according to $K_\theta$. The definition of emergence would turn into a contextualist definition of reducibility. But this does not follow having in mind that the relation I am considering is an aboutness relation: Not every sentence that holds for accessible from $K_\theta$ holds also for $K_\theta$. Whether *e* is reducible or not within $K_\theta$ may be indeterminate. But even then, there might be two relevant contexts on which $K_\theta$ is focused, such that one of which renders *e* as reducible, while the other renders it as irreducible.

Requiring an observational context for the characterization of emergence is crucial, at least for three main reasons. First, it allows us to distinguish the notion of emergent state from the notion of emergent phenomenon. To illustrate the importance of the latter, one can think of how tornados and interesting patterns in data sets are not only things that arise from the elements of a system, but also things that strike us, while arising, when we observe them. We see them emerging, independent from how we explain them theoretically in other epistemic contexts. Second, we need properties considered in observational contexts to be correlated with the increase of complexity described in a theoretical context. Note that the theoretical increase of complexity is not enough to determine whether a state is emergent or not. One could describe how the complexity of interacting air molecules increased over time to characterize a tornado, but only by pointing at them as an object, i.e. as a whole, can we consider the tornado as emergent, i.e. as something novel. The third main reason is directly associated with Kim's demand that a good theory of emergence should provide a positive characterization of the concept. As acknowledged above, there is hardly a way of giving a fully positive and empirical account of emergence. But there is a way of defining emergence that is based on empirical conditions and observational contexts allow us to include such conditions into our account.[20]

We may further illustrate the characterization of emergence just provided by considering how perception emerges from brain activity on different levels. We may focus on three (cf. Freeman 2007):

> *Microscopic level*. Raw sense data impression is represented by microscopic neuron spikes.
> *Mesoscopic level*. On the basis of the activity occurring on the microscopic level, spatiotemporal patterns of wave packets are generated.
> *Macroscopic level*. Local, mesoscopic activity generates states that involve major parts of the brain hemispheres.

It seems plausible to say that mesoscopic brain activity can be reduced to microscopic, neural activity, under particular conditions. However, the patterns generated at the mesoscopic scale might involve or be considered to be novel properties of the brain that play a relevant explanatory role and are thus irreducible, under given epistemic conditions. They are relevant for explanations of macroscopic activity. Considering this, mesoscopic brain states are emergent states. Now, they can also be considered a possible reductive basis for macroscopic states and, in a distinct epistemic context, the latter may be rendered as novel and irreducible. This shows in which sense brain states involved in the macroscopic level may also be rendered as emergent states.

# 8. Possible objections

I would like to consider now possible objections against the account defended here. First, I will show that the proposal offers an interesting and non-trivial notion of emergence. I will also try to clarify in which sense could contextual emergence be compatible with an ontological view on emergence. Then, I will briefly insist on the benefits related to the contextualist idea of reduction, as well as on the relevance of novelty and complexity.

## 8.1. Weakness and triviality

One may criticize the proposed definition of emergence arguing that it is too weak and even trivial, that emergence occurs as soon as there is some irreducibility according to some contexts and some reducibility according to others. As a response, we should note that the mere possibility of reduction in one context and of reduction in another is not sufficient, together with novelty, for emergence. Everything must be considered from a broader theoretical context $K_\theta$, which should involve certain criteria of relevance, according to which some contexts might be included or excluded. Thus, condition (d) guarantees non-triviality for the definition of emergence provided here.

Consider the following case in order to illustrate this. Let $e$ be the fact that some object $a$ has a certain mass. According to $K_{\theta_1}$, $e$ might not be reducible to other sets of states in any relevant epistemic context. Mass is not an emergent property in $K_{\theta_1}$ and, of course, there is no emergence involving $a$. Now, suppose that according to $K_{\theta_2}$, a context focused on mass generating mechanisms, there is a set of states $b$, to which $e$ is in principle reducible. Let $K_\phi$, $K_1$ and $K_2$ be accessible from $K_{\theta_2}$. Suppose that $e$ is reducible to $b$ in $K_1$, but is irreducible to $b$ in $K_2$. If the generation of mass can be considered novel on the basis of an observational context $K_\phi$, then, according to $K_{\theta_2}$, mass is an emergent property and $e$ is an emergent state that arises from $b$.

Here is another example. Any feature of a rabbit could be studied phylogenetically and ontogenetically as an emergent property. However, if we wanted to identify rabbit individuals for a population study, the characteristic features of rabbits would not be considered emergent properties. Probably, there would not be any relevant context according to which descriptions of those features could be reduced. Additionally, those features would probably not be rendered as novel properties either. These cases show that the notion of emergence proposed above is not trivial and that there is a clear sense in which some properties are non-emergent.

Is contextual emergence too weak? Well, it is clearly not a notion of strong emergence (cf. Bedau 1997; Chalmers 2006). A state is strongly emergent if it is not reducible even in principle. By contrast, it is proposed in this work that states must be reducible in principle to be considered emergent. Thus, contextual emergence is weak emergence. According to Mark Bedau's notion of weak emergence, a state $A$ is weakly emergent just in case it can be derived from a set of microstates $B$ and some conditions but only by simulation. As contextual emergence, Bedau's definition also requires reduction, considering that reductions are necessary for performing simulations. Now, although contextual emergence might be seen as some kind of weak emergence, it is in a certain sense less demanding than Bedau's: One can have emergent states even if they are reducible in ways that are different from simulation. Actually, according to the contextualist definition proposed in this work, emergent states must be functionally reducible. However, Bedau's notion can be included in the contextualist account as follows. A set of states $e$ emerges from another set of states $b$ according to a certain context $K_\theta$, if $e$ involves novel properties in some accessible context $K_\phi$, $e$ is functionally reducible to $b$ in some accessible context $K_1$ and, according to another accessible context $K_2$, $e$ is reduced to $b$ but only by simulation.

Something more must be said about relevance. It cannot be determined in an absolute way, but by the broadest contexts that guide an investigation, depending on the interests that constitute them. This does not mean that the choice of relevant topics has to be question-begging or trivial. A group of economists, for instance, may not be interested in how a particular economic crisis turned out to be surprising and related to an increase of complexity of some part of the economy under investigation. Instead, they might be only focused on the explanation of the crisis and on how it could have been predicted. Maybe, once they explain it, the crisis will not be conceived as emergent according to that group of economists, because the epistemic context on which they base their investigation may no longer focus on contexts in which it is irreducible. Such contexts are not relevant to them. Now, whether their decision allows for a good understanding of economic crises or not may be questioned from broader contexts (for example, political, sociological, philosophical or more inclusive economic contexts). Again, this is not a form of subjectivism. It would be, if there was no way of determining, according to a broad context of intersubjective knowledge, whether economic crises are better understood as emergent or as fully predictable processes. I believe that there is a way and it is not a matter of individual, subjective set of opinions and tastes.[21] This also holds for other cases of emergence. Of course, contexts are contingent. Whatever may have been the nature of the explanatory epistemic contexts for the assessment of an emergence relation, these contexts could have been different. But this does not mean that we cannot find, among the available contexts being considered, the ones that suit better our epistemic interests.

Epistemic explanatory contexts also vary with time and across different cultures or scientific communities. It is consequence of the account of emergence offered in this paper that a state that is emergent with respect to some context $K$ could have been understood as not emergent under a different epistemic context of assessment $K'$. Also, the same state can change from being emergent with respect to $K$ to be non-emergent, if $K$ changes. So, for example, the same phenomenon emergent in the 19th century could become reduced to its base during the 20th century. The same phenomenon can be emergent for a scientific community, and at the same time can be reducible to its base for a different independent scientific community. Is this a reason to reject the proposal? I think it is not. If we are confronted with a choice problem between two incompatible contexts, we are already considering them from a context that is of higher generality than the contexts under comparison. Nothing, in principle, precludes the possibility of choosing the best context from such a general perspective. The notion of context hierarchy introduced earlier allows this. Now, what guarantees the objectivity of the general context according to which we make the choice? This is briefly discussed in what follows.

## 8.2. Objectivity and ontology

As should be clear, the account proposed in this work does not characterize emergence as something that can be conceived in a purely objective fashion. To determine whether a state is emergent or not requires a quite special epistemic framework and the present proposal is an attempt to satisfy such a requirement, offering a contextualist notion of emergence. Nor is emergence conceived here in a purely subjective way. Again, the present proposal is contextualist, not subjectivist. Considering this, one may still demand an account of the non-epistemic aspects of emergence. What are emergent states? What is their nature? Which are their ontological aspects? This is not the same as asking what their objective aspects are. The view I assume is that the ontological aspects of emergence depend on its objective aspects. This assumption opposes the realist principle, according to which we may arrive at objective and true descriptions of nature if we look right at what there is (cf. Devitt 1991, Sankey 2008). Instead, following a method proposed by Quine (1948), I suggest focusing on the implications of our best and most objective epistemic contexts concerned with emergence and, according to them, determine what are its ontological aspects by fixing corresponding reference classes. Each epistemic context is associated with certain commitments that allow us to fix an ontology (or sets thereof).[22]

Given the contextualist account presented, we may postulate a level-based ontology. Statements of some contexts may depend asymmetrically and generally on statements of other contexts. On this basis, entities postulated by the former could be considered as less fundamental than entities postulated by the latter. For instance, relevant statements of contexts focused on cellular biology may be explained by statements of contexts focused on molecular biology, without there being an important and predominant explanatory dependence of the latter on the former. This may support the idea that a molecular ontology must be more fundamental than a cellular ontology. Molecules would be at a lower-level with respect to cells. Regarding this kind of level-based ontology and postulating ontological reduction relations from epistemic reduction relations as well, we may be committed to emergent states as states that are ontologically reducible to some levels but irreducible to others.

However, as Elizabeth Barnes (2013) rightly argues, the ontological commitments associated with emergence are, in general, opaque. She shows that a fundamentalist ontology can help to solve some longstanding issues about emergence that are often associated with a hierarchical, level-based ontology. According to a level-based ontology, non-fundamental things can be related in a hierarchical way, depending on their degrees of fundamentality. For instance, according to such an ontology, even if molecules can be conceived as derivative entities (i.e. as not being absolutely fundamental), they may be seen as more fundamental than cells. By contrast, according to a fundamentalist ontology, we fix a set of fundamental entities and claim that everything that is not fundamental exists in a non-hierarchical way thanks to being grounded on the fundamental. Cells and molecules would correspond to the same level, i.e. the level of entities that are derived from the fundamental ones. Together with this distinction, Barnes distinguishes the concept of fundamentality from the concept of dependence. She considers both concepts as primitive and, doing so, she does not offer analyses of them. However, she suggests to characterize them as follows. On the one hand, fundamental entities are the kind of entities from which entities of other kind are derived. If you have all the fundamental entities, you will get all the rest. On the other hand, dependence is the relation according to which some things cannot exist without other things. Barnes focuses on strong, ontological dependence, which should be distinguished, as she argues, from weak, causal dependence. A thing $b$ may be causally dependent on another thing $a$, without being ontologically dependent on $a$. Entity $b$ depends, in a strong sense, only on the things existing alongside $b$, without which $b$ could no longer exist. Barnes's example is clear (2013, p.880): Someone's existence depends causally on that person's parents, but, in a strong sense, it is not the case that at every time at which that person exists, that person's parents must also exist.

With these distinctions in mind, Barnes proposes a notion of ontological emergence that can be defined as follows (2013, p.884):

*Ontological emergence*. An entity $x$ is ontologically emergent from a set of entities $y$, if and only if $x$ is fundamental, but dependent on $y$.

For example, living things are fundamental, but they are not independent from simple things arranged in a certain way. In this sense, a cell is fundamental, but it still depends on molecular processes to exist. This characterization of emergence could help to solve some of the main problems usually related to emergence, such as the problem about the causal efficacy of emergent states.[23] How can emergent states have causal powers over and above the causal powers of the physical? According to Barnes (2013, p.895), this problem is consequence of a commitment to the levels ontology, as well as to causal physicalism. Recall that, according to the latter, all causation can be explained by the physical. And the physical is the fundamental, following the hierarchical ontology. But we can still claim, as Barnes argues, that all causation can be explained by the fundamental, without assuming that the set of physical things is the fundamental. Emergent states are fundamental states that may not be physical, according to her account. Although she does not offer a detailed account of how emergent states should be considered as fundamental,[24] I think such an explanation could be given within the present contextualist framework. I will now explore this very briefly, focusing on Barnes's discussion about gunky ontology.

It may seem that Barnes's perspective is radically distinct from mine. She proposes an ontological account on emergence, while I propose an epistemic account. This would be, however, too simplistic. There is a way to put them together coherently, having in mind the clarifications on objectivity made earlier. Barnes claims that a gunky framework may be seen as a substantial motivation for adopting her account of emergence. I do not only agree, but I think that an epistemic, contextualist framework like the one defended in this work could lead to a gunky ontology. In a gunky ontology there are no indivisible components and any kind of entity can be fundamental. According to Barnes, a defender of gunk could maintain that some kind of objects (e.g. electrons) and the parts that compose them are fundamental or that different kinds of things are, such as electrons and living beings (2013, p.889).

According to the contextualist account of emergence proposed here, we may find different epistemically fundamental elements in each context. For example, in observational contexts, (terms for) observable properties, experiences and phenomena in general are fundamental. From each of those contexts we may postulate corresponding entities to construct an ontology. Thus, if I have the experience of color red according to some context and if that context deserves enough relevance, I may postulate something such as the color red. That ontological property will be fundamental, according to that particular context. Nevertheless, it does not have to be an independent property. We can tell a story about how sentences regarding color experiences can be explained in neuroscientific terms. But, of course, we would need a neuroscientific context and an appropriate epistemic context to establish the relevant explanations. Then, we may postulate our ontologies about neural and emergent processes from the basis of the relevant theories and descriptions.[25]

Here, my aim has not been to argue that the contextual account of emergence implies a fundamentalist ontology. Actually, as pointed out, the account is also compatible, in principle, with a level-based ontology. It does not assume it, for sure. Furthermore, nothing precludes the possibility of starting with a level-based epistemology and ending up with a fundamentalist ontology (or vice versa). I just wanted to show here that the epistemic character of the proposal defended in this work does not obstruct the way towards an ontological account of emergence. It is mainly a matter of selecting suited epistemic and scientific contexts.

## 8.3. Contextualism and reductionism

Another objection against the concept of emergence proposed in this work might be based on questioning its effectiveness against Rosenberg's criticism, arguing that an epistemological perspective cannot be assumed to oppose arguments that involve ontological assumptions. Particularly, one could argue that an epistemological notion of reduction cannot be assumed against Rosenberg's arguments, because he is already assuming a stronger sense of reduction. Considering this, a contextual account of emergence would be innocuous against reductionism.

As a response, we should think, first, that proposing contextual emergence and showing its plausibility can indeed be seen as an argument against such sense of reduction. This is actually one of the aims of this work. Second, even defending an epistemic notion of emergence, we might agree with Rosenberg in the following: In many epistemic contexts, non-molecular states are neither autonomous nor explanatory primary with regard to molecular states. However, this does not imply that non-molecular states cannot be considered autonomous and explanatory primary in any scientifically interesting context. This prepares the way for illuminating notions of irreducibility and emergence.

## 8.4. Novelty and complexity

One may also criticize that novelty is not enough to say that emergent states arise from the increasing complexity of a system, as one may want to ensure. There might be cases in which novelty is produced simply on the basis of changes in the epistemic context, i.e. it is possible, in principle, to observe a novel property in a system that has not changed drastically with regard to its constitutive parts. I agree with this worry and think that such cases do not involve emergence. Even considering an epistemic notion of emergence, emergent states do not arise just because one takes a better look. This is another reason why we should include contextual reduction and complexity as necessary conditions for emergence. When emergent properties arise, the number of interactions between the parts of a system increases according to a reductive context. The following example may illustrate this. Suppose that we understand friendship as an emergent property that may arise between two persons. According to a reductive context, the system constituted by those persons might just have changed regarding the number of interactions between them. If, additionally, novel, irreducible properties are observed and considered from the perspective of different contexts, then we might establish that those properties are emergent. But, of course, in other scenarios, one might just come to realize that two persons have a special relationship without there being a relevant increment of interactions between them at the reductive level. This would not be a case of emergence.

## 9. Conclusion

The concept of emergence is not easy to define. The reasons for this are grounded on its link to the notions of reduction and causation. How can emergent states be causally relevant if they are irreducible? Furthermore, how can we view emergence in a positive way if irreducibility is the main feature of emergent states? These questions were approached in this work with a focus on a case considered by Alex Rosenberg on the basis of which he criticizes physicalist antireductionism. I have argued that the irreducibility of emergent states does not have to be absolute and propose a contextualist notion of irreducibility. In this sense, contextual irreducibility can be compatible with contextual reducibility. This is crucial for providing a characterization of emergence that involves a positive element: Emergent states are states that are reducible and irreducible at the same time, but from the perspectives of different epistemic contexts.

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## Notes

[1]The classical notion of emergence differs considerably from notions of emergence defined in terms of complexity. As explained later, the classical notion, which requires mainly irreducibility and supervenience, is not complete. I will explore how a condition regarding complexity might help us to establish a better and more complete definition, while retaining at the same time the spirit of traditional accounts. It should also become clear later that a definition of emergence based on complexity will not be enough unless it requires conditions related to irreducibility and supervenience.

[2]That bridge laws establish identities does not mean that they always hold a priori. Many identities involved in cases of derivational reduction have empirical grounds and hold, therefore, a posteriori.

[3]Robert Van Gulick (2001) offers a clarifying, critical revision of metaphysical and epistemic accounts on reduction.

[4]Kim also emphasizes the importance of explaining how downward causation is possible. I will not focus particularly on the notion of downward causation, but on the more general problem of clarifying in which sense emergent states can be causally efficacious at all. Settling this issue would surely help to clarify the possibility of downward causation.

[5]Generally, I will use lower-case letters to symbolize ontological items, such as states or events, and upper-case letters to symbolize descriptions thereof. I will focus later on the relation between ontology components and epistemic components.

[6]Two states playing distinct causal roles may be part of different systems. It may also be that both are part of the same system, but that the high level state is independent from the states that physically constitute the system, such that the former cannot be considered to be emergent from the latter. Perhaps some religious notions are good examples of this.

[7]A distinction can be made between causation as difference-making and physical causation (cf. Ney 2009). For the present purposes, any account of causation as difference-making would be appropriate. In this work, the main reason of my preference of causation as difference-making over physical causation is that the former can be applied to different levels of specificity and abstraction, while physical causation is either constrained to physical properties or to some notion of fundamental specificity.

[8]Causation can be understood as the relation holding between events described in a special case of explanation. This can be seen as one of the "controversial moves" considered by Rosenberg (1997, p.466). According to this move, causation depends conceptually on explanation. I agree that it may be controversial for the physicalist, but it does not have to be controversial for the antireductionist.

[9]The work of Robert Stalnaker (1999; 2014) provides deep approaches regarding the idea of context, speech and related matters, which may support the proposal developed here. A study of how his analyses could be compatible or incompatible with the present account is, however, beyond the scope of this work.

[10]Following his arguments, there does not seem to be an absolute principle on the basis of which we should prefer in every situation the narrowest reference class. Reductive physicalists might think that there is.

[11]Here, it is not relevant whether $P$ could have been observed in $f$, if the conditions had been different. Surprises depend basically on particular experiences and this characterization is based on that idea. Of course, novelty is not a sufficient condition for emergence.

[12]The reducing predicate involved in this sort of reducibility could be a disjunction of the properties that can realize the reduced property. Thus, multiply realized properties can be functionally reduced (cf. Melnyk 2003). A deeper discussion on the compatibility between multiple realizability and functional reduction is beyond the scope of this article.

[13]In a very general sense, this proposal is consistent with the results of Daniel Steel's (2003) argument in favor of the compatibility between reductionism and pluralism in biology, which is based on the importance of context, the levels of explanation and the goals of each particular inquiry.

[14]Of course, the fact that explanatory contexts determine which are the relevant variables to be considered in explanations does not imply that the correctness of explanations depends purely on those kinds of contexts. One may argue that we would still need to contrast expla-

nations with the world in order to evaluate whether they are true or not. According to the contextual account presented here, however, we do not have to assume this kind of correspondence. The notion of observational context is important here: Whether an explanation is correct or not depends on its correspondence with the relevant observational contexts.

[15]Further support of this can be found in the works of Laubichler and Wagner (2001), Kirschner and Gerhart (2005), and Brigandt (2010).

[16]Whether token physicalism is correct or not is far from the main topic of this work.

[17]The term "contextual emergence" is used by Harald Atmanspacher (2015; see also Bishop and Atmanspacher 2006 or Harbecke and Atmanspacher 2011) in the framework of a very illuminating and detailed account of epistemic emergence. I will not compare here different accounts of emergence that are based on the notion of a context. However, I think that the main features of Atmanspacher's approach are compatible with my characterization of emergence, which is more general and less developed. One of the main differences between his account and the one presented here is the fact that in the former there is no particular focus on the normative aspects that constitute epistemic contexts, while in the present proposal normative items such as preferences and theoretical aims are crucial. Other interesting account is the one proposed by Samuel Fletcher (2020), who characterizes emergence as relational and contextual. According to him, whether a property is emergent or not depends on how it is involved in a similarity structure construed on the basis of a set of models. His proposal involves the notions of relevance and representational overlap in key aspects of the characterization of emergence and is, thus, in line with mine.

[18]Interests and goals may depend on broader contexts, perhaps practical or social contexts. I will not focus in this work on how these are determined, but only assume that they are important parts of observational and theoretical contexts.

[19]Jeremy Butterfield (2011) also proposes an account of emergence that is compatible with a strong sense of reduction (i.e. reduction as deduction). Whether some emergent behavior is reducible depends on a set of parameters associated with the system being described. Clearly, this does not mean that his account is reductionistic. However, neither reduction nor irreducibility are essential features of emergent properties according to his characterization, which is rather mainly based on novelty and robustness.

[20]Intersubjectively comparable observational contexts are grounds for scientific measurement. Regarding the importance of measurement and considering different attempts to establish measures of complexity (cf. Peliti and Vulpiani 1988; Gell-Mann and Lloyd 1996), it is relevant to mention that the notion of complexity also contributes to the possibility of measuring some aspects of emergence and, therefore, to address the need for their positive characterization.

[21]This is in line with main assumptions of empiricist and pragmatist traditions (cf. Hempel 1983; Chang 2017). However, the present proposal does not represent a radical empiricist account. The consideration of theoretical contexts allows us to admit the relevance of rationalist methodology as well. What may be a pure conjecture in one context could be a firm conclusion in another.

[22]This is in line with the proposal developed by Charbel Niño El-Hani and Sami Lindström (2002) on emergence and pragmatic realism.

[23]Barnes considers further benefits of her proposal, such as how it deals with the understanding of non-reductive physicalism and with the ontological seriousness of emergent entities.

[24]Barnes argues for the fundamentality of emergence mainly providing general remarks and some examples. When considering the example of living beings, she supports their fundamentality simply claiming that these entities have special properties and irreducible causal powers.

[25]If I just focused on a single observational context, without associating it with other contexts, I could arrive at a sort of solipsism. I would not have reason to think that the experience of red, for example, depends on neural and physical processes.

## Acknowledgments

I am particularly indebted to Alan Baker, André Fuhrmann, Harald Atmanspacher, Karen Crowther, Miguel Fuentes, Oscar Orellana, Peter Baumann, Raúl Fuentes, Robert Van Gulick, Ronald Durán, Rubén Herzog, and Samuel Fletcher for their insightful comments on ideas proposed here, as well as to the support of the Chilean Commission for Scientific and Technological Research (CONICYT; FONDECYT projects #3160180, #1181414 and #11180624).