Synthese (2025) 206:241
https://doi.org/10.1007/s11229-025-05317-8

ORIGINAL RESEARCH

Why prosocial octopuses challenge the autonomy of psychological states

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Received: 29 April 2025 / Accepted: 8 October 2025
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Abstract

Researchers administered MDMA (known as ecstasy) to octopuses and observed their behavior. Due, at least in part, to serotonin transport systems nearly identical to human ones, octopuses on ecstasy behave in a prosocial manner. This observation suggests that neurochemicals, like serotonin, which are conserved across taxa, contribute to the realization of some psychological states. Since standard functionalism claims that not only can psychological states be multiply realized, but that psychological states are also autonomous from neural states, then this eccentric experiment reveals an important challenge. Using recent research in neuroscience and a mechanistic account of multiple realization, I argue that certain cases of multiply realized psychological states always include specific neurochemicals (i.e. neurotransmitters), and this undermines the kind of multiple realization that is needed to warrant autonomy. I conclude that the multiple realization of psychological states does not guarantee autonomy from neural states and that the functionalist claims for autonomy are not empirically justified.

Keywords Multiple realization · Psychological states · Mechanisms · Functionalism · Neurochemistry · Autonomy

In the philosophy of mind, the core doctrine of functionalism is usually interpreted to entail that psychological states are multiply realizable and, therefore, psychological states are autonomous from neural states.[1] This latter autonomy claim is the strongest of the two and is mostly responsible for the profound influence that functionalism

[1] While several variations of functionalism exist (i.e., machine state functionalism, psychofunctionalism, and computational functionalism), many of their differences are rather subtle. The issues that I will address

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Published online: 05 November 2025

has had on the cognitive sciences. However, a large portion of the recent literature critical of functionalism has mostly targeted multiple realization, while autonomy has received less attention, with some notable exceptions.[2,3] Perhaps the general assumption has been that autonomy is entailed by multiple realization; thus, to challenge functionalism, the proper target ought to be multiple realization.

Recently, some philosophers have narrowed their focus toward challenging the claim that psychology is autonomous from neuroscience or that psychological states are autonomous from neural states. Piccinini (2020) and collaborators (Piccinini & Craver, 2011; Boone & Piccinini, 2016) have advocated a cognitive neuroscience revolution or a paradigm shift in which cognitive neuroscience has emerged as the new approach to studying cognition.[4] This new paradigm replaces traditional cognitive science (influenced by functionalism), based on functional analysis and autonomy, with a multi-level mechanistic account of cognition. Within this paradigm shift, psychology cannot progress without incorporating the study of neural mechanisms. Importantly, functional states must be incorporated into and constrained by the neural structures that perform the functions. I will further support this paradigm shift to a multi-level mechanistic account of cognition by defending two empirically driven claims:

1.) Conserved neurochemicals (e.g., serotonin) contribute toward the realization of certain psychological states and are always present when these psychological states are realized.
2.) The kind of multiple realization of psychological states that is supported by empirical evidence does not support the autonomy of psychological states from neural states.

These theses will be motivated by a recent study in which researchers (Edsinger & Dölen, 2018) administered the psychoactive drug MDMA to octopuses. MDMA, also known as ecstasy, increases serotonin levels and produces prosocial, euphoric, and empathetic behavior in humans (Mustafa et al., 2020). Octopuses possess a serotonin transport system that is nearly identical to the human one. Researchers hypothesized that since octopuses have a similar serotonin system, a drug that increases serotonin within human synapses should also increase serotonin within octopus synapses. Furthermore, if serotonin has similar behavioral effects in humans and octopuses, increasing serotonin in octopuses might increase octopus prosocial behavior. Their unique experiment was able to confirm this hypothesis: octopuses on ecstasy are more socially engaged than control octopuses.

(multiple realization and especially autonomy) overlap with most versions of functionalism. Thus, when I refer to functionalism, I am referring to it in a broad sense.

[2] Challenges to multiple realization (Bechtel & Mundale, 1999; Shapiro, 2000; Bickle, 2003, 2010; Couch, 2004); Polger & Shapiro, 2008, 2016, 2023 (Cao, 2022).;

[3] Discourse on autonomy (Bechtel, 2006; Richardson, 2008; Gillett & Aizawa, 2011; Aizawa, 2018; Batterman, 2018; Fang, 2020; Piccinini, 2020): (Chapter 2); Aizawa & Gillet, unpublished.

[4] For similar approaches, see (Keeley, 2000; Bechtel, 2007; Kaplan, 2011; Cao, 2022).

While this experiment could be viewed as consistent with the multiple realization of psychological states between different species, I will argue that it creates a challenge for the autonomy of psychological states. If neurochemistry is not only making causal contributions toward the realization of certain psychological states but is also always present during this realization, and I will present empirical data that supports this, then autonomy claims are in a compromised position. To articulate this challenge, I adopt a new mechanistic framework for assessing multiple realization. Piccinini (2020) has defended three mechanistic kinds of multiple realization (MR_1 – MR_3), which provide a detailed account of how two or more systems can be multiply realized. I will argue that a fourth kind exists (MR_4), which will be relevant when discussing conserved neurochemicals. By considering multiple realization within a mechanistic framework, I will argue that the sources of multiple realization that are compatible with the evidence for the multiple realization of psychological states (MR_1 and especially MR_4) are not the sources needed to support the autonomy of psychological states (MR_2 and especially MR_3). Thus, we have empirical justification for the multiple realization of psychological states, but we do not have empirical justification for the autonomy of psychological states from neural states.

In the next section, I will discuss three different kinds of autonomy and highlight which kind of autonomy is relevant to this project. I will also discuss why I employ a mechanistic account of multiple realization in contrast to the dimensioned or the flat views. In the second section, I develop this mechanistic account of multiple realization and locate the proper sources of multiple realization needed to grant the kind of autonomy I have in mind. In the third section, I will demonstrate why the octopus experiment creates problems for the functionalist's autonomy claims. In the fourth section, motivated by the octopus experiment, I will discuss two other psychological states that appear to be driven by conserved neurochemicals, along with the possibility of conserved pain mechanisms. I will conclude section four with my argument that the autonomy of psychological states is not empirically justified since conserved neurochemistry is often present and makes important contributions toward the realization of various psychological states.

Going forward, when I refer to multiple realization, I will use the symbols MR, and when I refer to the multiple realization of psychological states, I will use the symbols MRΨ. Additionally, while the terms "multiple realization" and "multiple realizability" are closely related, there is an important difference. For two systems to be multiply realized, they must be realized in this world. Multiple realizability, on the other hand, is consistent with merely possible (as opposed to actual) multiple realization. With this project, I will leave out modal hypotheticals and focus on whether psychological states are (actually) multiply realized. Lastly, functionalists typically claim that psychological states are functional states. However, this definition is unsatisfactory when considering psychological states within a biological context. When I refer to a species realizing a psychological state, I have in mind mental conditions that include beliefs, desires, thoughts, and sensations that can motivate behavior.

1 Functional minds

The theoretical foundations of most theories of mind in psychology and cognitive science carry the fingerprints of functionalism, as it has shifted discussions away from neuroscientific evidence and towards evidence regarding the operations or functions of psychological states.

1.1 Detaching psychological software from neural hardware

Functionalism holds that the mind is the functional organization of the brain, or that mental or psychological states are functional states, and the nature of functional states is just their (relevant) causal relations with inputs, outputs, and each other (Piccinini, 2010). The infamous motto associated with functionalism is that the mind is the psychological software that is executed by brain hardware.[5] Importantly for the functionalist, psychological states can be multiply realized (MR'd), that is, a psychological kind can be realized by various physical kinds. The classic example introduced by Putnam (1967) considers the mental or psychological state of pain. In this view, pain can be MR'd since the hardware that realizes pain in humans is not the same hardware that realizes pain in other species, like octopuses. According to this multiple realization argument, psychological states or processes cannot be identified with brain states or processes since psychological states can be MR'd (Polger & Shapiro, 2023). Additionally, non-biological materials are perfectly capable of producing psychological states, like pain or hunger, as long as the output is a functional state. Or as Putnam (1975) sarcastically claimed, even if we were made of Swiss cheese this wouldn't preclude us from having psychological states.

Richardson has pointed out that the multiple realization argument has "historically mandated the autonomy of psychology, and its principled irreducibility to neuroscience" (2008, p. 526). Likewise, Bechtel and Mundale, in their critique of the multiple realization argument, frame it as a claim that "information about the brain is of little or no relevance to understanding psychological processes" (1999, p. 176). Bechtel and Mundale infer what Richardson explicitly stated, that the multiple realization argument is committed to the view that psychology, in some sense, is autonomous from neuroscience. However, what exactly is meant by the autonomy of psychology, or autonomy in general, is often unclear. While the concept of autonomy is frequently discussed within MR discourse, specific definitions or a detailed taxonomy of autonomy are in short supply.[6] This lack of exposition regarding autonomy is significant since it is the autonomy claim (not MR) that dissociates psychology (and/or psychological states) from neuroscience (and/or neural states).

Since functionalism is largely an anti-reductionist philosophy, the best way to get a handle on autonomy is to develop it as the antonym of reductionism. Sarkar

[5] Depending on the version of functionalism this motto is either a metaphor or it is a literal claim. Computational functionalism would advocate for the latter since it holds that mental states are computational states.

[6] For discussion on autonomy within MR discourse, see (Fodor, 1997; Bechtel, 2006; Richardson, 2008);: Gillet & Aizawa, 2011 (Aizawa, 2018; Batterman, 2018; Fang, 2020; Piccinini, 2020); Aizawa & Gillet, unpublished.

(1992) has developed three categories of reductionism: theory, explanatory, and constitutive reductionism. As a result, I propose three categories of autonomy that run in the opposite direction: theory, explanatory, and constitutive autonomy. According to Sarkar, *theory reductionism* is a relation between theories (or laws) in which one theory (or law) can be reduced to another when the reduced theory (or law) is derived from the reducing theory (or law). *Explanatory reduction* occurs when a reduced entity can be explained by a reducing entity. *Constitutive reduction* is a kind of ontological reduction in which an upper-level system (or entity) is dependent on or conforms to a lower-level system (or entity). In this view, a higher-level system (or non-fundamental level) does not have distinct causal powers from its lower level (or fundamental level).

Taking Sarkar's three categories of reduction in the opposite direction, we have *theory autonomy*, in which the theories (or laws) of some higher-level scientific discipline are not derived from the theories (or laws) of some lower-level scientific discipline. With *explanatory autonomy*, higher-level explanations are distinct from lower-level explanations. *Constitutive Autonomy* is the view that the causal powers of a higher-level system (or entity) are distinct from the causal powers of its lower level.

Regarding the current project, theory autonomy is the claim that psychology as a discipline is distinct from neuroscience as a discipline since psychological theories or laws are not derived from neuroscientific theories or laws. Concerning explanatory autonomy, explanations of psychological phenomena are distinct from neuroscientific explanations, since they do not need to appeal to the lower neurological level. Lastly, constitutive autonomy is the claim that psychological states, since they are functional states (causal relations with inputs, outputs, and each other), are distinct from their neural realizers in the sense that they have at least some causal powers that are distinct from those of their neural realizers. Putnam's Swiss cheese statement, albeit heavily sarcastic, embodies constitutive autonomy since specific materials are not relevant with respect to achieving higher-level psychological states.

In my view, constitutive autonomy is the strongest of the three kinds of autonomy since it warrants the realization of psychological states in non-biological systems and will thus be the target of this paper. Note that constitutive autonomy captures what many might think accounts for MR. However, this assumption is mistaken. MR simpliciter is the claim that a higher-level property can be realized by multiple sets of realizers that differ in some way. Convergent evolution provides good examples of MR. However, in convergent evolution, there are often some similarities in the realizers across different systems. The MR argument, as it has typically been employed within philosophical discourse goes further and claims that different realizers can be fully distinct from one another. This claim for the full distinction between different realizers is the kind of MR that establishes constitutive autonomy. Thus, as I see it, the MR argument that psychological states can be realized without any biological anchoring requires the right sort of MR. With this project, I will argue that constitutive autonomy lacks empirical justification since some putative cases of the multiple realization of psychological states (MRΨ) always include the same neural realizers.

1.2 Anticipating an early objection

One could dismiss my project and claim that the kinds of autonomy that are discussed within the literature are predominantly theory autonomy and explanatory autonomy, not constitutive autonomy. For example, Fodor claims that "a law or theory that figures in bona fide empirical explanations, but that is not reducible to a law or theory of physics, is ipso facto *autonomous* … the states whose behavior such laws or theories specify are functional states" (1997, p. 149). Here, it seems like Fodor is directly appealing to theory autonomy and explanatory autonomy. Constitutive autonomy is not addressed. Aizawa (2009), along with his collaborator Gillet (unpublished), has made this point. In their view, no one except Putnam in his early work endorses the claim that neural hardware is totally irrelevant to the software of psychological states. However, in my view, constitutive autonomy is endorsed by most functionalists. Consider Block and Fodor: "it is possible to build a machine which is similar to the organism psychologically, but physiologically sufficiently different from the organism that the psychophysical correlation does not hold for the machine" (Block & Fodor, 1972, p. 161). On this account, if a machine can realize psychological states, then neural material is not necessary for the realization of psychological states. This quote appears to be a direct endorsement of constitutive autonomy. Consider Fodor again: "psychological states are functional and laws and theories that figure in psychological explanations are autonomous" (1997, p. 149). Here, Fodor is appealing to both theory and explanatory autonomy, but an endorsement of constitutive autonomy is cloaked within this quote since he appeals to psychological states as functional. Broadly speaking, functionalists, including Fodor, endorse the view that psychological states are functional states. On this account, functional states are characterized by what they do as opposed to what they are made of. As a result, functional states can be implemented and thus realized in a variety of materials, including non-biological ones. This is an endorsement of constitutive autonomy. Furthermore, its assumed truth is evident in several influential research programs that claim that minds do not need to be anchored by neural material (e.g., classical cognitive science, artificial intelligence, and many versions of the computational theory of mind).

1.3 Multiple realization: flat, dimensioned, or mechanistic

The range and feasibility of MR depend upon one's conception of singular realization or the realization relation. Realization is a relation between higher-level properties and their lower-level realizers. The flat view of realization states that the causal powers of higher-level realized properties are subsets of the lower-level realizing properties that belong to one and the same entity. The dimensioned view, on the other hand, assumes a sort of building relation in which the causal powers of lower-level realizers contribute toward the causal powers of the higher-level realized property, and the realizing properties belong to the components of the entity that has the realized property. The lower-level realizers are a different set of causal powers that give rise to (or realize) distinct higher-level causal powers.

Concerning MR, defenders of the flat view claim that two or more systems are MR'd when the same function is realized with different lower-level causal systems.

Defenders of the dimensioned view of realization grant that two or more systems can be MR'd when different sets of properties realize the same property. Acceptance of either account of (multiple) realization commits one to a variety of ontological positions. For example, the flat view assumes a stance sympathetic to reductionism regarding realized properties in relation to their realizers, while the dimensioned view assumes a non-reductionistic stance. Additionally, as critics have pointed out, the dimensioned view makes MR a potentially trivial notion since any difference between two or more realizers can justify MR (Shapiro, 2000; Polger & Shapiro, 2008, 2016). Conversely, critics of the flat view have pointed out that it is overly restrictive and ultimately dispenses with MR in favor of a reductionistic ontology that denies higher-level properties any unique causal powers (Gillett, 2003; Aizawa & Gillett, 2009; Gillett & Aizawa, 2011; Aizawa, 2017).

An alternative to the flat and dimensioned views of MR is a mechanistic account defended by Piccinini. On this account, when the "same capacity of two systems is explained by two relevantly different mechanisms, the two systems count as different realizations" (Piccinini, 2020, p. 47). The reductionistic flavor of the flat view and the non-reductionism of the dimensioned view are avoided since higher-level realized properties are an aspect of their lower-level realizers.[7] Additionally, this mechanistic account of MR permits certain elements of both the flat and the dimensioned views while avoiding their difficulties. For example, this mechanistic account of MR, unlike the flat view, does not subsume the causal powers of the higher-level realized properties as subsets to their lower-level realizers that belong to the same entity. Rather, like the dimensioned view, this mechanistic account claims that the higher-level realized property is brought about by the causal powers of lower-level realizers, and the realizing properties belong to the components of the entity that has the realized property.

One of the most important reasons for introducing a mechanistic account of MR is that it inherits a well-established new mechanistic ontology that can demonstrate how mechanisms are composed and operate. This ontology can then be employed to provide a more precise account of how and why two or more systems can be MR'd. This contrasts with the flat and dimensioned views, which often discuss MR in more abstract or conceptual terms. Importantly for this project, a mechanistic account of MR can also demonstrate why MR does not entail autonomy since it can locate specific kinds of MR that still share some or all of their realizing parts (or components or entities) while differing in other relevant areas.

2 The mechanisms of multiple realization

The formal approaches advanced by the logical empiricists that dominated the philosophy of science for much of the 20th century eventually ran into a variety of problems. Notably, their formal programs could not tether down the largely lawless

[7] This balance between reductionism and non-reductionism is plausible given Piccinini's egalitarian ontology (Piccinini, 2020). However, I do not think one needs to fully endorse this ontology to accept a mechanistic account of MR. Anyone sympathetic to a new mechanistic ontology could accept this mechanistic account of MR.

special sciences. Mechanistic thinking, since it is more compatible with the special sciences, presents a material alternative.

2.1 Mechanistic thinking

The broad claim coming from neo-mechanistic thinking is that a wide array of natural phenomena arises through mechanistic operations. A concise and useful definition of what a mechanism is has been provided by Glennan, according to whom a mechanism "for a phenomenon consists of entities (or parts) whose activities and interactions are organized so as to be responsible for the phenomenon" (Glennan, 2017, p. 17). By entities, Glennan means the components or the parts that make up a mechanism (e.g., neurons, receptors, neurotransmitters). Entities have mostly defined borders and exist in space-time. Activities are the actions of a mechanism that result when entities interact (e.g., pumping, pulling, firing). Organization refers to the spatial, temporal, and causal arrangement (among others) of the entities that allow for activities to occur. Collectively, the interaction of entities through their organization produces activities that ultimately give rise to the production of a phenomenon. The image below is my rendition of what has become known as a Craver diagram (for an original version see, Povich and Craver, 2017) (Fig. 1).

The mechanism as a whole or system S is a complex entity that performs some activity or function Ψ (see upper level). A system, on this account, is a whole that is composed of multiple mechanisms that perform various activities or functions. At a lower level below S Ψ-ing, an organization of entities $X_1 – X_4$ is engaging in activities Φ_1- Φ_4 (see middle level). The arrangement of the nodes represents the spatial organization, while the arrows between each node represent the temporal organization of the mechanism. Each entity at the middle level is also composed of entities

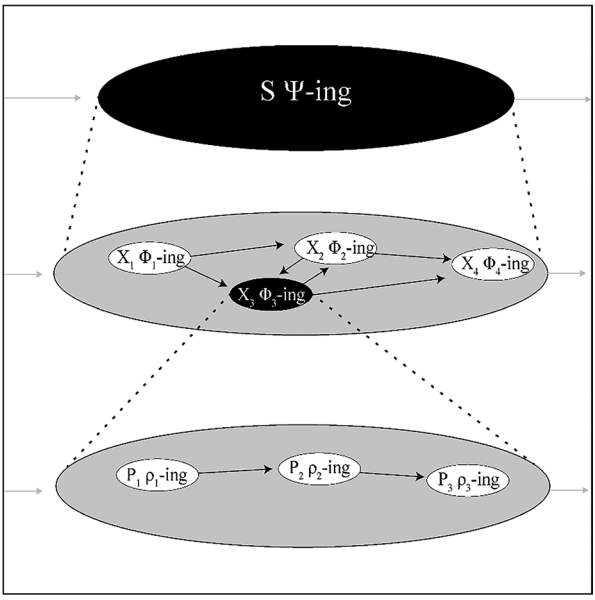


Fig. 1 Craver-type diagram of a mechanism

and activities at a lower level as well. We can say that each entity from the middle level (Xs Φ-ing) is produced by the mechanisms at the lower level (Ps ρ-ing). The whole system S is composed of multiple levels of mechanisms nestled within one another that allow a system to engage in the performance of a higher-level function.

Glennan's account of mechanism is largely accepted as capturing the concept of a mechanism. However, some variations regarding the more specific details of how mechanisms should be represented still exist. Piccinini (2017) has argued that we can account for all of the important aspects of a mechanism without positing activities (in addition to properties). On his account, activities are just the manifestations of causal powers (or capacities) that occur when entities (components) are introduced to their appropriate partners (other components). Thus, on his account, a mechanism can be explained by the components that compose it, along with their capacities and the overall organization of the components. Going forward, I will use Piccinini's mechanistic terminology (components over entities, and component capacities/causal powers over activities). This will be especially useful when distinguishing the different sources of MR.

Three additional details need to be clarified regarding Piccinini's mechanistic account of MR (2020). Firstly, when referring to the same component types we are referring to components that share the same capacities or causal powers, even though they can differ in their materials. For example, if one switched out a hard-plastic component of my printer with a hard rubber component of the same shape, this would count as two components being the same type since their capacities (shape and hardness) are the same. Conversely, two-component types would be different if they did not share the same capacities or causal powers.

Secondly, two organizations would be the same as long as they occupy the same spatial, temporal, operational, and causal arrangements. Spatial sameness occurs when components are arranged in the same way. Temporal sameness refers to the same sequence of operations. Operational sameness refers to the same operations that are needed to produce a given capacity. Causal sameness refers to the sameness of causal powers that affect each component. Differences in any of those types of organization would yield a different organization of a given system.

Thirdly, while mechanisms can be composed of multiple levels, concerning MR, only the highest level (the realized level) and the level below it (the realizing level) are relevant since, according to Piccinini, realization is the relation between two adjacent mechanistic levels within a multi-level mechanism. On this account, when comparing two different mechanisms that are realizing the same higher-level property or function (the realized level), only the direct level beneath it (the realizing level) is compared to one another. Thus, going forward, all discourse and representation of mechanisms are dual leveled: a realized level and a realizing level.

2.2 The mechanisms of multiple realization

Piccinini's (2020) mechanistic framework encompasses three sources of MR. The first source occurs "when the same component types exhibit the same capacities, but the organization of those components differs" (Piccinini, 2020, p. 55). This source of

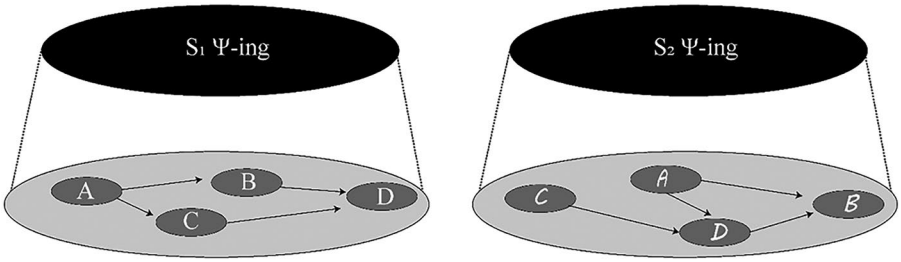


Fig. 2 MR_1

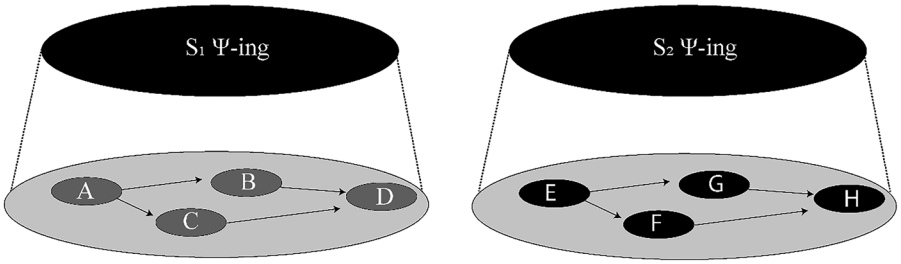


Fig. 3 MR_2

MR is referred to by Piccinini as MR_1. The Craver-type diagram in Fig. 2 represents MR_1.

Here, S_1 and S_2 are different systems performing the same activity or function, Ψ-ing. Notice that both systems are composed of the same component types, A, B, C, and D. However, their organization is entirely different. As I said, by the same component types we mean the same capacities or causal powers, not necessarily the same materials, thus the different font in system 2 in the image above. With the different organizations, differences could occur via spatial, temporal, operational, and/or causal arrangements.

Many cases of convergent evolution would be an example of MR_1. Convergent evolution occurs when distantly related species separately acquire similar phenotypes through the pressures of natural selection (Alcock, 2009). For example, octopus eyes and vertebrate eyes evolved separately, yet they are both camera eyes with similar composition and function. They both have retinas, photoreceptors, optic nerves, corneas, etc (Harris, 1997). The components, being composed of similar biological material retain the same causal powers, yet the spatial and temporal organizations differ.

The second source of MR, MR_2, occurs when "components of different types are organized in the same way to exhibit the same capacity" (Piccinini, 2020, p. 56). The diagram in Fig. 3 represents MR_2.

Here, the capacities of the component types are entirely different, while the organization is the same. Notice that the system on the left is composed of different components (A, B, C, D) in contrast to the system on the right (E, F, G, H), yet they maintain the same organization. MR_2 would be a source of MR when two or more systems

share the same organization, yet one system is composed of biological material while the other is composed of non-biological material. For example, artificial eyes have been created that maintain the same structure and organization of a human eye, yet with non-biological components (the eyeball is a metal shell, the retina possesses a dense array of light-sensitive nanowires that act as photoreceptors, and liquid metal wires act as the nerve fibers) (Gu et al., 2020).

The third source of MR, MR_3, is a combination of both MR_1 and MR_2. Here, two mechanisms produce the same function while being composed of different component types (including different causal powers) and different organizations (spatial, temporal, operational, and/or causal). The diagram in Fig. 4 represents MR_3.

Here, nothing about either mechanism is the same, except for the function that is produced. For example, bats and submarines use echolocation, yet this function is realized through different components and organization. Bats produce their sounds through their larynx while they receive the returning sound through their ears (Moss et al., 2023). Submarines transmit and receive their sounds through non-biological components and organization.[8]

There is a kind of MR not mentioned by Piccinini. Consider a hybrid case, in which two systems that produce the same function have some similarities, either some shared components, some shared organization, or a combination of some shared components and organizations. I refer to this source of MR as MR_4. Figure 5 is a limited representation in that I only present a version that shares components, not organization (this version is particularly relevant).

Here, both component types A and C are present in both systems, yet the other components differ, and the organizations differ.

In contrast to convergent evolution, conserved characters refer to phenotypes that have largely been retained from ancestral descendants (Futuyma, 2005). In these cases, some genes or clusters of genes have been conserved across taxa since they produce phenotypes that have proven to be essential for producing normal functioning. Cases of conserved characters would be examples of MR_4 since they retain some components, yet everything else regarding the two systems is different. In sections 3

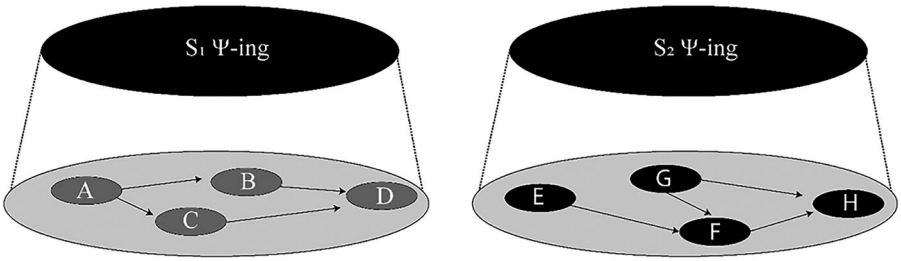


Fig. 4 MR_3

[8] While echolocation in species like bats is a sensory perception that provides spatial awareness through sensations and thus could be described as a psychological state, I would not consider the submarine as having a psychological state. Thus, what is being MR'd in the bat and submarine example is an echolocation that provides spatial information as opposed to spatial sensations.

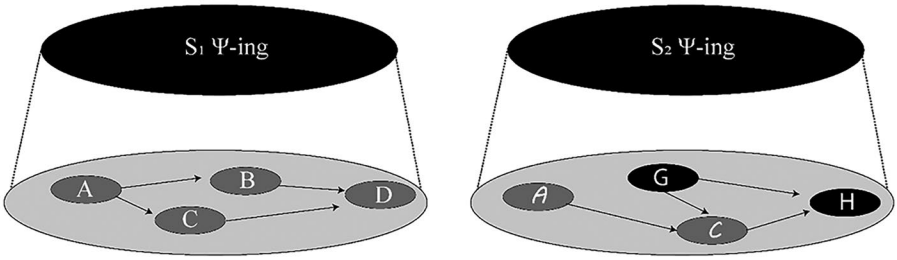


Fig. 5 MR_4

and 4 I will discuss several cases of MR_4. Below is a summary of the four mechanistic sources of MR:

MR_1: difference in organization yet component types are the same.
MR_2: difference in component types, yet the organization is the same.
MR_3: difference in both organization and component types.
MR_4: some shared component types and/or some shared organization.

Is there a source or sources of MR that is compatible with constitutive autonomy? For example, let S_1 be a human, and S_2 a robot, and Ψ-ing wincing. Thus, S_1 Ψ-ing is a human wincing, and S_2 Ψ-ing is a robot wincing. In order to justify autonomy, the neurological components and organization that realize the wincing in S_1 cannot be included in S_2. This stipulation would remove MR_1 from consideration as a source of autonomy. While MR_1 can justify MRΨ, as in cases of convergent evolution, MR_1 cannot justify autonomy since systems that embody MR_1 share the same components and capacities. Regarding MR_4, this is a source of MR in which some component types and organization are shared across systems, and, like MR_1, this would preclude the justification of autonomy as well.

MR_2 and MR_3 would be the live options that can justify autonomy since they involve different component types across two or more systems. For instance, S_1 Ψ-ing and S_2 Ψ-ing must have different component types; the neurological material in S_1 cannot be in S_2, thus autonomy is justified in MR_2 and MR_3. However, it should be noted that for discussions regarding the autonomy of psychological states from any neurological basis, MR_2 is an eccentric case since it requires different components and the same organization across systems. On this account, the neural organization in S_1 would need to be in S_2. However, it is unclear whether the organization of neural mechanisms is what is really driving the realization of psychological states. Thus, MR_3 is the strongest and most likely source of MR that can justify autonomy since it requires a difference in both component types and organization among two or more mechanisms performing the same function. In the upcoming sections, I will argue that due to conserved neurochemistry, the evidence for certain cases of MRΨ can only be supported by MR_4 (or possibly MR_1), which are not the sources of MR that can justify autonomy (MR_2 and MR_3).

3 When octopuses take ecstasy

Prosocial behaviors encompass a range of interactions that are intended to promote positive social outcomes. On this account, prosocial behaviors embody psychological states since they are realized by an individual's desire to positively interact with another individual. At the molecular level, serotonin is well known for its ability to influence prosocial behaviors (Siegel & Crockett, 2013). The serotonin transporter, or SERT, which is encoded by the gene SLC6A4, is responsible for the transport and reuptake of serotonin among neurons, and it is also the main target site for MDMA (Murphy et al., 2004). MDMA acts as an agonist to the presynaptic terminal, thus preventing the reuptake of serotonin (Carhart-Harris et al., 2015). This reuptake prevention allows for more serotonin to populate a synapse, which increases the likelihood of additional serotonin to latch onto postsynaptic receptors.

Recently, orthologs that encode the human serotonin transporter protein (SERT) have been identified in various species, including *Drosophila melanogaster*, *C. elegans*, several vertebrates, and *Octopus bimaculoides* (Edsinger & Dölen, 2018). Orthologs are "homologous genes that relate through speciation from a single ancestral gene present in their latest common ancestor" (Kuzniar et al., 2008, p. 540). Importantly, proteins that are encoded by these homologous genes maintain their function throughout evolutionary time. Thus, if the gene that encodes the SERT protein is discovered among a wide variety of species, then its overall function is thought to be conserved. Since MDMA blocks the reuptake of serotonin, making more of it available in the synaptic cleft, any species that possesses the genes that encode SERT and that uses serotonin to regulate prosocial behavior could, in principle, exhibit prosocial behavior when administered MDMA.

In Edsinger and Dölen (2018), researchers Eric Edsinger and Gül Dölen administered MDMA to octopuses to study whether the drug would influence social behavior. This endeavor is especially interesting since human and octopus lineages are separated by 500 million years (Kröger et al., 2011) and they maintain significant anatomical differences in brain composition. The main question was, do ancient neurotransmitter systems that are conserved across a variety of vertebrate and invertebrate species maintain the same function?

For their experiment, each octopus ($n=4$) was placed into a glass aquarium with three equally sized chambers. For each trial, a single octopus was placed in the vacant center chamber. One lateral chamber contained a novel object, a ball, which was restrained by a perforated plastic container; the researchers referred to this as the novel object chamber. The other lateral chamber contained a male octopus also restrained by a similar container; the researchers referred to this as the social object chamber.

The results for the pre-trial (no MDMA) showed that octopuses spent, on average, over half of their time in the novel object chamber. Pre-trial octopuses, on average, spent the least amount of time in the center chamber. They spent a little more time on average in the social object chamber than in the center chamber. Two of the four octopuses spent almost no time in the social object chamber.

The results for the post-trial (on MDMA) demonstrated a noteworthy change from the pre-trial. The time spent in the center chamber did not change significantly. How-

ever, the average time spent with social objects increased in contrast to the pre-trial (from around 400s to around 900s), while the average time spent with the novel object decreased in contrast to the pre-trial (from around 1000s to around 600s). Significantly, all four of the octopuses spent less time in the novel object chamber in the post-trial, while each octopus spent more time in the social object chamber than in the pre-trial. Interestingly, the two octopuses who spent under 100 seconds with the social object during the pre-trial spent more than 400 seconds in the social object chamber during the post-trial.

Additionally, the quality of the social interactions in the post-trial revealed a significant difference from the pre-trial interactions. During the pre-trial stage, when the octopuses were in the social chamber, they demonstrated minimal contact with the social object. Usually they extended only one tentacle. The post-trial octopuses, on the other hand, were much more engaged with the social object: "social interactions were characterized by extensive ventral surface contact, which appeared to be exploratory rather than aggressive in nature" (Edsinger & Dölen, 2018, p. 4). Not only did the post-trial octopuses spend more time in the social object chamber, but they also interacted with the object with much greater intrigue. They appeared to be genuinely interested in the social object.

It is important to point out that octopuses are by nature a solitary, asocial species (Scheel et al., 2016). They do not often demonstrate prosocial behaviors unless they are attempting to mate, and they tend to have minimal contact with members of the same sex (Huffard, 2013). Thus, the pre-trial results are what one should expect from the socially adverse octopus. Therefore, the post-trial reversal in social behavior after MDMA administration is significant.

There are some obvious challenges to the above experiment. Replication has not yet occurred, and the sample size for the octopuses used is small ($n=4$). However, I am not trying to claim that the experiment *proves* anything in my favor. I am merely using the experiment as a case study that highlights where the functionalist claims regarding autonomy are not empirically justified. If conserved neurochemicals, like serotonin, are always present during the realization of certain psychological states, then their pervasive presence disqualifies any justification for autonomy. Thus, in this instance, a psychological state that promotes prosocial behavior can be multiply realized; however, autonomy does not follow since serotonin is the common component across systems. Recall that the source of MR that is compatible with conserved characters is MR_4, since it permits some of the same components to be present in different systems. Thus, if a specific psychological state, such as a state that promotes prosocial behavior, is only realized when serotonin is present, then this position is only compatible with MR_4 (possibly MR_1). The sources that justify autonomy, MR_2 and MR_3, are not compatible with this evidence since they require different components as the realizers between two or more systems.

4 Conserved neurochemical realizers

In this section, I will present two other examples of conserved neurochemicals that are always present when certain psychological states are realized. These instantiate MR_4, not MR_2 or MR_3.

4.1 A conserved food seeking peptide

Along with pain, hunger was commonly employed as a type of psychological state in Putnam's early writings (Putnam, 1967). On this account, hunger is a psychological state since it promotes the desire to seek out food. Ghrelin, a peptide hormone produced mainly in gastrointestinal organs, has powerful appetite-stimulating effects. These effects include appetite regulation and food-seeking behavior (Kojima & Kangawa, 2005). Furthermore, ghrelin is the only known appetite-stimulating gut hormone (Kaiya et al., 2008) and has been discovered in all vertebrate species (Kojima & Kangawa, 2005).

While ghrelin is widespread across species, it does perform other important functions, including energy balance, the regulation of cell proliferation, and growth hormone stimulation (Seim et al., 2016). However, the role that ghrelin plays in appetite regulation and food-seeking behavior appears conserved across taxa (Kaiya et al., 2008). Furthermore, ghrelin's appetitive powers do not require any tailoring to species-specific digestive systems. Lab studies have shown that when rat ghrelin was injected into rainbow trout, the fish increased their food intake (Jönsson et al., 2007).

If the above evidence is correct that ghrelin is making causal contributions toward the realization of the psychological state of hunger, then this is another instance of the problem for autonomy claims that we've been discussing. If the psychological state of hunger can only be produced when ghrelin is present, then MR_2 or MR_3 cannot be options for the MRΨ on this account; thus, autonomy is not plausible here. The proliferation of ghrelin among such a wide array of species in the realization of the psychological state of hunger seems to only justify MR_4.

4.2 A conserved social and parental bonding peptide

Parental bonding is an emotional and physical connection between a child and its parent. It is essential for the child's development and is realized by expressions of love and care that bring about feelings of security. The emotional component and the desires to provide this kind of care qualifies parental bonding as a psychological state. The neuropeptide oxytocin has been linked to influencing parental bonding, along with social interactions and sexual behavior among a variety of species (Feldman et al., 2016). While oxytocin has also been implicated as an important contributor to other behaviors (memory, homeostasis, gustatory functions, and balancing energy), modulating social behavior and reproductive bonding appears to be its principal function (Feldman et al., 2016).

Oxytocin has been identified in all mammals, most vertebrates, and a variety of invertebrate species, including mollusks (Beets et al., 2013; Feldman et al., 2016). The proliferation of oxytocin among diverse taxa suggests that it has been present

in endocrine systems early in evolutionary history (Beets et al., 2013). Furthermore, researchers have suggested that ancestral hormonal systems "may be the primary mechanism through which long-term cooperative relationships develop between both kin and non-kin in mammals" (Crockford et al., 2013, p. 1).

Oxytocin's role in sexual behavior was famously demonstrated when comparing two similar vole species, the monogamous prairie vole (*Microtus ochrogaster*) and the polygamous montane vole (*Microtus montanus*) (Insel & Shapiro, 1992). Researchers observed that the montane vole had higher oxytocin receptor density in brain areas believed to be important for social and emotional cognition (Insel & Shapiro, 1992). Interestingly, the injection of oxytocin in the prairie voles increased pair bonding, while oxytocin antagonists prevented pair bonding (Lee et al., 2009).

Oxytocin has been shown to affect sociality among a variety of species as well. Intranasal administration of oxytocin among African lions increased social tolerance among both in-group and out-group lions (Burkhart et al., 2022). When sprayed with oxytocin, dogs showed higher affiliation and overall greater social interactions not only among conspecifics but also with their human partners as well (Romero et al., 2014).

The conservation of oxytocin across taxa and its prevalence in social behavior suggests that it is a vital component for the output of social bonding and nurturing behavior. At the moment, we know of no chemical component that can produce the same social and parental bonding behaviors other than oxytocin. Like the ghrelin case above, the prevalence of oxytocin in social bonding and/or parental care can only justify MR_4, not MR_2 or MR_3.

4.3 Conserved pain systems

Pain is often understood to be a psychological state that informs organisms that damage has occurred, along with the recognition of discomfort (Walters & Williams, 2019). C-fibers and A-delta fibers, which are responsible for the production of pain, are nociceptors and are present in nearly all species whose pain mechanisms have been studied. Nociceptors are sensory neurons that detect noxious stimuli.

Furthermore, nociceptors "make use of neuronal mechanisms that appear to be highly conserved and widespread throughout the animal kingdom" (Crook & Walters, 2011, p. 192). Species that are known to possess nociceptors include all mammals, fruit flies (*Drosophila*), roundworms (*C. elegans*), leeches, mollusks (including octopuses), fish, snakes, birds, reptiles, and amphibians (Sneddon, 2017). While the discovery of a conserved lower-level component for the realization of pain has yet to occur, there is optimism that one exists. Candidate realizers of (aspects of) pain realization include acid-sensing ion channels (ASIC), transient receptor potential (TRP) channels, and opioid receptors. ASICs facilitate responses to acids present in the environment. Furthermore, the mechanisms that produce neuronal sensitivity to acids appear conserved across taxa and are necessary for this type of nociception (Sneddon, 2019). TRPs transduce noxious stimuli into currents when sensations relating to chemical and physical stimuli, such as temperature, light, and pressure, are established by nociceptors (Sneddon, 2019). Endogenous opioid systems that mitigate or relieve pain have been observed in both vertebrates and invertebrates. The presence

of similar pain-reducing mechanisms in species with highly divergent lineages, especially at the chemical level, suggests that these systems have been conserved for millions of years. Thus, it is likely that conserved pain mechanisms do exist across species (Walters & Williams, 2019).

While nociceptors are highly complex and much more research is required to fully understand these mechanisms, there do appear to be important similarities between pain systems at the molecular level. However, according to the infamous functionalist toy example, since C-fibers firing produces pain in mammals, yet some other mechanisms produce pain in octopuses, say O-fibers, then MRΨ has occurred. Nevertheless, the mechanistic details matter. This could be a case of MR_1 if the biological components have the same causal powers and the organization differs, or it could be another example of MR_4 since nociceptors are conserved across taxa. Ironically, even on the infamous toy example of pain, both MR_2 and MR_3 (the necessary targets for the autonomy of psychological states) could not be sources for the MR of pain as long as humans and octopuses share some of the same conserved nociceptor mechanisms.

4.4 Vital neurochemicals

I argue that, since the evidence above suggests that conserved neurochemicals make causal contributions toward the realization of some psychological states, claims for constitutive autonomy are in a compromised position. Due to the presence of conserved neurochemicals, claims for MRΨ are only empirically justified via MR_4 (possibly MR_1). MR_2 and MR_3 are not empirically justified since they require completely different components (including causal powers), and this would leave out the conserved neurochemicals discussed above. This doesn't bode well for autonomy claims since MR_3 is the source of MR needed to demonstrate that psychological states can be achieved without neural realizers.

Perhaps the only option to salvage autonomy would be to examine whether neurochemistry can be multiply realized with non-biological substrates. Since serotonin, ghrelin, and oxytocin appear to be the vital components in realizing their respective functions, then maybe it is possible to look at their molecular structure and consider if they can be MR'd. However, to give functionalists what they want regarding autonomy, they would have to demonstrate that the conserved neurochemicals can be MR'd with non-biological substrates. This would permit MR_3, and I would grant the functionalist victory. However, this would require empirical data to justify this claim, and I am not aware of any research that has demonstrated that neurochemistry can be MR'd with non-biological substrates.

By ignoring neural realizers, such as neurotransmitters, functionalists and many within the cognitive sciences have advocated for a position (constitutive autonomy) that currently lacks empirical justification. As the proponents of the cognitive neuroscience revolution have argued, cognition is a multi-layered structural phenomenon, and both neuroscience and psychology ought to constrain one another. The conserved nature of neurochemistry and its prevalence in making causal contributions toward the realization of some psychological states undermine autonomy claims. However, since autonomy was boldly asserted without waiting for neuroscience to fully develop, many promoted a version of psychology that does not currently fit within

the framework presented by cognitive neuroscience. In my view, autonomy claims should be considered false until more evidence emerges that can demonstrate that neurochemicals like serotonin can be MR'd and thus are not essential for the realization of certain psychological states.

Finally, it should also be noted that highlighting the importance of neurochemistry in realizing psychological states is not a form of traditional reductionism. For example, I am not claiming that psychological states can be reduced to the molecules that contribute to their realization. This kind of ruthless reduction, advocated by Bickle (2003), is not a consequence of my position once a mechanistic framework is employed. Recall that a mechanistic framework for some phenomena is multi-level and requires the interaction of multiple components along with their causal powers to produce that phenomenon. Regarding neurochemistry, the molecules that make it up cannot be fully credited for realizing a psychological state. Rather, the molecules require the interaction of several other neural substrates, which collectively work together to realize a psychological state several levels above the molecular level. So, while serotonin molecules might be an aspect of a psychological state, they alone are incapable of the realization. This distinction that my appeal to neurochemistry does not commit me to reductionism is additionally important, as it reveals a novel path that could be navigated between the reductionism and MR debate.

Bickle (2003), in his defense of reductionism against MR, points to empirical research that suggests memory consolidation among mammals, *Aplysia*, and *Drosophila* is uniquely realized by a particular molecular pathway. In contrast, Aizawa (2007) argues that Bickle's examples of a uniquely realized memory consolidation mechanism are examples of MR since there are differences in the amino acid sequences.[9] Aizawa points out that homologous structures, like Bickle's examples of memory consolidation mechanisms, have some differences in their secondary, tertiary, and quaternary structures, thus MR is preserved. I concur with Aizawa that differences in amino acid sequences deny claims for a uniquely realized memory consolidation mechanism. However, I would also add that Aizawa's examples and most cases of homologous structures or evolutionarily conserved components (e.g., nociceptors) are cases of MR_4. Recall that MR_4 is a source of MR, along with MR_1, that still justifies placing a high value on particular lower-level realizers. Thus, if a reductionist like Bickle embraces certain kinds of MR, like MR_4, since they do not minimize the importance of cellular and molecular realizers, then they can avoid anti-reductive MR challenges like Aizawa's. While Bickle's other commitments to reductionism may preclude him from endorsing a mechanistic account of MR, it should be a fruitful enterprise to revisit other debates between reductionists and anti-reductionist advocates of MR to see how this mechanistic account of MR could potentially present alternative solutions. As I have argued throughout this project, only particular kinds of MR warrant autonomy, and it is the autonomy claim that minimizes the importance of lower-level realizers.

[9] I am not discussing memory consolidation as a case of MRΨ; I view it as a cognitive process, in contrast to a psychological state. Rather, I am including this debate to demonstrate how a mechanistic account of MR can be sympathetic to aspects of reductionism since it preserves the importance of lower-level realizers (e.g., cells and molecules).

5 Conclusion

Due to nearly identical serotonin transporter systems, humans and octopuses both behave in a pro-social manner when administered MDMA. Since serotonin appears to be making causal contributions toward the realization of pro-social psychological states, this suggests that specific neural realization is vital for producing various psychological states. This undermines autonomy. Additionally, by incorporating a mechanistic framework of MR, I was able to further establish that the sources of MR that are common examples of MRΨ (MR_1 and MR_4) do not justify autonomy. The examples I presented for MRΨ always include some of the same materials across two or more systems and are thus either sources of MR_1 or MR_4, not MR_2 or MR_3, which do justify autonomy. The presence of conserved neurochemicals in the realization of some psychological states denies autonomy since it claims that psychological states are not anchored by neurological realizers. Until evidence emerges that neurochemistry can be MR'd with non-biological material, autonomy's dominant status within the philosophy of mind and the cognitive sciences ought to be downgraded.

Acknowledgements I would like to thank numerous individuals who helped me with various versions of this paper, including Gualtiero Piccinini, Jon Livengood, Ken Aizawa, John Hummel, and multiple anonymous reviewers. Additionally, I would like to thank audience members at the Society for Philosophy and Neuroscience and the Indiana Philosophical Association meeting for their comments.

Funding No funding was received to assist with the preparation of this manuscript.

Data availability The author confirms that all data analyzed during this study are included in this published article. All referenced research papers are included in the Reference section and contains a Digital Object Identifier (DOI).

Declarations

Ethical approval The author confirms that all ethical guidelines have been met.

Competing interests The author has no competing interests to declare that are relevant to the content of this manuscript.

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