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RESEARCH ARTICLE

Multiple Realizability and Disjunction for the Special Sciences

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Abstract: One way to secure the autonomy of special sciences like psychology is to block reductive strategies by assuming that higher-order properties in psychology are multiply realizable. Multiple realizability would then secure both metaphysical irreducibility and dependency by exploring the variety of ways in which higher-order phenomena can be realized in different systems. Originally, a promising way to understand this variability was in terms of the possible realization role played by property disjunction. However, the non-projectability of disjunctive predicates into explanatory generalizations undermines the multiple realizability strategy mainly because a condition for these generalizations to have scientific weight is that they be based on the existence of natural kinds. Traditionally, disjunctive properties have no reference to kinds. In this paper I explore the character of disjunctive properties as cases of homeostatic property clusters sufficient to be classified as genuine natural kinds, and the consequences for the question of the autonomy of the special sciences.

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1. Introduction

Since its introduction into the philosophy of mind (Fodor, 1997; Putnam, 1992), multiple realizability has focused on the conceptual relation between non-reducible properties and their physical realization by means of disjunctive property bases. The idea was to block type-to-type identities that were thought to be necessary to achieve the reduction of one property to another (Smart, 1959). The blocking strategy consists in combining the realization of higher-order properties with a *variability* in the ways in which that realization can be achieved. This variability can be thought of as sets of disjunctive properties satisfying a one-to-many realization relation between a target phenomenon and its explananda. Disjunction of properties amounts to the idea of physical components and their properties forming groups, the many part of the realization relation, held together through Boolean "OR" logical operator. The members of the group function as realization bases for other properties and most importantly membership is conditioned by variability such that one or more members can be replaced or added without that affecting their realization potential. By making use of sets of disjunctive properties, the proponents of multiple realizability want to make irreducibility and ontological dependence compatible with each other; higher-order properties like mental ones are ontologically based on their physical bases, but they are nonetheless properties of a different kind, which do not reduce to the latter (Clapp, 2001; Jaworski, 2002). The irreducibility of mental properties is then achieved through the kind of variability provided by disjunction which then is thought to effectively block type to type identities. That kind of variability in realization bases given by disjunction of properties represents then the multiple realizability character of higher-order properties. As a result, multiple realizability represents, metaphysically speaking, a case of non-reductive physicalism. Critics hold that multiple realizability is a flawed metaphysical project given that what first seemed to be a virtue in the use of disjunctive realizers – i.e., the use of disjunction to establish irreducibility – actually undermines the

coherence of the multiple realizability thesis itself (Dosanjh, 2021; Francescotti, 1997). Therefore, according to the critiques, disjunctive properties make irreducibility prima facie possible, but at the high cost of making multiply realized properties scientifically wild or unprojectable into explanatory predicates. That is, using disjunctive properties as the bases for establishing explanatory relations between physical bases and higher-order properties renders whatever predicates could be derived from those relations explanatory empty. Disjunctive properties cannot figure in explanatory frameworks, because explanatory generalizations cannot be based on properties whose inherent variability does not represent cases of *stable* natural kinds. Moreover, to the extent that multiply realized properties are part of the conceptual and explanatory frameworks of special science, this criticism would have implications for the integrity of those sciences as well (Bechtel and McCauley, 1999).

2. Disjunction of properties

A set of properties is disjunctive with respect to a higher-order phenomenon, such as a certain type of memory, if the properties in that set either play the defining functional role characteristic of it, or the set represents the actual physical constituents that make up the memory as such (Tonegawa et al., 2015). Further, the members of the set *vary* from time to time and so cannot be the same each time they happen to instantiate the same kind of higher-order phenomenon. Disjunction then means that the members of the realizing set can vary, and yet the memory remains the same by keeping properties presenting its functional and phenomenological integrity stable. Thus, we could illustrate the disjunctive relationship between e.g. a cognitive function such as episodic memory and the brain states responsible for its realization by means of the software/hardware metaphor for the mind-body relationship. For example, the memory of my tour of the Palazzo Pitti is disjunctively realized whenever different physical brain bases computationally implement the occupant role defining that memory, or the very presence of those physical brain bases materially constitutes the presence of that episodic memory (Quiroga, 2020, 2023; Suthana et al., 2021). The software here, i.e. the episodic memory of the tour, is realized by a disjunction

of brain states and their properties, i.e. the hardware. Importantly, episodic memory in general is regarded as a intelligible psychological phenomenon whose physical dependency yet cognitive autonomy from its brain bases is secured by the fact that the brain bases involved in the realization of the memory would vary from occasion to occasion either as functional role occupants or as physical constituents (Anderson, 2016; Colaço, 2022; Edelman and Gally, 2001; McCaffrey, 2023). Moreover, the character of this variability represents physical states extending both within and across individuals of the same and different species (Noppeney et al., 2004; Noppeney et al., 2006). In other words, realizing the same general property by disjunction involves individuals of different species and individuals within the same species (Minelli, 2019). Therefore, in the case of the memory of Palazzo Pitti, we could say that the identification of the set of disjunctive properties responsible for this higher-level phenomenon is tantamount to the identification of the physical causes responsible for its realization. Moreover, based on the disjunctive character of the set, an explanatory relation between the set and the phenomenon can be developed.

3. The dilemma of disjunction

So far, so good, but opponents point out that the problem with disjunctive properties featuring in explanatory models is that they are not commonly classed as natural kinds, and thus do not lend themselves to projection into theoretical generalizations (Antony, 2003). A common expectation and implicit requirement for the development of scientific explanations is that the models involved in these explanations range over the existence of certain properties that qualify as natural kinds (Boyd, 2021). Whatever the understanding of what it means to be a natural kind, a basic condition is that this kind be relevant to the development of testable hypotheses and theories within the framework of established scientific practices. Therefore, if disjunctive properties *do not* fall under the natural kind category then they cannot constitute nor contribute to the formation of explanatory generalizations. In order to respond to this objection some important observations regarding the relationship between disjunction and realization are in place here. Thus, disjunctive properties can realize other properties through

the implementation of functional roles, as well as through their constituents/component characteristics. Thus, they cover both ideas behind *physical* realization: realization as a constitutive physical relation and realization as occupant causal role implementation or what even amounts to the idea of psychophysical functional realization. Within the framework of associating mental properties with brain states, disjunction suggests that realization can be ascribed to material constitution, psychophysical functional realization, or potentially a combination of the two. Sets of disjunctive properties could even correspond to *restricted* instances or partitions of physical properties realizing the functions responsible for higher-order properties. From a material point of view, the occurrence of disjunctive properties occupying restricted partitions of space and time is the necessary basis on which higher-order phenomena like memory and mental state contents can be materially grounded. Nonetheless, not all partitions of a set of disjunctive properties would count as necessary for the realization of the higher-order phenomenon. Only those partitions that currently satisfy a sufficient condition for entailing realization would count; that condition being that the disjunctive bases instantiate the *right* type of constituent or the *right* type of functional role. Nevertheless, it is crucial for the character of disjunction that the physical states being members of the sets sufficient for the realization of the higher-order phenomena *vary* and fluctuate from time to time. In other words, disjunctive physical states must be in principle interchangeable as members of realizing sets. Therefore, disjunctive properties participating in the realization relation denote a *relative* condition not an absolute one. The combination of a limited number of set members with the requirement of variation represent key aspects behind the relative condition characteristic in the use of disjunction as realization bases; the limitation ensures that a relevant combination of properties is sufficient and necessary for the realization to happen and the variation ensures that the realization relation is both robust and flexible. Yet, critics want to point out that the relative character behind the choice of disjunctive physical states is in fact an *arbitrary* decision made by the observer. The question of which properties are relevant set members and how variability should be measured track at best an epistemological condition dependent on the observer but does not necessary correspond to an ontological condition independent of the observer

(Bechtel and Mundale, 1999). In the range of possible realizers available through disjunction it is the observer who picks up one or many different sets that could play the role of realization. The observer's decision could be based on implicit pragmatic and methodological issues. Thus, the critics argue that the character of the ontology is guided by the observer's epistemology. A consequence of this is that if the kind of variability offered by disjunction is based on arbitrary decisions then that would inevitably limit the generalizability of possible explanations based on disjunctive variability. Thus, if organisms from species O and O* are in physiological state H sharing the common experience *M* of *feeling hungry* at time *t*, then H is realized disjunctively in O and O* at *t* by a set **S** of relevant yet different base properties responsible for H in both O and O*. Furthermore, the property members of **S** will not be the same at another time *t** the higher-order property ***M*** is being instantiated in both O and O* as a function of H. Moreover, not only do the members of **S** vary from time to time but so even the very sets themselves. In other words, the realization relation between M and set S is not a necessary relationship and cannot be projectable to new cases. This situation does not support *generalizations* because realization by disjunction is a relative and *contingent* relation. Given the broad range of variability typical for disjunctive properties and their corresponding instantiating physical states, any attempt to make use of them in explanatory propositions is doomed to fail. The domain of possible explananda becomes *too broad* and irregular because of the very range of variability and this is which makes disjunctive properties *explanatory wild*. Thus, the critics conclude that given such an irregular character, disjunctive properties when used as examples of multiple realization actually undermine any possible explanatory power behind the thesis of multiple realizability (Sober, 1999). Therefore, the multiple realization of higher-order properties on the basis of disjunction is not an option that is either theoretically or scientifically sound (Schneider, 2012). The sort of contingency involved in the use of disjunctive properties affecting explanatory generalizability is symptomatic of disjunctive properties being *explanatorily lawless* i.e., they do not pick up nomological relationships because such properties do not classify as instances of natural kinds. Thus, disjunctive properties as realizers cannot be part of scientific explanations if an essential condition for the properties to

be part of those explanations is that they enter into lawful regularities by means of picking up natural kinds. Since only natural kinds represent the kind of general and recurrent entities that make it possible for them to appear in explanatory models, disjunctive properties that lack lawfulness and generalizability disqualify them as examples of natural kinds. So, on the one hand making use of disjunction for realization supports the irreducibility emphasized by the multiple realizability thesis; disjunctive properties provide for the kind of variability required for the multiple one-to-many character of the realizing bases involved. On the other hand, disjunctive properties not being examples of natural kinds means the realization relation between $\boldsymbol{M}$ and **S** should be understood as a *brute* fact. This situation creates a conflict for the proponent of multiple realizability: disjunction seems to secure non-reducibility at the cost of the realization relation being a brute fact and so apparently it becomes non-tractable for scientific analysis and research.

As an answer, the proponent of multiple realizability would like to emphasize the following observation. If our best scientific evidence is indicative of mental properties in general being realized by brain states and if those states correspond to correlated sets of disjunctive properties, then because of disjunction, or better expressed in virtue of being disjunctive, we would lack the *bridge laws* required for establishing the conditions necessary for the reduction of M to **S**. Bridge laws provide the theoretical matching between the properties of one level of explanation in terms of properties pertaining to another level of explanation (such as in the translation of temperature as a phenomenon into the language of statistical thermodynamics). Once the bridge laws are in place then the possibility of reduction between theories and apparently different properties becomes a serious possibility (Hempel, 1988). Now, disjunctive properties do not apparently meet the requirement for entering into lawful explanatory frameworks, not so either into the frameworks of bridge laws. Thus, to the extent that the properties of a supervenient domain M are identified with the properties of its subvenient physical domain P, disjunctive properties as physical realizers of M actually block the reduction of M to P because disjunctive properties in general do not fall into bridge laws. There is further an interesting conceptual similarity here between the mind being *anomalous* and disjunctive

properties being *contingent* in general. The contingent and non-generalizable character of disjunctive properties reflects in the explanatory anomalous character of the mind (Davidson, 2006). The common denominator for both the contingency of disjunction and the anomalous character of the mind is that both exempt of falling under the scope of bridge laws and whose absence prevents reduction. Thus, in the context of non-reductive physicalism and using the computer metaphor of mind for means of illustration, the mind would be metaphysically determined by the physical nature of the brain, yet the mind, at least at the algorithmic functional level, operates in ways undetermined by the purely physical processes of brain i.e., the hardware level. Disjunctive properties as physical realizers metaphysically determine other properties but are themselves explanatory undetermined because they are contingently based. Thus, such properties realize other properties but are exempted from falling into bridge laws as a precondition for establishing theoretical reduction among properties belonging to different levels of organization. This should be good news for the *non-reductive* physicalist appealing to multiple realizability. Nonetheless, this condition leaves us with the uncomfortable situation of the relation between $\boldsymbol{M}$ and **S** being contingent and not strict, and so again metaphysically speaking, wild. The sciences dealing with properties like *M* and H, special sciences like psychology and physiology, would under such conditions of realization be context-dependent, and the inferred regularities invoked in their explanations would lack explanatory and metaphysical depth in the strict sense of the fundamental sciences like physics. Furthermore, an additionally uncomfortable effect against the supporter of non-reductive physicalism appealing to multiple realization is that if the relation between $\boldsymbol{M}$ (higher-order) and **S** (realizing bases) represents a non-necessary condition, it implies the possibility at least in principle of **S** not being physical at all. Disjunctive realization being a brute fact means that whatever alternative sets of disjunctive properties suitably arranged would instantiate the function and constitution of the higher-level phenomenon. It is not metaphysically speaking a necessary condition for those properties to be *physical* at all; even non-physical states and their properties would do the job and this is bad news for the non-reductive *physicalist*.

Thus, supporters of multiple realizability end up in a dilemma: on the one hand, making use of disjunctive properties we allow for irreducibility at the expense of explanatory powers and generalization; on the other hand, we can opt for giving up disjunction and hold to generalization to secure explanation, but then we sacrifice the variation provided by disjunction and jeopardize irreducibility. Thus, disjunction and variability of realizing properties as required by multiple realizability go hand in hand. As a result, when variability as a key component to multiple realizability becomes jeopardized by rejecting disjunction the very idea of irreducibility is rendered hollow. Even more, when appealing to disjunction as a basis to avoid reduction the explanatory and ontological status of the special sciences like Psychology seems also jeopardized. As we see, many things stand and fall with the consistency of multiple realizability and the use of disjunction as a means of variability to secure irreducibility. To come out of this dilemma we need to deal with some specific issues to provide an answer to the critics: Could we eliminate one horn of the dilemma by securing the condition of disjunctive properties being natural kinds? Can we keep irreducibility by means of disjunction and still secure explanatory powers for special sciences? Does variability or multiplicity of realization require disjunction? Key to approaching the dilemma is what we understand by a *natural kind*.

4. Disjunctive properties as natural kinds

On an essentialist understanding of natural kinds, a property G is a natural kind because it is an indispensable and constitutive element of reality as identified by our best current scientific practices (Devitt, 2021; Wilkins, 2013). Property G is then included in the ontological furniture of the world. Property G is a natural kind also in the sense that it has the power to reliably contribute to our scientific understanding whenever it is included in our best theoretical efforts to describe the world. G is therefore also an essential part of our epistemic systems and models; it enters into explanatory predicates mainly in terms of the effective differences it makes in the causal network of the world (Khalidi, 2018). Most importantly from the essentialist point of view a natural kind is independent for its existence from human reality; where there no human cognizers there will still be natural

kinds such as elementary particles. The ontological and epistemological conditions that characterize essential kinds are also reinforced by their applied and pragmatic significance, such as whenever our best technical achievements derive their success from the existence and character of these kinds in the background of reality. Thus, advanced medical equipment such as magnetic resonance spectroscopy would not provide successful diagnostic aid if *protons* were not cases of a natural kind basic to the constitution and function of the measuring device (Soares and Law, 2009). Interestingly, from the point of view of special sciences like psychology the question arises: would theoretical thinking about the workings of the mind provide successful guidance and understanding at all if mental structures such as *schemas* and *mental representations* were not also cases of higher-order natural kinds fundamental to the constitution and function of the mind? In other words, are mental and cognitive structures also cases of natural kinds on pair with protons and electrons such that they constitute kinds of their own different in character from those of the basic sciences but nonetheless as real as protons and electrons? It is also of paramount importance for the essential character of natural kinds that they take part in and play a role in lawful regularities. According to these defining standards, disjunctive properties do not capture the conditions for instantiating essential kinds. Now, not any natural kind is an *essential* kind. The scope of essential kinds could be limited to the microstructure of the world. Still, it is an open possibility that other levels of reality and the sciences operating on them make use of kinds whose character and behavior differs from the ones used in the basic sciences. Thus, it can be observed that many of the kinds that sciences such as biology and psychology deal with in categorizing and classifying their subject phenomena are different from those in sciences such as chemistry and physics (Cacioppo and Tassinary, 1990). As an example, the concept of *biological species* is basic to biological theorizing but recognizably heterogenous enough not to count as an *essential* natural kind in the straightforward sense of basic kinds such as electrons (Ereshefsky, 1992). Instead of an essentialist view of natural kinds, fields like psychology and systems biology make use of a pluralist view on kinds and understand them as clusters of homeostatic properties; *homeostatic property clusters*, HPCs (Boyd, 1991, 2021; Bruggeman and Westerhoff, 2007). Here, a cluster of properties

shows a *recurrent pattern of explanatory stability* whenever used to explain a complex phenomenon. HPCs are *stable enough* to provide epistemic guidance in the construction of explanatory models, yet *flexible enough* to reflect the context dependent and often malleable ontology of phenomena studied in psychology and biology (Onishi and Serpico, 2022). Thus, HPCs are not the sort of basic/atomistic objects like elementary particles and their properties. Rather, they reflect the more collective and contextual character of the interdependent qualities found in higher-order phenomena and their defining properties (Magnus, 2014). What is important for understanding HPCs as cases of natural kinds is their ability to function as heterogeneous interconnected clusters of properties capable of representing conditions in the causal structure of the world, or at least that part of the world under investigation (Wilson et al., 2007). Making use of HPCs as examples of natural kinds points to the *plurality* of relevant but interdependent properties that when causally combined aid to the metaphysical and scientific understanding of the phenomenon in question (Esfeld, 2005). Thus, in the economics of psychological phenomena, having a desire for water is not an isolated property but rather a conglomerate, a cluster of adjacent and relevantly interconnected physiological conditions, mental states and behaviors, like sensations, intentions and actions all contributing to the formation and identification of the desire. My need for water is then at the psychological level an example of the mental kind *Desire* which represents a contextual and distributed set of properties including among other memories, beliefs and decisions. As a kind then such contextual properties act together as *one* causally coherent set endowed with explanatory powers relevant for the type of behavior being exposed; my desire explains my behavior. The causal coherency of such properties reflects in the homeostatic character of the clusters representing their level of recurrence and stability. Correspondingly, at the neuronal level of implementation, it is not unreasonable to assume that interconnected assemblies of neurons implementing integration and segregation processing, supported by neuroplastic mechanisms, would reflect the contextual and distributed character of mental phenomena such as beliefs and desires (Seitz and Angel, 2012). Now, referring to collective and contextual clusters of properties seem counterintuitive and do not reflect our intuitions of what we mean by *a* natural kind being an *essential* and

unique property integral to nature´s furniture. Yet, the more interdependent and contextually sensitive a phenomenon is such as memory consolidation and phenotypic adaptation, the more different yet relevant clusters of properties act *together* to ground the very phenomenon (Lemeire, 2021).

The boundaries of the clusters at the subvenient constituent level are permeable enough to allow one and the same constituent property to vary as a member and participate in the constitutive function of other clusters without endangering the overall stability of the higher-level phenomenon being realized (Brigandt, 2003; Dewhurst and Isaac, 2023). Such clusters are robust and flexible enough to reflect the resiliency of the phenomenon itself (Austin, 2020; Chirimuuta, 2018). For example, biological species is not a term that refers to a monolithic, unchanging kind, but rather a concept that denotes an inherently variable category depending on its explanatory use in different fields of biological investigation (Barberousse et al., 2020). Recalling one part of our dilemma: the status of disjunctive properties as natural kinds, the idea then is to approach a solution by way of thinking of disjunctive properties *as* cases of HPCs. The realization of a mental property M by a set of disjunctive properties P must reflect, at the level of the realizers, the flexibility and permeability necessary to match the contextual and interdependent character of the property M being realized (Balari and Lorenzo, 2019). In a sense then, the degree and level of granularity between M and P matches both explanatory and componentially. Thus, the kind of *explanations* framed in the vocabulary of a science Ψ acknowledging of the role of P bases, reflect aspects of contextuality and conceptual interdependencies present in properties both across P and M-levels. Hence, in terms of property instantiation; the sort of component properties at the realization level P show interrelatedness and malleability in a way the same as the properties at the level of M. So, if mental property M* represents the single *belief* "I'm thirsty now", then according to the idea of homeostatic property clusters, M* is a case of a *composite* natural property belonging to the broader categorical type ***Belief*** to which cases of M* belongs. Here M* represents a case of the natural kind ***Belief***. Further, M* is a composite because there are many factors contributing to the instantiation of M* on both the psychological and physiological levels. Thus, my single belief that M*, is a *plural* construct tracking the existence of relevant

causal networks stable enough to keep its meaning and significance as a constitutive and explanatory property. In other words, M* plays an explanatory role in the current psychological state that I happen to be in, because it traces causal roles and correlations that explain my behavior. Importantly as well, the set of realizing properties P under which M* subsumes is *also* a composite of properties; a disjunctive set of physical states and their properties that are causally relevant for the instantiation of M* and still homeostatic or stable enough to guarantee the ontological status of M*. Therefore, if disjunctive properties correspond to HPCs and homeostatic property clusters classify as members in the ontological furniture of the world, then we may have a way to secure the status of disjunctive properties *as* natural kinds both at the psychological and at the physical level of realization. To repeat, the way disjunctive properties realize a second order property is either by means of functional role implementation or by material constitution. Nothing seems to prevent disjunctive realizing properties from taking on the defining character of homeostatic property clusters, so long as they make an identifiable causal contribution to the relations they enter into the world. What matters is that the clusters are stable, homeostatic, but permeable enough to implement functional role descriptions and to enter into material constitutive relations characterized by variability and plurality. Now, the critics may rebut that basically, this is the very requirement that enables even opponents to multiple realizability to make use of disjunctive properties on their behalf for the *reduction* of M* to P. Disjunctive properties even as cases of homeostatic property clusters are stable and recurrent enough to enable for reduction by means of *local identities*. Thus, Hunger as general phenomenon is realized differently by different species (Smith and Grueter, 2022). However, this does not hinder Hunger being locally realized across species such that we can identify even recurrent property clusters specific for *dog hunger*, *human hunger*, *mollusk hunger*. Hence, in this sense, disjunction of realization is compatible with reduction *by identification* between e.g., dog hunger, human hunger, mollusk hunger and their corresponding *local* HPCs. Furthermore, local reductionism is in a sense even compatible with non-reduction to overarching types by means multiple realization; dog hunger, human hunger and mollusk hunger are realized by a *multiplicity* of HPCs typical to their species. The multiple realization of a

higher-order property is just a *local phenomenon* carried out by recurrent yet differing sets of disjunctions being *locally realized*. In general, if multiple realizability allows for both reductionism and non-reductivism then conceptually speaking it is a contradictory thesis. As a corollary, if higher-level properties are not grounded in identities but in non-reducing disjunctions representing brute facts of nature, then the risk is imminently big that higher-level properties are causally speaking, epiphenomenal. In other words, if we want to secure the causal effectiveness of properties like M* we better do that by virtue of identifying the causal powers of M* with those held by P, even in those cases where P represents examples of HPCs which by virtue of their causal and constitutive relevance surpass the condition of mere brute facts. It is only to the extent that higher-level properties are identical with their disjunctive realizers at the local level of realization typical for a member X of a species S that higher-level properties typical for X are causally relevant at all. Two questions need to be answered to counter the critics. First, are homeostatic property clusters really cases of natural kinds and so on what bases? Second, are homeostatic property clusters then the sort of natural kinds that would be relevant for avoiding type identities even of the local sort as described above and can they consequently still grant causal efficacy to the phenomenon they realize?

5. Homeostatic property clusters as natural kinds

Two kind of conditions seems necessary to be fulfilled for clusters of properties to count as natural kinds; one is an epistemic and the other a metaphysical condition. Epistemically speaking, homeostatic property clusters must be possible to incorporate into explanatory models; they must contribute to our understanding of the world. Metaphysically speaking, homeostatic property clusters must reflect the structure of the world; in other words, they must have ontic weight. In order for homeostatic property clusters truly reflecting the structure of the world such that we can be sure they contribute to explanatory work in the sciences, they must first be identified *as* true natural kinds. Therefore, they must be stable and recurrent enough to be regarded as constituents of their phenomena both within and between individuals as in the case of biological structures; within and across species.

Furthermore, the clusters must be variable and flexible enough to allow for a variety of realizations of biological properties, avoiding the contradiction of allowing both reducibility and non-reducibility at the same time. Biological and psychological phenomena represent systemic properties whose nature and function are best reflected by structures the behavior of which echo the inherent plasticity and variability typical of biological systems, i.e., the condition of flexibility yet stability imposed on homeostatic property clusters (Bressler and Kelso, 2016). HPCs representing systemic properties such as those found in biology can accommodate to the synergy of both, on the one hand, reductively *local within-species* and on the other hand non-reductively *global* or *generally shared cross-species* properties, without contradiction. Thus, characteristic properties of a biological species such as morphology, reproductive isolation, predation, symbiosis and competition are locally defined by the species' local position within the available context of ecosystems to which it is adapted (Mazzocchi, 2008). At the same time the species properties transcend the limit of the ecological niche because they are *also* the result of *extended* patterns of adaptation in time through the process of evolution. Properties like robustness and generative integrity as articulated in the explanatory models of systems biology, trace actual conditions for the phenotypic expression of a particular behavior (Austin, 2016; Mason et al., 2015). Biological properties with both local and extended characteristics represent cases of homeostatic property clusters characterized by their ability to evolve new adaptations that require variability and plasticity at their level of realization (Duffau, 2006; Galván, 2010). Disjunction of properties would then be a possible grounding mechanism through which biological species develop new properties as an answer to the demands on developmental variability and evolutionary adaptation imposed by their environment. Further, homeostatic property clusters are by means of the variability, permeability and causal relevance characteristic of their structure and behavior cases of components implementing the characteristics of disjunctive property sets. Thus, if homeostatic property clusters basically correspond to the defining characteristics of sets of properties held together by disjunction and if we are willing to concede that disjunctive properties are cases of pluralistic natural kinds then at least by conceptual implication, HPCs should count as examples of natural kinds as well.

What we have established so far is the plausibility of both disjunctive properties and HPCs representing cases of natural kinds tracking the causal network structures and compositional aspects of the phenomena they refer to. Following this line of thought, the fact then that homeostatic property clusters can appear in explanatory predicates and projectible generalizations secures the status of disjunctive properties as natural kinds because disjunctive properties correspond to cases of HPCs and vice versa. More importantly, many systemic-oriented sciences, such as biology and psychology, seek to understand phenomena that are pluralistic. The explanations and generalizations developed in these sciences are consistent with properties that can be recognized as HPCs cases. Disjunctive properties as examples of HPCs can then appear as candidates of natural kinds and enter into realizing relations operating at the level of psychological and biological properties. The further implication is that property disjunction as a physical basis of realization would also block reduction by identities. This way we can answer the first horn of the dilemma: how to use disjunctive properties to provide irreducibility without sacrificing explanatory power. HPCs are locally stable clusters of realizing properties which in addition with their open-ended and context sensitive character still allows for the identification of causally relevant patterns of behavior globally extended over time. Thus, HPCs are even globally identifiable clusters of realizing properties whose instantiation reflects the historicity and iterability of evolutionary processes. From these patterns of behavior truly scientific explanations can be abstracted and developed as in the case of evolutionary and developmental biology (Gilbert, 2016; Watson et al., 2016). The same characteristics apply to disjunctive property sets when used in the recognition of realization relations. However, we must answer a further objection: granted that disjunctive properties have their own status as natural kinds as represented by the function and structure of HPCs, still, they cannot figure into *strict* lawful regularities and provide for the kind of theoretical generalizations that reflect those regularities. As the critics say, it is precisely the condition of "lawless" variability imposed on the definition of property disjunction as a realization relation that prevents its extension into lawful regularities. Consequently, disjunctive properties lack the metaphysical robustness to serve as the foundational basis for explanatory models in sciences like psychology.

Furthermore, this limitation results from the intrinsically *non-regular* nature of disjunction in the characterization of psychological phenomena. In other words, by saying that disjunctive properties have an inherently "non-lawful character", critics highlight that these properties do not follow consistent, predictable patterns that can be reliably used to predict and explain psychological phenomena. As a result, if sets of disjunctive properties represent the presence of HPCs as realization bases, psychological properties based on explanatory yet non-regular homeostatic property clusters would also be rendered explanatorily wild. Disjunctive properties and so even HPCs realize psychological properties but *do not* project nomically and therefore Psychology as a science would lack a firm metaphysical ground on which base its explanations in the context of non-reductive *physicalism.* Therefore, we can doubt the adequacy of the use of property disjunction, even as an instance of HPCs, as a coherent explanatory strategy capable of producing testable explanations. One preliminary answer could be: Psychology is not a strict science in the sense that it implements a copy of the methodological tools and conceptual schemas used in basic sciences like Physics. Psychological methodology is not *primarily* concerned with identifying the existence of bridging laws by which it could be reduced to a more basic science like neuro-physiology by the discovery of identity relations. Given the complexity of human behavior and cognition, psychology is not either *strictly* restricted to establishing in every case of analysis the conditions for ceteris paribus requirements to obtain: it's often difficult to account for all relevant variables involved in the gestation and function of psychological phenomena specially those concerned with the processes being characteristic to social cognition (Kelly et al., 2019). This leads to the conclusion that ceteris paribus conditions are more challenging in psychology than in some of the other sciences (de Jong, 2002). According to the critics, the realization of psychological properties at the level of their physical disjunctive sets would also render psychological properties causally inert. In a causally closed physical world all the causal effects are derived from the activity of the realizing physical bases. It could be granted there is no obstacle to the use of disjunctive base properties to causally realize psychological properties as long as their causal work is *determined by* the activity of those base properties. However, what the critics seems to oversee is that

when considered at the level of systemic properties, psychological phenomena remain causally effective on their own. Systemic properties transcend local causal limitations imposed by their physical brain bases because they involve even boundary breaking historical and context sensitive dimensions (Burnston, 2016a, 2016b, 2021). Thus, mental states carry the conditions of their past instantiations into their present constitution, and the same conditions are prospective for their future configurations in a way that makes them causally relevant. Besides, the brain itself at a systemic level is causally speaking boundary-breaking with regard to its physical structure because of its capability to form predictive loops embedded in the boundaries between its inner computations and its environmental context (Friston, 2010; Friston and Kiebel, 2009; McCaffrey, 2015). Psychological properties are also inherently contextual, embedded, and open-ended (Clark, 2017; Nave et al., 2020). This does not stop psychologists searching for *causal explanations* to construct explanatory models of human behavior such as under the controlled conditions of rigorous experimental set ups. However, to recognize that the subject matter of psychology does not conform to the *strict* methodological generalizations of fundamental sciences like physics is one thing. To deny that psychology can provide explanations appropriate to the properties that are typical at its own level of inquiry is something quite different (Fodor, 1980). Evidence-based psychology seeks explanations of behavior and mental content in terms of mechanisms and/or processes that conform to both intersubjective and intra-subjective regularities from which generalizations can be derived. The existence of these mechanisms and regularities is the theoretical bedrock on which an understanding of people´s behavior rests. Nonetheless, the kind of properties used in the discovery and explanation of those mechanisms are proper to the field; they are context-dependent and malleable. Psychological properties and mental properties in general reflect strong contextual and developmental aspects (Cacioppo et al., 2008; Sarter et al., 1996).

6. Disjunctive realization and special sciences

Psychological explanations generalize at their own level of analysis because the properties used are *permeable* yet *stable enough* to constitute

kinds in themselves from which explanatory generalizations can be drawn (Brick et al., 2022). For example, the content and function of psychological constructs such as our attitudes and attributional styles reflect the contextual character of our thoughts, the contingent features of our emotions, and the embedded conditions of our behavioral patterns. Psychological phenomena constitute *clusters of properties* held together by their systemic and synergetic causal effects. Psychological phenomena and their properties are *coarse* meaning they are broad in scope and multifactorial. Furthermore, the character of many psychological phenomena varies as a function of time, environmental and developmental effects. Thus, strictly speaking by their very *cluster character*, psychological properties cannot be reducible to neuroscientific type-to-type identities because these do not reflect the coarse character of psychological property variability. Psychological phenomena are realized by cluster properties and they enter into explanatory generalizations by virtue of their very disjunctive character. Thus, the coarse and contextual-developmental aspect of psychological kinds at their systemic level is matched at the realization level by the disjunction of coarse and pluripotential brain bases (Viola, 2021; Viola and Zanin, 2017). Explanations couched in the language of psychological theory link the broad character of the phenomenon to the coarse character of the factors and properties conforming to its realization. Psychology develops its own explanations for psychological properties without necessarily translating these explanations into the vocabulary of the sciences that typically deal with the physical instantiation of its properties. Thus, psychological explanations are coarse also because they involve many variables interacting with each other in often multidirectional causal ways. It is therefore that whenever matching psychological proprieties to their neurophysiological bases the coarse character of the psychological phenomenon must be considered. So, a right understanding of the coarse character of psychological phenomena can and should be reflected by the pluripotential properties of the instantiation bases; pluripotential brain states matching the multivariable character of psychological phenomena. Ontologically speaking then, psychological phenomena retain their irreducibility and explanatory autonomy without losing the power of being objects of theoretical generalization once we recognize that they represent homogenous and coarse properties. In other

words, psychological properties represent clusters of properties that, by virtue of being homeostatic, *also* possess the stability required to figure in recurrent causal explanations tracing ontic conditions. In other words, psychological phenomena and their properties as cases of homeostatic property clusters represent a realization by disjunction that still manages to preserve irreducibility and theoretical projectability for higher-order properties. Additionally, by regarding disjunctive bases as examples of HPCs, we establish their condition as natural kinds suitable for the explanatory purposes of special sciences like psychology and systems biology. Disjunctive bases as examples of HPCs then correspond to cases of *disjunctive realization* meaning that a variety of physical bases and their properties come together recurrently and differently to generate higher-order objects and their properties. These bases and their properties correspond to different patterns of realization that are stable enough to allow for explanatory generalizations as well. Moreover, the homeostatic character of the properties involved in disjunctive realization traces the existence of causally relevant patterns of behavior stable enough to indicate the presence of natural kinds; *disjunctive natural kinds*.

7. Systemic properties and their disjunctive realizations

Now, the critics might counter and say: granted that disjunctive realizations are explanatorily relevant reflecting the existence of disjunctive natural kinds in sciences like psychology. Still, this does not completely block reduction by identities because the pluralistic regularities observed at the level of psychological phenomena could be systematically translated to regularities at the level of their physical realizations, even in a pluralistic way. Thus, no matter how homeostatic and variable in character, properties and regularities described by special sciences such as psychology can still be explained in terms of the properties and regularities of realizing physical types. Reduction by identities is not prevented by disjunctive realization as conceived here. The question then is how much of the very *homeostatic character* of disjunctive kinds makes it possible to use that very stability and causal coherence to pursue actual identities. Thus, the critique goes that we could actually use HPCs as a backdoor strategy to provide the

necessary bridging laws that allow the reduction of psychological properties to neurophysiological ones (Bickle, 1992; Bickle et al., 2022). The ideal situation would be one in which the disjunctive properties of neuroscience *bridge the gap* between psychology and the brain, between the mental and the physical, giving rise to a unified picture of science including psychological science (Bickle, 1995). As an answer to this backdoor strategy, we need to consider the systemic nature of the brain and the nervous system as the biological bases responsible for the instantiation of psychological phenomena. Their systemic nature encompasses both synchronous and developmental as well as evolutionary processes that transcend the explanatory limitations imposed by purely physical, strictly law-based models of explanation. Thus, both synchronous and diachronic aspects of the brain's structure and functionality are represented by the systemic properties of the brain (Freeman, 2011). Synchronously, the brain is mechanistically constituted by the presence of intra-level non-causal components (Halina, 2017; Harbecke, 2015; Romero, 2015). Their very presence in the here and now in terms of their relations and activities constitutes the grounding bases of its structure and functionality (Darden, 2008; Machamer et al., 2000). Diachronously, these components are involved in the continuous making of casually relevant trajectories representing distal causes and effects. In other words, both structural and developmental aspects intersect to balance stability and variability in the development of the brain as a systemic organ. Because systemic structures such as the brain balance both stability and variability, they can be characterized by the coherent activity of homeostatic property clusters. Furthermore, such activity is indicative of causally informative relationships that are stable yet open enough to keep the system in a continuous flow of information and energy exchange with its environment. The backdoor strategy of locally founded reductionism is then blocked by the very systemic nature of the cluster kinds that condition explanations of psychological properties and their correlated brain states. Cluster types represent statistically based open-ended and time-dependent variables that defeat apparent property identities in terms of local species types (Lisman, 2017). The mere homeostatic character of disjunctive kinds cannot be used to trace identities in the way the critics mean. The backdoor strategy misunderstands the way "homeostatic character" is understood in sciences that

deal with both synchronic and diachronic aspects of realization, such as in psychology. Mental traits, for example, do not follow strict laws, but follow contextual and correlational patterns that vary from time to time within individuals, depending on the effects of phylogenetic, developmental, and environmental conditions affecting the subject. Such time dependent variability at the level of the mental is matched at the level of the realizing bases by means of variability and malleability among the constituents (Schulz and Hausmann, 2017). In other words, whatever the character of the realizing brain states and mechanisms responsible for the realization of higher-order cognitive properties, they must also be flexible enough to reflect the open-ended and dynamic nature of those properties (Kamaleddin, 2022). These conditions break the required symmetry between types standing in a reductive relation to each other. The crucial point for the establishment of type identity reductions among properties is that both types of properties instantiate more or less essentialist and monolithic types but the critiques implicitly misinterpret the pluralistic character of higher-order types and the pluripotential variability of their realizers. On the other hand, if they are willing to coincide that such pluralistic character must be matched by an equal plural character at the level of realizers then they are playing the game of the multiple realizability supporters and so entering into the realm on non-reductivism. Moreover, special sciences such as psychology have a different explanatory burden than the basic sciences because they must keep track of synchronous mechanistic properties as well as diachronous or historically extended properties. A psychological explanation of the effect of attitudes on people's behavior must not only consider conditions in the subject's proximal environment as well as distal factors but so even *reasons* conditioned by past events and experiences (Castelli and Tomelleri, 2008; Mezulis et al., 2004). Psychological agents act motivated by reasons and intentional content. Psychological properties own a historical and developmental dimension reflecting their permeability towards the environment; they are evolutionary and organismically based (Feinberg and Mallatt, 2016). The nature of the physical properties that realize them should at least functionally match this permeability, allowing for the necessary variability and diversity at the level of the constituents to play their realizing role. Disjunctive properties grounding psychological properties can then

instantiate both synchronous constitutive and diachronous developmental relations. Psychological properties are realized both by their brain-based constituents in a synchronous *here-and-now* manner and diachronously across spans of time by the shaping effects of *time extended* evolutionary mechanisms (Baciadonna et al., 2021). In other words, psychological properties are inherently dynamic. The constitutive relation between a higher-order phenomenon and the subvenient brain properties is one in which the latter aggregate temporally to instantiate the former. Explaining such patterns is best done by neuroscientific work based on the dynamics of brain states (Farmer, 2011). Thus, the neuroscientific bases realizing psychological properties will reflect the dynamical nature of those properties and by themselves show patterns of interchangeability, contextuality, and interdependent features of connectivity as well as functionality (Buzsaki, 2007; Nguyen et al., 2024). Dynamically interconnected brain networks showing patterns of synchronicities and distributed coupled oscillations seems to be the proper realizer candidates matching the temporal aspect of psychological properties (Deco et al., 2017; Demertzi et al., 2019). Explaining the evolutionary and developmental features of psychological kinds is currently done in the explanatory vocabulary of evolutionary and developmental psychology. Therefore, psychology as a science of the mind and behavior *depends* on the synchronous physical realization of neuroscientific kinds. At the same time, the diachronous character of psychological kinds reflects the open-ended character of those kinds whose behavior is best couched in the language of distributed networks representing dynamic activity patterns (Gallagher and Daly, 2018). Psychological explanations are representative cases of explanatory frameworks in the special sciences. Therefore, they do not necessarily follow the same methodology as the basic sciences, mainly because of the character of the properties they deal with. Such properties instantiate causal powers that are explained in terms of the dynamics of the systems that realize them. The role played by properties in the explanatory frameworks of sciences such as psychology and systems biology reveal the involvement of systemic and synergistic mechanisms and processes. Causally, such mechanisms and processes instantiate proximal and distal effects. These effects cannot be ordered into type-to-type identities that trace a one-to-one relationship. The establishing of such relationships is blocked by

contextual, evolutionary, and synergistic effects. Thus, "can we keep irreducibility by means of disjunction and still secure explanatory powers for special sciences?" As a primary answer, it seems plausible that we can have our cake and eat it too; we retain both irreducibility and theoretical projectability for the special sciences and their higher-order properties. Crucial to this effect is the characterization of the properties of the objects and phenomena treated in these sciences as genuine cases of natural kinds realized by equally genuine cases of instantiating natural kinds; disjunctive kinds. In this way we secure explanatory autonomy and value at the level of both systemic properties and their disjunctive realizations, complemented by irreducibility for higher-order properties. Still, critics may ask what sort of conditions apply to conglomerates of disjunctive properties to instantiate higher-level phenomena. By what means does disjunction of properties realize higher order properties? In other words, how does the *variability* implied by disjunction relate to the realization of irreducible properties?

8. Does variability or multiplicity require disjunction?

Thus, we need to answer the question of how variability or multiplicity relates to disjunction in order to establish irreducibility. We begin by observing that the general function of disjunctive properties is to realize higher order properties such as "desire for water" D(W). Further, we need to look more closely at what we mean by realization and the relation of disjunctive properties to functional performance. We have taken realization here to mean physical realization and, at first glance, to imply both functional occupant role implementation and material constitution. Realization is a variant of a metaphysical dependency relation offered as an alternative to identity theories (Polger and Shapiro: 2016 p.20). One understanding of realization then is to conceive of a set of physical properties P occupying a set of causal relations R such that the property D(W) is realized whenever the relevant set of physical properties in question, P, instantiates the set of causal relations R describing D(W). That is, D(W) is obtained at time t by virtue of P being in state R, at t. In other words, D(W) represents a causal role instantiation by P. What matters here is that my desire for water D(W) is functionally described as the relation that holds between P and R, and is

effectively realized whenever P executes R. What we have then is a view of realization that emphasizes the functional role description of higher order properties, where physical objects occupy functional roles; in this case of "desire for water": psycho-functionalism. More generally, a functional role description of D(W) highlights the set of inputs, internal states, and outputs representative of this higher-level property. Together, the members of this set describe the functional role of D(W) in relation to other similar properties in the broader network of psychological properties and their correlated behaviors. Thus, this set of inputs, internal states, and outputs captures a functional description **F** of D(W) in terms of the causal structure (C) of the behaviors and states characteristic of D(W). **F** is then the higher-order *abstraction* of the behavior represented by (C) and its corresponding states, hence F (my desire for water and my opening a soda can). This means that any suitably arranged set of objects and relevant properties similar to P instantiating causal structure (C) will suffice for the realization of D(W), because (C) is equivalent to P being in state R which in turn is the basis for the formation of **F**. In other words, it might be plausible that properly arranged pieces of cheese, i.e. suitably instantiating (C), will suffice for there to be D(W). This is obviously counterintuitive to common sense. The common-sense suspicion is based on the idea that cheese in general does not support mentality. Cheese has never been observed to instantiate a mental property; no hunk of cheese has ever screamed in pain when cut. There is something about the composition of cheese that excludes it as an appropriate realizer of mentality, however isomorphic its internal state arrangement might be to (C). Nevertheless, we should keep in mind the possibility that cheese, suitably arranged, can support other higher-order properties besides those traditionally associated with mentality, e.g., those properties inherent to its nature, such as its viscosity and hydrophobic structure. The objection to cheese as an appropriate realization of mental properties is based on the idea that something is *missing* from the microstructural-functional configuration of cheese the presence of which is necessary for giving rise to a subjective mental property. In general, this missing component would prevent cheese from exhibiting higher-order properties typical of other non-cheese systems and so there is no possibility for a chunk of cheese to realize the abstraction of a behavioral function such as **F**. This limitation refers to

a missing property or *the* missing property that if possessed by cheese, would allow cheese to instantiate D(W) or even cheese-pain. The same logic applies to disjunctive properties, since we could have disjunctive varieties of cheeses whose respective internal configurations would still lack the property by which D(W) is obtained. Alternatively, we override common sense intuitions and allow a liberal conception of realization as functional role occupancy even in the case of cheese. In other words, we reject the idea of a necessary property or set of properties, the presence of which would be crucial for the instantiation of properties like pain and desire. In other words, we allow that all objects whose internal configuration (C) represents F are sufficient for the realization of D(W) (Koskinen, 2020). If so, we are talking about conditions of *multiplicity* or variability for realizations to obtain, either by allowing a *restricted* set of key properties being distributed over the population of possible realizer systems, or by denying the existence of the missing key property and thus allowing for wildly different realizers in many different systems. The problem with the latter "wild" alternative is that multiple realization would then allow for an anything goes conception of realization, as long as it is variable yet stable enough to support realization. Variability in this sense seems to threaten the stability required by a higher-order property to maintain its defining characteristics across different domains. The background question is: wouldn't unrestricted variability in instantiating systems and their properties backfire on the coherence and homogeneity of the higher phenomenon being realized?

9. Ontological constitution, neurons and constrained disjunctive constitution

Alternatively, **P** and **R** represent sets of physical properties and their causal relations such that *not any* physical property nor *any causal relation* as proper part of those sets would be sufficient to realize **D(W)** and so obtain **F.** Only those properties and causal relations relevant in the sense of **P** instantiating a unique function $\boldsymbol{G^*}$, $\mathbf{F}(\boldsymbol{G^*})$, representing **D(W)** would do the job. Here **P** would stand for the relevant physical properties instantiating $\mathrm{F}(\boldsymbol{G^*})$. Those relevant properties represent then *a range* of limited constituents necessary for **D(W).** Thus, a second way of understanding

realization is as a case of ontological *constitution.* The property D(W) exists at all because it is physically constituted by realizers standing in a constitutive relation like that between a statue and the bronze of which it is made; the statue is its bronze and the bronze takes the form of the statue (Polger and Shapiro: 2016 p.20). What matters here is that it is physically constituted, or that it fulfills the condition of possessing a certain internal organizational structure relevant to its constitution (Melnyk, 2003). One important condition here is that a particular internal organization assumes the relevant functional role by virtue of its very constitutive nature. The statue being its bronze and the bronze being the statue cannot be anything other than the synchronous instantiation of the relevant functional roles occupied by the constituents themselves. The very presence of the constituents is the very presence of the functional roles that describe the phenomenon. The functionality automatically follows together with the arrangement of the constituent parts because the phenomenon is both structurally and functionally the typical arrangement of its constituent parts; it is the constituents that occupy the functional roles. Thus, in the framework of the mind-body relationship this version of physical realization is compatible with psycho-functionalism; the idea of *filler or occupant* functional role on the mind (Block, 2007). The mind certainly performs functions that can be captured by a functional description that traces the causal pathways of its relevant states. But these functions are also the result of its physical constitution being there in the first place; the mind is a function of constitution, not so much of causation; *the mind is in the flesh, not so much in the motion.* The unique function $\mathbf{F}(\boldsymbol{G^*})$, representing $\mathbf{D(W)}$ is there at all, as a matter of the right type of constituent relation being there at all. Functional role instantiation, then, is secondary but complementary to physical constitution, and it is the presence of the right kind of constituents that ensures that the right kind of function is performed at all. In other words, realization through constitution and realization through functional role occupancy are complementary sides of the same phenomenon; where there is constitution, there is function, and where there is function, there is constitution. However, this relationship is *ontologically asymmetrical* in the sense that the right type of constituent determines the right type of functionality, but not vice versa. The constitution, the bronze of which the statute is

made, is what matters ontologically. On the other hand, the functional description is what matters epistemically, because it informs about the special character of the relevant constituents and why there are constraints on the number of possible constituents. We could in principle have an approximate functional description of the phenomenon in question, allowing for the kind of variability of the constituents that physically realize the phenomenon. However, any kind of constituents would not suffice without misrepresenting the nature of the phenomenon itself. In filler role occupancy there are then certain *unique constituents* like neurons the role of which is to *embody* causal role (C) characteristic of D(W) for the realization of **F**. There is something about, and perhaps only about, neurons as constituents that makes them suitable for the realization of mental properties such as D(W). For all alternative objects other than neurons, such as silicon chips, which are in a one-to-one isomorphic relationship with the structural constitution of the biological neuron, something would still be missing for these objects to express D(W) (Shoemaker, 2009).

Thus, filler role occupancy describes the *epistemic consequences* of the *right type of constituents* being present to embody (C). It is by their very aggregate nature and instantiation as microconstituents that the right type of constituents such as neurons realize mental properties. What counts here is not so much the causal role (C) played by the neurons, but their spatial-temporal location which is what allows (C) to be embodied at all. In other words, what counts for the realization of D(W) by P is not so much that P performs R, but that P realizes D(W) through the very materialization of (C) by P; to realize is not primarily to cause, but to constitute. The condition of causal role fulfilment is secondary and subordinate to the condition of material constitution yet they are complementary. The functional role description *abstracts* from the constitutive level of the realizers the defining characteristics of the properties to be realized. The formation and constitution of D(W) by P is done by the type of mechanisms representing P synchronously and non-causally. The functional description in terms of causal specification represents the way the physical constituents "filler out" those mechanisms (Melnyk, 2018). Extending this idea to our understanding of the mind in a purely physicalist way, we can say that we hold beliefs about the world not because of the functions of the beliefs we hold, but because

of what our beliefs are made of; neurons synchronously constituting our beliefs right now in combination with their filling role properties. The right kind of material constitution then represents a sort of non-causal physical realization. There are then obvious selective constraints on the kinds of constituents that can realize higher-order properties, which in turn impose constraints on the kinds of *variability* that are open to the realization of properties like mental ones. Thus, from the point of view of multiple realization, constituents, as instances of physical realizations, impose limits on the kind of variability that can exist among realizers. Physical realization by constitution then represents a more conservative condition of realization because of its limitations on the scope of variability. What exactly are these limits? In other words, what counts as relevant but limited constitutive variability? The answer depends on the convergence of two conditions. One of them is that the evolutionary background conditions on Earth are unique. If the original conditions present at the beginning of time necessary for the chain of reactions leading to the realization of mental properties were to be repeated, there would be no exception to the rule that neurons and only neurons would support mentality by virtue of their distinctive biological properties. Moreover, if the original background conditions, including physical and biological conditions, were to deviate from the original conditions, then no mentality would ever have evolved because no neurons would ever have evolved either. Where there are no neurons, there are no functional role occupants of the right kind necessary for mentality to arise. The second condition implies the *property uniqueness* of the constituents e.g., the fact that neurons implement thinking is to be distinguished from the possibility of artificial systems based on other units than neurons implementing thinking. Neurons as such possess a property that makes them irrevocably unique as *units of mind* distinct from any other possible replica that could be designed; there is a special stuff, the constituent properties of evolved neurons, that makes them unique as realizers of mind. This is not to revive vitalism nor entelechies to explain the mind through realization. Rather, the unique combination of neurons as computational and constitutive elements of mind is an adaptive and autopoietic property, understood in terms of its evolutionary development and its ability to allow for and handle complexity in biological systems such as brains. Neurons, and only neurons as a type, are

the real stuff of the mind. This does not exclude that there may be *varieties* of neurons across species and within species, as in fact there are (Cauli et al., 1997). It is the richness of this diversity that leads to the diversity of cognitive abilities in living things, as long as this variability is limited by the constraints imposed by the evolutionary process (Güntürkün, 2012). The combination of these conditions (i.e., the evolutionary background conditions on Earth are unique and repeatable plus the property uniqueness of the constituents as seen in their ability to handle complexity through computational and constitutive properties) is also compatible with these conditions being exemplified by disjunctive properties as well, i.e., neurons possess and implement disjunctive qualities (Emery and Clayton, 2004). Neurons vary in types and within their types; there is variation at the individual scales of structural configuration as a result of the activities they enroll in, such as their synaptic activity and the arboreal networks they form and are shaped by (Clascá et al., 2012; Grafman, 2000; Lisman, 2017; Waschke et al., 2021). Neurons are plastic and implement learning at different scales of constitution (Toricelli et al., 2021). The conceptual association between neurons, homeostatic properties and realization by means of disjunction is the result of neurons having plasticity-based adaptative mechanisms and disjunctive properties characterized by both their structural and functional variability and malleability (Lisman, 2017). Nevertheless, it may still in the context of constituent realization be possible to have neurons representing cases of disjunctively-organized property clusters that realize species-specific local identities in a framework of conservative constituent realizability. Thus, *human pain* is in terms of constituents a local phenomenon the same way *mollusk pain* is constitutively local to the relevant mechanisms representing the relevant constituents; the functional networks specific to each species as implemented by their neuronal structures (Coninx, 2023) . The characterization of the constitutive condition is then a combination between metaphysical possibility regarding the variability of systems available for the instantiation of Pain, and empirical observations confirming both the existence of Pain as an across-species general property and the variability among its realizers. As such physical realization by constitution is conceptually compatible with multiple realization because constitution even in this conservative framework does not exclude variability when aspects of

plasticity and adaptability are taken into consideration. Let us call this condition for *constrained disjunctive constitution*. Thus, both metaphysical and empirical requirements are preserved for disjunctive constitution; metaphysically, one and the same property could be realized by a disjunction of relevant constituents, such as different types of neurons in aliens and other species. Empirically there is support for the kind of variability exemplified by disjunctive constitution being constraining but flexible enough to afford realization (Schouten and de Jong, 1999; Strappini et al., 2020). Still there is one important caveat to this story. Disjunctive properties instantiating functional roles as constituents in humans means sets of neurons standing to each other in *synchronous non-causal relations* to each other. Only their structural arrangement is metaphysically necessary for realization as long as they fulfill the requirement of being neurons. Disjunctive properties as instantiations of restricted constituents require then the presence of one and the same type of constituents for realizing higher-order properties such as D(W). Thus, because constrained disjunctive constitution represents *types* of properties, it is still open for those constitutive properties to express variability as *tokens* of that type. Anyhow, the restrictions imposed on realizers representing *the right type* of constituents makes this variant of disjunctive property realization explicitly conservative and chauvinistic. What physical realization by constitution apparently misses is the role played by the *dynamics* of the constituents; neurons do not realize mental properties only *as* neurons but essentially by the instantiation of their communication and connectivity patterns in brain networks (Demertzi et al., 2013; Fernandez-Espejo et al., 2012; Zhao et al., 2019). Thus, constitutive realization should be complemented by the dynamics of its components; their open-ended, synergistic, and distributed character exemplifying the degree of constraint and variability. The important question now is whether physical realization by constitution actually provides the right background for understanding the kind of variability relevant to multiple realization. Therefore, we are now in a position to evaluate the virtues of functional role occupancy and constitutive realization either in isolation or in combination. Several points we have already touched upon give us reason to doubt that physical realization by constitution alone can provide the kind of variability intended by multiply realizing systems. Following

multiple realization, this kind of variability must be sufficiently flexible yet stable enough to block reduction by type identities. First, in cases where multiple realizability is assumed, constitution is openly chauvinistic in the sense that it requires the existence of a unique property or a limited set of properties to be recurrent; this represents a *parochial attitude* towards realizability (Shoemaker, 2011). In line with multiple realizability, it seems implausible to believe that the diversity of the realizing bases by which nature may opt for the realization of higher-order properties would be so restricted.

Second, constitution explains higher-order properties like beliefs in terms of their material constituents or what seems to be equal to, in terms of their grounding mechanisms. This strategy misinterprets the very psychological character of our belief systems because its emphasis on constitution leaves out the *reasons, motives, purposes* and *contents* of our beliefs by means of which they are just what they are; beliefs. Third, a constitution view of realization regards variability as more or less static, *non-causally synchronous*, missing the role of the dynamics involved in the *formation and maintenance* of higher-order properties in psychology and biology. Fourth, realization by constitution is compatible with reduction through species-specific local identities. Fifth, constitution makes the functions played by the properties being realized dangerously epiphenomenal and relative to the causal efficacy of their material constitution. In other words, a closer look at the role of disjunctive constitution does not seem to serve the prospects of multiple realizability. Taken together, these points give us reasons to regard the kind of variability expressed by physical constituents as different in kind from the kind of variability intended by multiple realizability.

10. Amending constitution by making it dynamic

If disjunction of properties tracks variability it better does so by a different route than constitution *alone*. The suggestion is that a more reasonable alternative would be to *combine* the merits of constitution with the more ontologically relaxed claims of causal role functionalism. The emphasis here is on the *flow* of the connectivity pattern instantiating the functional

description, making the requirement on the constituents more relaxed without ignoring the existence of natural constraints. Thus, in theory, suitably arranged sets of constituents could implement the defining causal role (C) and do the same work, as long as they are sensitive to the variability in the flow of the processes necessary to create and maintain the phenomenon. In order to block the risk of inflation on the choice of constituents, at least some of the constraining characteristics imposed by constitution should be preserved and recognized as valuable: the variability of the causal connectivity patterns implemented by the realizing properties of the system states must be constrained by evolutionary and developmental background conditions and consequently by certain reasonable restrictions imposed on the material composition of the constituents. Therefore, many cases of realizers might do but not *any one* of them would do either; we do not obtain mental properties by combining varieties of cheese. Physical realization as constitution is about synchronously and non-causally grounding the existence of mental properties and nothing more. Once higher-order properties have so been grounded it is up to them to function in whatever way their special conditioning circumstances necessitate. They are merely grounded by their constituents, that´s all. Their functional profile is the result of embedded synergies. Further, physical realization by constitution does not mean higher-order properties necessarily inhere all their qualities from their realizers. Instead they develop own qualities and responses at their proper level of organization as a result of the adaptive needs specific to the system. Some structures and properties depending on their level of complexity would be strictly grounded in the common arrangement of the constituents giving rise to the higher-order property in question, others not (Gillett, 2010). Thus, the cutting index of diamonds is a higher-order property irreducible to its constituents; the carbon atoms in isolation by themselves do not cut and are not indexed by cutting values. It is their collective configuration that allows the diamond as a whole to possess the functional property of cutting through glass. Obviously, the presence of the carbon atoms and their atomic configurations *is* paramount for the diamond being a diamond at all, because no other elements than carbon can be arranged in the proper way to *be* a diamond. The explanation and description of the cutting index of diamonds is expressed by the suitable vocabulary of minerology.

Applying the same reasoning to the mind then, constitution as grounding relation would explain why mental properties exist at all but make no epistemological claims about why they are the way they are; making use of constitution as physical realization for mental properties is primarily about ontology not about epistemology. A further illustration would make the point hopefully clearer. In the statue-bronze example the statue and the bronze represent a mereological relation; the whole (the statue) is made by the parts (the bronze atoms) and the parts made up the whole. Still, the mereological relation misses the *idea* with the statue as such i.e., its representational content. The statue may represent Beethoven or a unicorn; the mereological relation is the same but the intended representation varies. The shape of the statue then is the *abstraction* out of which the constitution makes sense and may play a role in the network of contingent factors making up the networks of values and signifying properties it belongs to (Barbieri, 2011; Maran and Kleisner, 2010). In the same way, neurons constitute their mental properties both locally and collectively at the level of brain activity, but the idea or purpose with the constitution is to implement, among other things, thinking, and thinking is abstraction. Neurons and only neurons could be fundamental for the development of thinking minds. Nevertheless, their constituent character must express the presence of variability at the level of the thinking mind. The dynamics of the responsible constituents must counterbalance the dynamics of thinking as observed in its contextual and developmental aspects. From a scientific point of view, the grounding ontology of mental properties in the context of physicalism is best approached by the neurosciences but the proper explanation of mentality *as a function* of the mind implemented in behavior is best achieved by the science of psychology. Therefore, we can have a plurality of explanations for mental properties running in parallel encompassing different levels of representation without having reduction. Constituents *occupy* the functional roles of higher-order properties as the metaphysical conditions necessary for those roles to exist but nothing more besides that. Constituently speaking, any changes at the level of mental properties is reflective of changes in the grounding conditions provided by their brain constituents and their inherent dynamics.

Yet, the *dynamics* of those changes is characterized by the *abstracting behavior* of mental properties not by their brain constituents. It is in the domain of psychological science that the dynamics of these abstract models of behaviors are best approached and integrated into an explanatory framework that considers, among other things, the context-dependent and embodied nature of these properties (Albarracin and Pitliya, 2022; Buccino and Colage, 2022). The main virtue of constituents as grounding conditions is that their very constraining character provides the necessary stability conditions for non-reducible properties to obtain at all. Nothing changes this picture if we replace realizing bases by disjunctive properties acting as constituents, as long as these sets of disjunctions represent natural kinds in the way of HPCs intended here. In a sense, realization by constitution is compatible with a weak form of emergence, because constitution provides for higher-order properties that are derivable but whose proper functioning is not fully explainable by the constituent properties of their realizers alone. As a result, disjunction as constitution would be compatible with multiple realizability even under constrained conditions. The only caveat to keep in mind here is that constitution as disjunction is selective in the sense that only a limited range of properties allow for the kind of variability needed for multiple realization to follow. The nature of diamonds is limiting when it comes to disjunction, because no configuration other than those present in the atomic boundaries of carbon atoms present in diamonds would do the job. In the case of mental properties, we assume a more relaxed attitude towards their possible constituents and their variability. The running intuition is that mental properties are natural properties that are distributed across species, retaining unique properties in specific instantiations. The experience of hunger seems at least from a coarse point of view common to many creatures, and as such represents a unifying experiential as well as functional ground, but the specifics of the physiology that realizes hunger vary from species to species (Jourjine, 2017).

11. Conclusion

So far, we have established that if we assume that disjunction of properties represents natural kinds in terms of homeostatic property clusters,

then realization by disjunction finds a reasonable way out of the originally stated dilemma. We also see that disjunction as material constitution takes up restricted sets of realizing properties, but that any reduction by local identities can be blocked by these disjunctive properties grounding a form of weak emergence. We also observe that the explanatory value of irreducible properties lies in epistemological claims that are best addressed by relevant special sciences such as psychology, mineralogy, and biology. The abstractions from physical details are important as a way of understanding the phenomenon and the hallmark of special sciences is their capacity to produce abstractions with explanatory weight. Making use of constitutive disjunction does not preclude either the explanatory powers of higher-order sciences and their properties. Rather, the virtue behind constitutive disjunction lies in making it possible and even reasonable to expect the explanation of the functional aspects behind these properties couched in the vocabulary typical of those sciences in which *generalizable abstractions* of behavior play a fundamental role. Our analysis shows that: a) Higher-order properties can be realized by disjunction of lower-order properties without necessarily jeopardizing the requirement on *natural kindness* imposed on the latter. b) The kind of variability imposed by the multiple realizability thesis can be selectively restricted for certain properties such as mental ones being realized by neurons c) That the constraining effects of physical realization by constitution must also be counterbalanced by causal role instantiation in order to realize the *dynamical* characteristics of higher-order properties d) Explaining the nature of a higher-order property like the desire for water is in part achieved by the metaphysical grounding of its neuroscientific constituents but that the explanation of its functional role is best achieved by the explanatory powers of non-reducible sciences like psychology. e) Abstraction plays an important role in the realization relation.

In general, there seems to be a way out of the disjunctive dilemma that, according to the critics, affects multiple realizability: combining the virtues of property disjunction as cases of homeostatic property clusters with the selective constitution of realizers, complemented by functional role explanations. The variability appealed to in multiple realizability, which is necessary to ensure irreducibility, is not blocked by the use of disjunctive properties as the basis for this variability. Multiple realizability then stands as

an open alternative to the irreducibility of mental properties to their neuronal constituents; mental properties could be constitutively realized by only one kind of structures and their properties, i.e., neurons. Still, this picture is stationary and inherently "locationalist" enhancing the role of constituents as examples of mereological and non-casual synchronous properties. The dynamical aspect of the realization involved requires a liberalization of the role played by constitution in a complementary way that enhances global and distributed patterns of realization. Constitution must capture the dynamics of realization, and so this can be done both by having disjunctive constitution as one option and by having functional role implementation as its complement (Bressler and Kelso, 2016). The goal of this paper has been to work on the analytical flaws and virtues of multiple realizability. One of these vices, according to the critics, is the use of disjunctive properties to ground the variability of realization. The analysis has been intended to show that the plausibility of multiple realizability thesis still stands the test even when based on the use of disjunction as the subvenient ground for realization.

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