

# Rethinking Cohesion and Species Individuality

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**Abstract** According to the species-as-individuals thesis (hereafter S-A-I), species are cohesive entities. Barker and Wilson recently pointed out that the type of cohesion exhibited by species is fundamentally different from that of organisms (paradigmatic individuals), suggesting that species are homeostatic property cluster kinds. In this article, I propose a shift in how to approach cohesion in the context of S-A-I: instead of analyzing the different types of cohesion and questioning whether species have them, I focus on the role played by cohesion in the identity of individuals. This shift allows us to recognize why cohesion matters to S-A-I, as well as to reconceive the analogy between species and organisms (paradigmatic individuals), and also allows us to highlight the context sensitivity of both “cohesion” and “individuals.” From this perspective, I identify two problems in Barker and Wilson’s argumentation. Firstly, the authors fail to recognize that species are individuals even if they do not have the same type of cohesion that organisms have. Secondly, their argument relies on a misinterpretation of S-A-I. I conclude that species cohesion is still best framed as a feature of species individuality rather than a feature of species as homeostatic property cluster kinds. The arguments presented here contribute to the re-articulation and reevaluation of S-A-I in the face of contemporary discussions.

**Keywords** Classes · Cohesion · Homeostatic property cluster kinds · Identity · Species

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## Introduction

Four decades since its first articulation, the species-as-individuals thesis (hereafter S-A-I) is now widely accepted among philosophers of biology (Ereshefsky 2010). An influential defense of this thesis is due to Hull, who established a contrast between two types of entities: *individuals* and *classes* (1976, 1978). Hull proposed that individuals are entities localized in space and time; entities with a beginning, an ending, and a particular history (1976, p. 177). Individuals are also “cohesive wholes”—each of them is an independent unity composed of organized parts (1978, p. 370). Hull treats biological organisms as “paradigmatic individuals” since they exhibit the distinctive features of individuality, namely: spatiotemporal localization, historical continuity, and cohesion. In contrast, classes are not localized in space and time. *By themselves*, classes also do not have a beginning, an ending, and a history in between. Moreover, classes have members, not organized parts, and are defined according to properties necessarily possessed by all members. For example, the property “having the atomic number 79” is what defines the chemical class “gold” (1978, p. 375). The instantiation of this property is necessary and sufficient for a thing to be considered a member of that class.

Hull argued that species are individuals rather than classes (1976, 1977, 1978, 1999). His argument begins with the idea that organisms are paradigmatic individuals and then establishes an analogy between organisms and species, concluding that species are also individuals. By clearly exemplifying the distinctive features of individuality, organisms serve as analogues to evaluate whether species are individuals or not. From this perspective, Hull’s analogical reasoning can be phrased as follows: *if* species are sufficiently analogous to organisms (in having the

distinctive features of individuality), *then* they should be considered individuals.

Hull argues that species, as understood in evolutionary biology, are sufficiently analogous to organisms. Species have a history, usually starting with the splitting of an ancestor population (i.e., speciation), then proliferating and changing continuously through time until an endpoint (i.e., extinction or a new speciation) (1978, p. 369). Thus, species exist in space and persist through time, as organisms do. Hull also claims that species have cohesion through processes such as gene flow, homeostasis, and common selection pressure, which contribute to the cohesion of each species (1978, p. 370). More simply, such processes contribute to the organization of organisms and populations in reasonably discrete and independent entities called “species.” This is analogous to biological and chemical processes contributing to the organization of different parts in discrete organisms.

Hull’s argument for S-A-I has been challenged in various ways by several authors (Boyd 1999; Dupré 2001; Crane 2004; Wilson et al. 2007). A recent criticism by Barker and Wilson (2010) focuses on the idea that individuals are cohesive entities, exploring its consequences for the analogy between species and organisms.<sup>1</sup> According to the authors, Hull implies that individuals have integrative cohesion, which is present in organisms and should also be present in species (Barker and Wilson 2010, p. 64). However, Barker and Wilson (2010, pp. 76–77) find that species do not typically have integrative cohesion and, therefore, cannot be individuals in Hull’s sense.<sup>2</sup>

Barker and Wilson defend the alternative characterization that species are *homeostatic property cluster kinds* (hereafter HPC kinds). A HPC kind is a class jointly defined by a cluster of properties, and a cluster of their causally underlying mechanisms (Boyd 1999, pp. 143–145). Each member of a HPC kind instantiates a relevant set of properties and mechanisms within those clusters. However, in contrast to the above-mentioned traditional notion of “classes,” all members of a HPC kind do not need to instantiate the *same* properties and mechanisms. This allows the existence of variation among such members. At the same time, those members still share many properties and mechanisms (Boyd 1999, p. 142). Hence, by treating species as HPC kinds, Barker and Wilson assume that they are discrete and independent entities insofar as conspecific organisms have many

properties and mechanisms in common (2010, p. 77). Such organisms are not understood as “organized parts” of distinct “cohesive wholes,” but as members of (non-traditional) classes. So defined, the theory of HPC kinds is currently not only the main alternative to S-A-I nowadays, but HPC also avoids Hull’s dichotomy between individuals and classes (Wilson et al. 2007).

In this article, I show how the relation between cohesion and individuality should be understood, indicating why Barker and Wilson’s positions are not tenable. Firstly, I reconstruct the concept of “cohesion” according to Hull and Barker and Wilson, and some of its historical antecedents (in the next section, “Defining Cohesion”). Secondly, I propose a shift in the debate concerning S-A-I (“The Theoretical Role of Cohesion in Individuality” section). Until now this debate has focused on the types and causes of cohesion, discussing whether species do have it. In contrast, I understand the need of focusing primarily on the *theoretical role* that cohesion plays in individuality more generally. This shift allows us to recognize why cohesion matters to S-A-I in the first place, as well as to reconceive the analogy between species and organisms (paradigmatic individuals), and to highlight the context sensitivity of both terms, “cohesion” and “individuals.” My central thesis is that cohesion has the theoretical role of providing *identity criteria* to individuals. This thesis is supported by Hull’s work and some recent approaches to individuality (e.g., Hamilton et al. 2009; Ereshefsky and Pedroso 2015). Thirdly, I develop two criticisms of Barker and Wilson’s position. The first criticism is that Barker and Wilson’s reasoning fails to capture the relation between cohesion and individuals properly (“Barker and Wilson’s First Mistake” section). As I show, the authors do not recognize that species can be individuals even if they do not have integrative cohesion. The second criticism is that Barker and Wilson misinterpret Hull’s argument, failing to meet its original target (“Barker and Wilson’s Second Mistake” section). I conclude that species cohesion is still best characterized by assuming that species are individuals. In doing so, I am not so much concerned with the defense of S-A-I, but with its re-articulation in the face of contemporary debates.

## Defining Cohesion

Discussions about cohesion are frequent in biology since the Modern Synthesis, in particular due to the work of Mayr (1963, 1970). Mayr highlights the role of gene flow (defined as the flux of genes due to reproductive events within populations or migration among populations) in the formation and maintenance of a species. According to him, species are composed of local populations sharing genetic

<sup>1</sup> Barker and Wilson’s (2010) paper focuses mainly on the role of gene flow on species cohesion, arguing against the idea that gene flow is the main cause of cohesion. Here I am interested only in their criticism of Hull, which appears at the end of their paper.

<sup>2</sup> An obvious way to block Barker and Wilson’s criticism is to claim that cohesion is not a necessary feature of individuals. This view is adopted by Ghiselin (1997), and I will briefly discuss it later in the article.

resources (or capable of sharing them). This sharing promotes the stabilization and coadaptation of genes within the boundaries of a species, leading to a considerable degree of genotypic and phenotypic similarity among conspecific organisms (Mayr 1963, pp. 521–522). By promoting similarity among such organisms, gene flow causes them to behave and change in similar ways due to similar evolutionary pressures (Barker 2007, p. 655). In this context, some biologists define species cohesion as the tendency of conspecific populations to evolve in similar ways through time, i.e., the tendency of conspecific organisms to express similar changes across generations (Wiley 1981, p. 75).

During the second half of the 20th century, biologists have highlighted many causes of species cohesion beyond gene flow, such as demographic change, common selection pressure, and homeostasis (Ehrlich and Raven 1969). The term “cohesion” has become a way to describe a generic product of such different causes, namely, species being fairly recognizable and independent entities in nature. This use of the term seems to have contributed to its looseness but also to its spreading throughout the literature. For instance, the wider use of such a term in the 1980s was mainly due to the work of biologist Alan Templeton, who has explored the concept of cohesion in an attempt to solve the so-called species problem (Templeton 1989). With this aim in mind, Templeton has equated cohesion to genetic and phenotypic similarity, claiming that such a similarity is at stake whenever biologists talk about species (1989, pp. 168–169). In the last 50 years, a considerable part of Templeton’s research has been dedicated to species cohesion and its genetic and phylogenetic analysis (Templeton 2001).

Some recent studies on species systematics and phylogeny follow on Templeton’s track, aiming at the delimitation of “highly cohesive” species (Vinuesa et al. 2005; Bond and Stockman 2008). In such studies, the term “cohesion” refers to genetic similarity within single species. If we contrast this use of the term with previous ones, we can notice slight differences. Some biologists have been using “cohesion” as a generic term, making reference to evolutionary tendencies and/or to products of different causes. Other biologists add more precision to such uses in order to make them useful for the actual recognition of species. These biologists appeal to phylogenetic and genetic analyses of similarity, for example.

In the 1970s, Hull began to apply the term “cohesion” in a philosophical context (Hull 1976). Instead of discussing species cohesion and its causes straight away, he firstly maintained that *individuals* are cohesive entities. But it is difficult to understand what Hull means by individuals having cohesion, especially because he describes it abstractly as some form of organization among the parts of

an individual (1976, 1978). After all, what does “organization” mean? In Hull’s works, sometimes “organization” makes reference to the causal connection among parts of an individual, but sometimes it makes reference to *external* causes acting independently upon each of such parts (Hull 1976, pp. 183–184). It is not clear what makes both types of organization instances of cohesion. Furthermore, the characterization of organisms as “paradigmatic individuals” does not help to clarify Hull’s approach to cohesion. He describes cohesion in organisms as “internal organization,” but he is not clear about whether this “internal organization” implies any of the types of organization mentioned above (Hull 1978, pp. 371–374). Additionally, he is also not clear about how this “internal organization” applies to individuals that are not organisms.

In a classic paper, Hull discusses cohesion in the specific context of natural selection (1980). He makes reference to his early distinction between individuals and classes, emphasizing that individuals in natural selection are cohesive entities. Then he distinguishes two types of cohesive entities: “functional wholes” and “structural wholes” (1980, p. 314).<sup>3</sup> The first type refers to *interactors*, entities that interact with the environment “as a whole.” Interactors are cohesive entities in the sense that their parts have different but complementary functions. Such functions are responsible for the viability of the “whole,” promoting activities that guarantee the existence of that “whole” (e.g., a heart’s function of pumping blood is important to a human organism’s existence). Furthermore, functions are responsible for the ways in which the “whole” interacts with the environment. The second type of cohesive entities discussed by Hull refers to *replicators*, entities that replicate indefinitely through generations. These entities are cohesive in the sense that each of them has a specific structural (material) composition that is faithfully copied through generations.

By the end of the 1980 paper, Hull discusses a different type of individual, namely: *lineages*. This type of individual is not part of the selection process (in contrast to replicators and interactors), but it is a result of such a process. Populations and species are examples of lineages and, therefore, cohesive entities (Hull 1980, p. 327). However, what does it mean for a species to be a cohesive entity? To answer this question, Hull refers to the works of Wiley and Mayr. He suggests that species are reasonably independent units composed of populations and have a tendency to evolve similarly due to processes such as gene flow (Hull 1980, p. 328).

Recently Barker and Wilson (2010) have offered a different treatment of cohesion, proposing a distinction

<sup>3</sup> This distinction is inspired by—but also slightly different from—Dawkins (1976).

between two types of cohesion (see also Barker 2007; Wilson et al. 2007).<sup>4</sup> On the one hand, *responsive cohesion* is the unitary behavior of an entity produced by its components responding similarly to common external stimuli. For example, a neighborhood has responsive cohesion after a power cut if the neighbors independently call the electricity company to complain about the cut. The unitary behavior of the neighborhood is due to each of the neighbors behaving similarly in the face of a single common external stimulus—the power cut (Barker and Wilson 2010, p. 64). On the other hand, *integrative cohesion* refers to the unitary behavior of an entity produced by causal interactions among its components. Imagine that, in the face of the power cut, neighbors exchange ideas and organize a protest. Each neighbor does not need to behave similarly to create a protest. Instead, they causally relate to one another and generate a unitary behavior (i.e., a protest) that could not exist in the absence of this relationship. In sum, the behavior is produced by causal interactions among components, instead of being a mere sum of independent responses (interactions) of each component to the environment.

The distinction between responsive and integrative cohesion has allowed Barker and Wilson (2010) to analyze both species and organism cohesion. The authors evaluate the analogical reasoning of Hull, relying on some textual evidence according to which Hull claims that species and organisms have the *same type* of cohesion (Hull 1977, p. 93). Barker and Wilson question whether both species and organisms have integrative or responsive cohesion. This question underlies their criticism of Hull, as well as their defense of the theory of HPC kinds. However, before I discuss Barker and Wilson's positions, I will approach the concept of "cohesion" from a new angle. I will put the traditional concerns about different types and causes of cohesion aside and focus on the theoretical role that the concept of "cohesion" has in individuality.

### The Theoretical Role of Cohesion in Individuality

As a traditional topic in metaphysics, identity raises many questions in contemporary philosophy (Noonan and Curtis 2014). One such question concerns *identity criteria*, i.e., the issue of what makes a particular entity the very same entity it is. More technically, such criteria should provide a well-grounded standard to evaluate whether and why an entity is numerically identical to itself (Lowe 2003, p. 73). By the same token, these criteria provide a standard to

evaluate whether and why an entity is numerically different from others. It consists of defining what an entity has to be in order to remain the same—what prevents this entity from being something else.

The issue of identity criteria can be refined in at least two different issues (Lowe 2003, p. 90). Firstly, there is the issue of *synchronic* identity, which evaluates whether an entity at time T' is identical to itself at the same time-slice T'. This issue concerns the relation of "sameness" an entity has to itself at a specific point in time. Secondly, there is the issue of *diachronic* identity, which refers to whether an entity at time T' is identical to itself at a different time-slice T". This issue concerns the identity of an entity over time, inquiring about the standards to evaluate the persistence of the same entity through different periods of time. Both issues about identity criteria are traditionally discussed in relation to individuality in metaphysics (Strawson 2002; Wiggins 1980). Like the arguments for S-A-I promoted by Hull, these issues usually focus on examples of "paradigmatic individuals," such as human beings and other multicellular organisms. Interestingly, just a few philosophers have paid attention to the connection between identity criteria and individuality in the context of S-A-I (Ereshefsky 2001).

Individuals were previously defined as spatiotemporally localized, historically continuous, and cohesive entities (see the "Introduction" section). Hull discusses the cohesiveness of individuals using biological examples (1978, p. 372). As he shows, organisms of the taxonomic groups *Hydrozoa* and *Scyphozoa* are capable of merging into one another, losing parts, and splitting into different living beings. These organisms defy our commonsense intuition about how to individuate things and raise questions about when an individual ceases to be that *same* individual. In this sense, Hull's examples illustrate how controversial it is to establish the identity of individuals. His suggestion is that the identity of an individual (in particular, its persistence over time) depends on how much of its organization is broken down (or still remains intact). Hence, an individual is the same individual only if its particular organization is not disrupted (Hull 1978, p. 373).

Hull describes cohesion very often as a sort of "organization" (1978, pp. 370–373). For this reason, I take him to be suggesting that the identity of an individual depends on the maintenance or "disruption" of its cohesion. Without such a cohesion there is no longer a single individual made of different parts, but just separate things. Hence, cohesion is what keeps things together into a single "whole," making them "parts" of a specific individual. These considerations lead me to conclude that the concept of "cohesion" plays an important theoretical role in individuality: it refers

<sup>4</sup> This distinction is not entirely new, but explicitly based on Mishler and Brandon (1987).

abstractly to *identity criteria* for individuals. Such a concept refers to whatever makes an individual the one and the same individual it is, indicating what this individual must have in order to remain the same individual. In the remainder of this section, I will clarify this theoretical role of cohesion.

The empirical means that promote species cohesion are described by Hull as *relations* (1978, pp. 370–374). In particular, Hull considers gene flow, homeostasis, and selection pressure as promoting species cohesion.<sup>5</sup> Gene flow is clearly a relational process since it refers to the migration and transmission of genes among organisms and populations (“[Defining Cohesion](#)” section). But what about homeostasis and selection pressure? Homeostasis is a process through which genotypes continue to produce the same well-adapted phenotypes in the face of environmental and genetic changes (Ereshefsky 2001, p. 115). Common selective regimes occur when members of the same species are exposed to the same selective pressure, thus having the tendency of exhibiting similar phenotypes and genotypes. So defined, both processes are relational ones, since they are based on relations between conspecific organisms and their environment.

To a certain extent, the aforementioned relations are analogous to the ones present in single organisms (paradigmatic individuals). The appropriate analogy between organisms and species is that the identity of both entities is based on *spatiotemporal relations*. Organs, systems, and structures within an organism are physically and biochemically interrelated. They causally interact, such that it makes sense to speak about the organism “as a whole.” If species are individuals, then their organisms and population must also be spatiotemporally related in a way that it makes sense to treat species “as a whole.” However, as I will argue later, the causal interaction among the “parts” is not the only way to establish spatiotemporal relations. For now, the important point is simply this: the identity criteria of individuals are based on such relations, whatever they may be. I claim that the term “cohesion” refers precisely to this general idea. When saying that an individual is cohesive, we are referring to the fact that its identity necessarily relies on part-whole relationships occurring in space and time. In sum, the role of that term is not only to refer to identity criteria for individuals, but also to indicate that such criteria are satisfied by spatiotemporal relations, whatever they may actually be.

<sup>5</sup> Sometimes Hull seems to associate the term “cohesion” only with synchronic identity (1976, p. 183). But it is necessary to be cautious here. First, Hull takes genealogical relations as providing species identity over time (see Ereshefsky 2014). In this sense, genealogy promotes cohesion. Second, the other aforementioned processes also occur over time. For these reasons, I attach “cohesion” to identity without relating it particularly to synchronic or diachronic identity.

In a recent paper, Hamilton et al. (2009) seem to endorse the described theoretical role of “cohesion.” These authors maintain that cohesion is a product of relations and is crucial to individuality. They coin the term *cohesion generating relationships* (CGRs) to encompass the type of relations “that binds the parts into a unified whole” (Hamilton et al. 2009, p. 575). These relations assure the unification of parts into a single individual, being a necessary condition for the existence/persistence of an individual as one and the same individual. Hence, the authors recognize the importance of cohesion as establishing identity criteria for individuals, but also suggest that such criteria rely on part-whole relationships occurring in space and time.<sup>6</sup>

According to Hamilton et al. (2009), the notion of CGRs works as a *placeholder* for the actual part-whole relationships capable of generating cohesion in individuals. These relations vary in nature and degree from one research context to the other (2009, p. 578). From this perspective, the concept of “cohesion” has some context sensitivity. This term plays a general role in individuality, but it is not capable of specifying the *actual* cohesive (part-whole) relations occurring in a certain individual—the actual CGRs (2009, p. 575). Such relations can only be specified in the face of a particular research context in which cohesion and individuality are being considered. Moreover, it is necessary to know which *kind* of individual is at stake in such a research context (2009, p. 577). For example, to discuss whether colonies are individuals, Hamilton et al. make clear the context in which the concept of “individual” should be understood, namely, individuals in natural selection (*units of selection*) (2009, p. 578). As I indicated above, this type of individual was even subdivided by Hull into two further types: replicators and interactors (cf., Godfrey-Smith 2009; Clarke 2010). Nonetheless, independently of how we frame it, natural selection is not the only research context where “individual” matters. For instance, individuality can also concern units in ecology, immunology, physiology, and elsewhere (Pradeu 2010; Huneman 2014; Ereshefsky and Pedroso 2015). This makes the general concept of “individuals” context sensitive.

<sup>6</sup> Hamilton et al.’s commitment to spatiotemporal relations as identity criteria for individuals is not explicit, but rather follows from another commitment they have: part-whole relations in individuals are empirical in nature and, therefore, should be understood by science. This point is also made by Haber (2015), who says that individual’s part-whole relations are not in agreement with classic mereology (the logical study of part-whole relations). In this article, however, I do not intend to discuss the nature of part-whole relations. The reference to such authors here is relevant only insofar as they conceive an individual’s identity as a matter of spatiotemporal relations and, as we shall see, treat “cohesion” as a context-sensitive term.

The context sensitivity of the concept of “individual” affects the context sensitivity of “cohesion.” This occurs because different kinds of individuals in different contexts require different kinds of part-whole relationships in space and time.<sup>7</sup> For instance, Hamilton et al. point out that physical integration, sociality, relatedness, and functional integration can produce a certain cohesion in colonies (2009, p. 578). These characteristics seem to make colonies good candidates for units of selection. Nonetheless, such characteristics are hardly enough to make colonies immunological units. The degree of physical integration required for an immunological unit is certainly higher than for a unit of selection (Pradeu 2010). Moreover, sociality seems not to be relevant to an immunological unit, but it can be for a unit of selection. These contrasts exemplify the variety of relations that can be associated with the term “cohesion.” More specifically, different relations are required at different research contexts to count as identity criteria for individuals in different contexts.

Taking the context sensitivity of “individual” and “cohesion” into consideration, the relation between cohesion and species individuality can just be understood when we have detailed the precise context of the latter. Hull’s argument for S-A-I draws on how species are described in evolutionary biology. As he pointed out in his 1980 paper, species are products of evolution (1980, p. 328). The way evolution proceeds entails a certain approach in how to characterize and classify them, i.e., a certain approach in systematics, which consists in treating species as genealogical lineages (e.g., Ereshefsky 2014). Hence, Hull’s position is thus that species are individuals in the sense that they are genealogical lineages *in systematics*. On the one hand, this position does not assume that species are individuals in natural selection (units of selection), in immunology or any other research context. On the other hand, it raises the question whether genealogical lineages should be considered individuals or natural kinds in systematics.

Hull’s argument for S-A-I depends fundamentally on his distinction between individuals and classes. As I noted in the introduction of this paper, individuals have parts, whereas classes (in the traditional sense) have members. Members of the same class need to share a common set of properties.<sup>8</sup> In contrast, parts of an individual need not

have properties in common but only need to be properly related in space–time. This relation can be one of causal interaction, but Hull has remained open about other sorts of relations as well (see above). By drawing the rough distinction between properties and relations, Hull was able to draw an equally rough analogy between organisms and species. He claimed that both organisms and species have parts, which are spatiotemporally related to one another.

The above contrast between individuals and classes can be better framed if we focus on the theoretical role of cohesion. On the one hand, the identity criteria for classes do make reference to properties shared by its members. To be one and the same class is to be defined by certain properties. These properties must be present within each one of its members. On the other hand, an individual’s identity criterion is based on cohesion: an individual is the same at a time and across time if it is maintained by certain spatiotemporal relations among its parts.<sup>9</sup> So understood, cohesion matters to S-A-I because it indicates how the identity of species in systematics is roughly conceived. This identity is a matter of a species’ organisms having certain spatiotemporal relationships (i.e., genealogy, gene flow, etc.), and not their sharing common properties that define a class.<sup>10</sup>

### Barker and Wilson’s First Mistake: Species-as-Individuals Without Integrative Cohesion

Now let’s turn back to Barker and Wilson’s position and analyze it based on the role of cohesion in individuality. As I described above, the authors make a distinction between integrative and responsive cohesion. The first is a product of causal interactions among the constituents of an entity, whereas the second is a product of constituents responding similarly but independently to a common external stimuli. Barker and Wilson claim that integrative cohesion—*not responsive cohesion*—is the distinctive feature of individuals (2010, pp. 76–77). They do not provide support for this claim but understand themselves as simply reproducing a claim originally made by Hull (I discuss this interpretation of Hull in the next section). The intuition behind such a claim is that organisms have integrative cohesion,

<sup>7</sup> The same type of context sensitivity in regard to “individuals” has been highlighted by Ereshefsky and Pedroso (2015). The authors point out that the sort of relation that matters for individuality depends on the particular type of individual being discussed (e.g., natural selection, systematics etc).

<sup>8</sup> Such properties are considered to be *intrinsic*, existing inside each member of a class (Wilson et al. 2007). Hence, in this traditional account of classes, relational properties are not allowed.

<sup>9</sup> I do not claim that cohesion establishes all the necessary and sufficient identity criteria for individuals, but rather that it establishes a necessary sort of identity criterion for them, namely, spatiotemporal part-whole relationships.

<sup>10</sup> Systematists rely on properties in order to diagnose species and to construct classifications. Notwithstanding, they usually imply that species are organized in terms of genealogical and reproductive relations (e.g., Simpson 1961; Hennig 1966). Such relations are examples of spatiotemporal part-whole relationships (see also Haber 2015).

being composed of organized parts causally interacting with each other, just like organs, systems, and other parts causally interact inside the human body. Different types of organisms, such as plants and bacteria, also seem to rely on causal interaction—they appear to us as somehow internally bounded due to physical and biochemical interactions.

Barker and Wilson argue that species do not typically exhibit integrative cohesion. They observe that species mostly consist of organisms and populations separated from each other due to subtle geographical, behavioral, and ecological barriers (Barker and Wilson 2010, pp. 66–67). Most conspecific populations and organisms are scattered over the globe, isolated by mountains and oceans, but also by geographically specific mating preferences and niche differences.<sup>11</sup> As a result, the authors claim that there are no *actual* causal interactions among all conspecific organisms and populations capable of generating integrative cohesion in the species “as a whole.”<sup>12</sup> Since Hull himself recognizes that most conspecific organisms and populations are isolated from each other, he would agree with Barker and Wilson: species do not typically exhibit integrative cohesion. From this perspective, the authors point out that Hull’s argument is intrinsically flawed (Barker and Wilson 2010, p. 77). Hull’s argument concludes that species are individuals, despite the fact that species do not satisfy a condition for individuality accepted by Hull himself.

Based on the theoretical role cohesion plays in S-A-I, I claim that Barker and Wilson’s reasoning is flawed. The idea that species are individuals only if they have integrative cohesion is wrong. To distinguish individuals from other ontological categories (e.g., classes), it is enough to say that individuals are cohesive entities without specifying the type of cohesion they have. *If* both integrative and responsive types are legitimate forms of cohesion in individuals (i.e., both highlight part-whole relations as promoters of the identity of individuals) and *if* alternative ontological categories do not capture any form of cohesion, then it is not necessary to say that species must have integrative cohesion to be individuals. Furthermore, since species are (responsive) cohesive entities, they are individuals. In this section, I defend this argument and give

reasons to accept its two central premises, namely: (1) like integrative cohesion, responsive cohesion highlights part-whole relations as promoters of the identity of individuals, and (2) alternatives to the category of “individuals” either fail to capture cohesion more generally or still cry out for philosophical analysis. In particular, I show that HPC kinds are still not adequate to capture the cohesive nature of species (cf. Wilson et al. 2007; Barker and Wilson 2010). I conclude this section by arguing that species cohesion is still best captured by S-A-I.<sup>13</sup>

Barker and Wilson (2010) define integrative cohesion as a product of causal interactions among the parts of an entity. The disruption of such interaction can lead to the “end” of that entity. In this sense, there is no doubt that integrative cohesion refers to part-whole relationships that promote the identity of individuals. But does the same conclusion apply to responsive cohesion? Responsive cohesion is a product of relations between certain elements and the environment. Therefore, it is relational. Nonetheless, responsive cohesion differs from integrative cohesion because no causal relation connecting the elements into a “whole” is presupposed. Given this difference, it is worth asking whether responsive cohesion is capable of establishing the identity of individuals.

To answer the question above, consider the case of species cohesion again. I agree with Barker and Wilson (2010) that species typically have responsive cohesion. Processes such as gene flow, common selective regimes, and homeostasis make conspecific organisms more likely to respond similarly to the same external stimuli (Sect. 3). But it is important to understand the nature of this stimuli-response relation. In fact, the relation between organisms and the environment is dynamic. Organisms and environment influence each other and this influence changes future generations of organisms and their environments. In this sense, the responses of both organisms and environment are interdependent and are part of feedback relations (also known as “reciprocal causation”) across time (Odling-Smee et al. 2003). The feedback relations between organisms and environment occur locally, usually on one geographic population. At this local level, such relations *can* rely on causal interactions among organisms, such as when gene flow occurs within a population or between geographically close populations. In such cases, the “global” responsive cohesion of a species can rely on—among other factors—locally causal interactions (i.e., “local” integrative

<sup>11</sup> Such differences can lead to further differentiation and speciation. Nonetheless, they are not enough to distinguish populations into different species.

<sup>12</sup> Two observations give more clarity to this claim. Firstly, Barker and Wilson assume that spatial isolation prevents the *biologically relevant* causal interaction (physical and biochemical) among conspecific organisms and populations. Secondly, Barker and Wilson admit that some species can have biologically relevant integrative cohesion (2010, p. 77). They argue that, even in these cases, integrative cohesion is not *typical* of those species.

<sup>13</sup> Contra Barker and Wilson, another line of reasoning could also be pursued here. It could be argued that many multicellular organisms are individuals even though they lack integrative cohesion. Interestingly, examples of such organisms—such as slime molds—were provided by Hull (1978). I thank one of the reviewers for pointing this out.

cohesion).<sup>14</sup> Genealogy is also an important factor for responsive cohesion since it assures the transmission of phenotypic and genotypic similarities. Such similarities reinforce the tendency of organisms to respond and affect the environment in similar ways. Considering all such ways to promote responsive cohesion, it is reasonable to conclude that this type of cohesion is grounded on spatiotemporal part-whole relationships that promote the identity of species. For instance, the disruption of such relations can lead to a new speciation event.

Barker and Wilson (2010) highlight the relational nature of both integrative and responsive cohesion and, I assume, would agree with me on the characterization of responsive cohesion. At the same time, the authors implicitly vindicate another difference between both types, namely, integrative cohesion relies only on some sort of causal or spatiotemporal relation, but responsive cohesion also relies on similarity (i.e., resemblance relations). In the case of species, to respond similarly to external stimuli conspecific organisms must be similar to each other—such organisms possess many traits in common (2010, p. 63). The presupposition of similarity also seems to be present in the example of the power cut (above). In that case, the neighbors react in the same way to the power cut because they share some similarities (e.g., politically, socially, economically, etc.).<sup>15</sup> Likewise, conspecific organisms show responsive cohesion at least in part *because* they are similar in certain respects, such as genetic resemblance.

If we agree with Barker and Wilson on the mentioned difference between integrative and responsive cohesion, it seems that we are forced to assume that species cohesion lacks an intuitive characteristic of individuals, namely, in

<sup>14</sup> As one reviewer has pointed out, the appeal to “local integrative cohesion” in species cohesion can blur the very distinction between integrative cohesion and responsive cohesion. This observation has important consequences, since it can suggest that the difference between integrative and responsive cohesion is a matter of degree not kind. I am sympathetic to this suggestion. Unfortunately, I cannot develop it here. At the same time, this suggestion does not affect my argument. Barker and Wilson claim that, to be individuals, a species needs to have integrative cohesion connecting *all* its organisms/populations (global integrative cohesion). I think *this* claim is wrong, but I remain neutral about the importance of “local integrative cohesion” to species cohesion. In this paper, whenever I use both “integrative cohesion” and “responsive cohesion” I am referring to the “global” versions of these theses.

<sup>15</sup> It must be recognized how limited is the example of the power cut. For instance, neighbors have to share some cultural similarity to be able to respond in a similar way to the cut. But this sharing seems also to be required for many causal interactions between neighbors as well (e.g., organizing a protest). Additionally, it is not clear how to individuate the “stimuli-response” chain. Is the power cut the only external cause leading to neighbors responding similarly on the occasion of a power cut? These problems make it hard to appreciate the complex relation between responsive and integrative cohesion, as well as their subtle differences and variations.

contrast to members of a class, parts of an individual are not (or need not be) similar to each other (see the introduction). Furthermore, it seems that we should ask ourselves whether, despite promoting the identity of individuals, responsive cohesion is an *exclusive* property of individuals. Barker and Wilson claim that it is not (2010, p. 77). In fact, they assume that integrative cohesion is an exclusive property of all individuals, whereas responsive cohesion is not. Ontological entities other than individuals also have responsive cohesion. For this reason, the fact that species have responsive cohesion is no guarantee that they are individuals. Barker and Wilson illustrate this point by saying that species (responsive) cohesion is captured by the theory of HPC kinds. In the remainder of this section, I show why Barker and Wilson’s point is not tenable.

The theory of HPC kinds is a well-known theory of natural kinds initially proposed by Boyd (1988). As described at the beginning of this article, a HPC kind is defined by the combination of two clusters. Firstly, there is a cluster of properties frequently co-instantiated by the members of the kind. Secondly, such properties (and their co-instantiations) are produced by underlying mechanisms, which are also frequently co-instantiated by the members of the kind (Boyd 1999, pp. 142–145). Each member of a HPC kind instantiates a particular set of properties and a particular set of mechanisms within those clusters. On the one hand, such members do not need to instantiate the very same properties and mechanisms. On the other hand, such members are still roughly similar to one another, once many properties and mechanisms are frequently correlated.

The theory of HPC kinds is taken to have many advantages over the traditional notion of classes (Boyd 1999, pp. 151–157). As described before, one advantage is that a HPC kind tolerates some variation of properties among its members. Another advantage has to do with the very nature of those properties/mechanisms. In contrast to traditional classes (e.g., gold), HPC kinds can have *relational* properties/mechanisms as part of their defining clusters (1999, pp. 153–154). For example, *if* species are HPC kinds, spatiotemporal relations such as genealogy, gene flow, homeostasis, and common selective pressure can be incorporated as parts of the clusters—either as properties or mechanisms (Wilson et al. 2007, pp. 23–24). Note that those relations are exactly the ones that Hull considers as causes of species cohesion. They are also exactly the ones that I considered spatiotemporal part-whole relationships or CGRs (see the previous section).

The prospect of incorporating spatiotemporal part-whole relationships in the definition of HPC kinds opens another possibility, namely, to treat the aforementioned causes of species cohesion as part of the definition of species as HPC kinds. In other words, such relations can figure as identity criteria for species as HPC kinds. This



possibility changes the whole debate about cohesion and S-A-I. According to the traditional distinction of Hull, the category of “individuals” was depicted as the only one capable of incorporating spatiotemporal relations as part of identity criteria for species. Therefore, this category seems to have a clear advantage over alternative categories in the debate about species’ ontological status. Nonetheless, once HPC kinds can incorporate that sort of relation in their definitions, they also seem capable of accounting for species identity. A consequence of this reasoning is that the appeal to species cohesion is not an argument for S-A-I over HPC kinds.

Ereshefsky and Matthen (2005) indicate that at least two of the main proponents of HPC kinds do *not* take spatiotemporal relations as identity criteria of such kinds and, therefore, cannot account for species identity. Boyd (1999) and Griffiths (1999) incorporate spatiotemporal relations in their approaches, according to Ereshefsky and Matthen, but they argue that such relations cannot replace the position of qualitative properties/mechanisms (i.e., those which give rise to similarity or resemblance relations) as the main criterion of identity of kinds in general (Ereshefsky and Matthen 2005, pp. 16–17). Whenever similarity and spatiotemporal relations clash, HPC kinds take the side of similarity. The problem with this is that, according to the majority of contemporary systematists, species identity is first and foremost relational (Ereshefsky 2010, p. 676). Biological systematists side with spatiotemporal relations, not with similarity. So, HPC kinds theory clashes with contemporary systematics by prioritizing similarity over those relations.

In their 2007 paper with Ingo Brigandt (Wilson et al. 2007), Barker and Wilson include different sorts of relations as possible identity criteria of HPC kinds. Their theory allows both spatiotemporal relations and qualitative properties/mechanisms to function as part of the definition of a particular kind. Once both are part of the definition, there is no privileging of one over the other (Wilson et al. 2007, p. 35). Implicitly the authors seem to assume that particular properties/mechanisms/relations do not contribute to the identity of a kind in isolation, but only do it in the context of a cluster. For example, if species are HPC kinds, their identity is established by particular clusters of properties, mechanisms, and relations *in combination*. Certain properties, mechanisms, and relations are part of a cluster, contributing to the membership of organisms to a specific species. Nevertheless, it makes no sense to discuss the isolated contribution made by each of these properties, mechanisms, or relations to that membership. As a result, the authors suggest that there is really no conflict between spatiotemporal relations and qualitative properties/mechanisms (i.e., similarity) within a cluster.

The reply offered by Wilson et al. (2007) is no solution to the conflict between similarity and spatiotemporal relations. For instance, consider when a population branches off from an original species (Ereshefsky and Reydon 2015, p. 978). For a considerable amount of time both resulting (isolated) populations still share many properties and mechanisms in common. Do organisms of both populations belong to the original species or not? Wilson et al. claim that the answer to this kind of question depends largely on empirical details about similarity (2007, p. 199). The problem with this reasoning is that, according to certain contexts in systematics (e.g., phylogenetics), there is no need for such a detailed empirical measurement about how similar organisms are. Such details can help taxonomists to identify separate species, but they are not the reason why such species are separate species in the first place. For instance, some models of speciation assume that the branching off demarcates the distinction between two species independently of how many properties they share (Ereshefsky and Reydon 2015, p. 978). Organisms are assigned to a different species according to branching off events, not according to a detailed empirical analysis of the properties/mechanisms shared by these organisms. Hence, Wilson et al.’s (2007) reply still entails that similarity matters more than spatiotemporal relations.

The theoretical role of cohesion described in the previous section demands that spatiotemporal relations have privilege over similarity as identity criteria of species. But, as I indicated, the theory of HPC kinds does not satisfy this demand. The result is that, up to the present moment, HPC theory is not equipped to capture species cohesion and its background role in species identity. The relational nature of species responsive cohesion is better captured by individuality. To sum up, species are good candidates for individuality, even if they don’t have integrative cohesion. In contrast to traditional classes and HPC kinds, the category of individuals is the one equipped to capture responsive cohesion.<sup>16</sup>

One last reply to my argument is to claim that, besides classes and HPC kinds, there are other alternatives to the category of individuals. This claim is indeed far from new and deserves more attention than I can give in this article. Categories such as “historical individuals” and “historical entities” have been proposed as ways to characterize species as “individual-like entities” without accepting Hull’s

<sup>16</sup> Spatiotemporal relations have priority over similarity in species cohesion, but it is still an open question whether species cohesion requires some degree of similarity. I remain neutral about the necessity of similarity to species cohesion. Nonetheless, my argumentative strategy here consists in showing that even if species have responsive cohesion in the precise way Barker and Wilson define, they are still individuals.

entire argument and, in particular, his use of the analogy with organisms (Wiley 1981; Ghiselin 1997; Ereshefsky 2001). Two considerations are worth mentioning about these alternative categories. Firstly, they still cry for philosophical analysis (Barker and Wilson 2010, p. 77). For example, these categories must deal with the issue of identity criteria, indicating which sort of conditions a particular entity must satisfy to remain that very same entity. Secondly, maybe such categories are not really alternatives to the category of “individuals” but subcategories or even supercategories of it. Some of the categories (e.g., “historical entities”) are defined as genealogical entities without cohesion (Ghiselin 1997). But are such categories *not* committed to cohesion? My approach in this article assumes that a way to make the notion of “cohesion” more clear and useful is to focus on its theoretical role. Broadly, cohesion refers to whatever spatiotemporal part-whole relationship promotes the identity of individuals. A more precise characterization of cohesion is only possible after we know the type of individual under study (e.g., immunological, individual in natural selection, etc.); different types of individuals require different types of spatiotemporal part-whole relationships. From this perspective, if we appeal to genealogy to define species as “historical individuals” or “historical entities,” then we are implicitly assuming that species are cohesive entities. Genealogy is a way to establish part-whole relationships that promote the identity of a species. Therefore, genealogy makes species be cohesive (Hamilton et al. 2009, p. 575).

The understanding of the precise theoretical role of cohesion helps us to make categorical distinctions, specifying what is distinctive about an individual’s identity. This specification allows us to evaluate the advantages and disadvantages of claiming that species are individuals rather than classes, HPC kinds, etc. For now, I think that the category of “individuals” is the most adequate to capture species cohesion. Other categories fail to account for species identity (cohesion) or are simply not clear about this issue. Nonetheless, I do not rule out the possibility of species being better understood by such “individual-like” categories in the future. What I do rule out is that species can be understood by means of a category that does *not* give priority to spatiotemporal relations over similarity and, therefore, that does *not* satisfy the theoretical role of “cohesion.”

### **Barker and Wilson’s Second Mistake: Misinterpreting the Species-as-Individuals Thesis**

My argument against Barker and Wilson in the last section is open to an immediate reply. Those authors could start by pointing out that their main concern is not to argue against

every characterization of S-A-I, but only against Hull’s analogical reasoning for it. Indeed, Barker and Wilson’s argumentation is a sort of *internal critic* of Hull’s reasoning: it reproduces (but does not accept) Hull’s argument only to point out its internal inconsistency. In this sense, Barker and Wilson could say that the above mistake I identified is a mistake made by Hull but not them. Since Hull is the one who allegedly thinks that individuals need to have integrative cohesion, he is the one who is mistaken. But this reply fails. As I am going to argue, Barker and Wilson misinterpret Hull’s original position.

It is true that Hull explores extensively the analogy between organisms and species, assuming that both entities are cohesive. In some passages, Hull even claims that organisms and species instantiate individuality “in a strong sense” and have “the same type of cohesion” (Hull 1977, p. 93; 1999, p. 32). But Barker and Wilson wrongly interpret that, according to Hull, “the same type of cohesion” means or entails *integrative cohesion*. This interpretation is not straightforward. For instance, if we consider Hull’s classic papers on S-A-I (1976, 1978), it is explicit that cohesion is not necessarily or exclusively a matter of causal interaction among the parts of an individual. In these papers, Hull argues that homeostasis and common selective regimes promote species cohesion. But, as we know, both processes act on conspecific organisms without requiring causal interactions among them (Ereshefsky 2001, p. 117). This could hardly have been overlooked by Hull since it follows from the very definitions of such processes (“The Theoretical Role of Cohesion in Individuality” section). Hence, *if* Hull requires species to have integrative cohesion, how could he even take homeostasis and selection regimes as promoters of cohesion in the first place? The problem for Barker and Wilson’s interpretation is to explain why Hull even considers those processes as leading to cohesion and individuality in the first place.<sup>17</sup>

Ereshefsky also does not interpret Hull’s notion of “cohesion” as necessarily referring to causal interactions among the parts of an individual (Ereshefsky 1991, 2001, 2014). He highlights that this notion abstractly refers to a certain “uniformity” or “common way of life” shared by organisms/populations of a species (1991, p. 89; 2001, p. 114). Ereshefsky suggests that integrative

<sup>17</sup> It could be replied by Barker and Wilson that Hull indeed overlooks that homeostasis and common selective pressure do not promote integrative cohesion. But this reply is based on a very uncharitable reading of the philosopher. Furthermore, it would ignore that Hull cites the work of biologists such as Ehrlich and Raven (1969), which shows the cohesive effects in isolated conspecific populations being exposed to similar selective regimes. Citations such as this rather suggest that Hull is aware of the fact that species cohesion need not imply causal interactions among conspecific organisms and populations.

cohesion is not implied by such abstract descriptions, making reference to some textual evidence to support his point (2001, p. 114; see Hull 1978, pp. 369–370). Taking such textual evidence into consideration, on many occasions Hull does not describe species cohesion as causal interactions among their organisms and populations (Ereshefsky 2001, p. 114; Hull 1978, p. 369). But *if* Hull requires species to have integrative cohesion, it is reasonable to expect that his descriptions of species cohesion would contain references to causal interaction. In other words, Barker and Wilson's interpretation must explain why Hull does not always describe species cohesion in terms of causal interactions among organisms or why he explicitly describes cohesion in noncausal terms. In agreement with Ereshefsky's interpretation, I assume that Hull does not provide such causal descriptions for a simple reason: Hull does not think that individuals need to be integrative cohesive entities.<sup>18</sup>

Barker and Wilson misinterpret Hull's ideas. For this reason, they fail to criticize the analogical reasoning proposed by him for S-A-I. Moreover, they relate a defense of HPC kinds with such a misinterpretation, providing a weak case for the HPC kinds.

## Conclusion

The concept of cohesion is an easy target to criticize. It is a general and abstract concept, especially when related to the philosophical context of S-A-I. In this context, David Hull's seminal work seems intriguing. His analogy between organisms and species opens the door to ambiguities, misinterpretations, and controversies surrounding the notion of cohesion. Taking such issues into consideration, I approached the concept of cohesion from a new angle, highlighting its theoretical role in individuality. This theoretical role can be traced back to Hull's work and is becoming clearer in contemporary debates about individuality (e.g., Hamilton et al. 2009; Haber 2013; Ereshefsky and Pedroso 2015). Here I took this theoretical role as a starting point for rethinking the relation between species cohesion and the S-A-I.

Barker and Wilson (2010) criticize how David Hull conceives species cohesion and individuality. In the last section, I argued that such criticism is not sound because it misinterprets Hull's original position. Putting exegetical issues aside, Barker and Wilson also build their argument on a wrong premise, namely, to be individuals, species must have integrative cohesion. My approach to the

concept of cohesion allowed me to attack such a premise. I showed that species fulfill the relevant role of cohesion in individuality (i.e., reference to identity criteria which are based on spatiotemporal part-whole relations), even though they are not integrative cohesive entities. I also showed that the theory of HPC kinds fails, since its present forms do not capture species cohesion correctly. Nonetheless, I am conscious that new reformulations of HPC or alternative categories can shift the argumentative landscape in the future. In this article, I did not aim to provide a complete and satisfactory defense of the S-A-I against HPC kinds and other alternatives. My primary aim consisted in rethinking the place of cohesion within the debate over individuality and species ontology.

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<sup>18</sup> Indeed, this is precisely what distinguishes Hull's understanding of individuality from Sober's (1993) understanding of individuality (see also Ereshefsky 2001, pp. 115–116).

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