revista CONTROVÉRSIA
ISSN 1808-5253
UNISINOS

ABSTRACTION AS METHODOLOGY: CHOMSKY AND THE THEORETICAL BOUNDARIES OF EMBODIED COGNITION

DOI: https://doi.org/10.4013/con.2025.213.11

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ABSTRACT:
This article aims to identify Chomsky's position regarding embodied cognition, showing how his counterpoints can contribute to a more nuanced debate in the philosophy of cognitive science. The analysis unfolds in three stages: examining how Chomsky's perspective on cognition aligns with so-called classic cognitivism as commonly interpreted by embodied cognition theorists; identifying which embodied conceptions he preemptively questioned; and demonstrating that such objections anchor in methodological naturalism and biological "truism". We interpret that Chomsky would view minimal embodiment (ME) as raising concerns about triviality unless it formulates a precise concept of body; full embodiment (FE) as conflicting with poverty of stimulus arguments for cognitive acquisition; and radical embodiment (RE) as epistemically problematic due to its rejection of mental representations. We further argue that Chomsky's epistemological stance encourages embodied cognition to rely on theoretical abstractions for explanatory power, specifically through a moderate approach framing embodied cognitive capacities as coextensive with sets of bodily codes or formats. This approach avoids reductionism while enabling testable hypotheses about bodily-influenced cognition, thus answering Chomsky's enduring challenge to formulate nontrivial claims about what is embodied in cognition.

KEYWORDS:
Embodied Cognition. Noam Chomsky. Methodological Naturalism. Bodily Formats.

ABSTRAÇÃO COMO METODOLOGIA: CHOMSKY E OS LIMITES TEÓRICOS DA COGNIÇÃO CORPORIFICADA

RESUMO:

Este artigo tem como objetivo identificar a posição de Chomsky relativamente à cognição corporificada, mostrando como seus contrapontos podem contribuir para um debate mais nuançado na filosofia da ciência cognitiva. A análise se desenvolve em três etapas: examinando como a perspectiva de Chomsky sobre a cognição se alinha com o chamado cognitivismo clássico como comumente interpretado pelos teóricos da cognição corporificada; identificando quais concepções corporificadas ele preventivamente questionou; e demonstrando que tais objeções se ancoram no naturalismo metodológico e no "truísmo" biológico. Interpretamos que Chomsky consideraria a corporificação mínima (ME) como preocupante em relação à trivialidade, a menos que formule um conceito preciso de corpo; a corporificação completa (FE) como conflitante com os argumentos de pobreza de estímulo para a aquisição cognitiva; e a corporificação radical (RE) como epistemicamente problemática devido à sua rejeição de representações mentais. Argumentamos ainda que a posição epistemológica de Chomsky incentiva a cognição corporificada a depender de abstrações teóricas para obter poder explicativo, especificamente por meio de uma abordagem moderada que enquadra capacidades cognitivas corporificadas como coextensivas aos conjuntos de códigos ou formatos corporais. Essa abordagem evita o reducionismo e, ao mesmo tempo, permite hipóteses testáveis sobre as influências corporais na cognição, respondendo, assim, ao persistente desafio de Chomsky quanto à formulação de alegações não triviais sobre o que é corporificado na cognição.

PALAVRAS-CHAVE:

Cognição Corporificada. Noam Chomsky. Naturalismo Metodológico. Formatos Corporais.

1 Introduction

Noam Chomsky occupies a unique position in the debate over embodied cognition. Although he never explicitly uses the term, his ideas are often interpreted as a counterpoint to it (Calvo and Gomila, 2008; Dove, 2011; Wilson and Golonka, 2013; Goldinger *et al.*, 2016). There are at least two reasons for this. The first lies in the frequent, mostly unintended, association of Chomsky with classical cognitivism, a paradigm that embodied cognition came to radically challenge from the 1990s onward as part of post-cognitivist movements. The second reason stems from the fact that, decades before embodied cognition emerged as a distinct strand, Chomsky was already criticizing the assumptions that are now attributed to it, such as the idea that higher cognitive processes arise from sensorimotor interaction with the environment.

However, it would be inaccurate to reduce Chomsky to a mere opponent of embodied cognition, not only because of the plurality of research programs grouped under this label, but also because his critiques are mainly directed at methodological limitations that he himself acknowledges might eventually be overcome. At no point does Chomsky reject the possibility of embodied cognition; his argument is merely that, in the case of certain cognitive capacities, the explanatory hypotheses most consistent with

the empirical evidence available thus far are computational in nature. On the other hand, it is true that Chomsky adopts an epistemological stance according to which it is legitimate to ask whether the kinds of knowledge required to ground a science of embodied cognition are in fact within the reach of the human mind.

The aim of this work is to accurately identify Chomsky's position regarding embodied cognition, in order to show how his counterpoints can contribute to a more nuanced debate in the philosophy of cognitive science. The analysis will unfold in three distinct stages. The first step will be to examine in what terms, and to what extent, Chomsky's perspective on cognition aligns with so-called classic cognitivism as commonly interpreted by embodied cognition theorists. Next, we will identify which conceptions now associated with embodied cognition were preemptively questioned by Chomsky and remained subject to his critique in the ensuing decades. We conclude by showing that such objections are anchored in the two pillars of Chomsky's epistemological stance—methodological naturalism and biological "truism"—and we suggest that by taking them seriously research in embodied cognition can advance toward a more sophisticated heuristic.

2.1 Representation, rules, and computation

Which assumptions are at play when we describe someone as a cognitivist? In its classical expression, as formulated by authors such as Newell and Simon (1972), Fodor (1975, 1981, 2000), and Pylyshyn (1984), what came to be called cognitivism can be understood asthe theoretical inclination to account for the mind as a system capable of manipulating internal representations through formal rules, and consequently interpreting its cognitive processes as a mode of symbolic computation. Newell and Simon (1972) take this to mean conceiving human problem solving as the transformation of internal symbolic structures under the application of well-defined operators; Fodor (1975) interprets it as executing syntactic operations on mental representations expressed in a "language of thought"; and Pylyshyn (1984) regards it as the functioning of a physical symbol system whose states possess semantic content and whose dynamics are governed by formal properties.

Though this portrayal establishes a common ground for cognitivist thought, it leaves room for internal contention about the nature of representations, structures, and symbols, the limits of the computational metaphor, its alignment with connectionist architectures, and a host of other disputes. Recognizing such adiversity proves indispensable for preventing oversimplifications of this school, even if one may opt for a more succinct rendering of it for expository convenience.

It is along these lines that we shall quickly take as our starting point the interpretive horizon used by some theorists of embodied cognition to oppose cognitivism, portraying Chomsky as one of its representatives. We do so not to fully endorse their interpretation, but to demonstrate, within its own logic, how it misrepresents the richness of Chomsky's ideas on cognition. Thus, our hermeneutic focus here concerns Chomsky's conception of cognition itself, not his alleged cognitivism. Whether he might, on the basis of the positions we shall outline below and under whatever definition of the term, be regarded as a cognitivist is a matter we deliberately bracket in the present discussion.

From proponents of embodied cognition like Anderson (2003), Gomila and Calvo (2008), Matheson and Barsalou (2018), and Shapiro (2019 [2011]), one can extract a succinct account of cognitivism as a framework wherein cognition is understood as the rule-based processing of representational content implemented in the brain's physical substrate. These authors adopt this definition as a tool to critique some of the following features they commonly attribute to the cognitivist view: (1) representationalism, "the idea that cognition centrally involves *representation*" (Anderson, 2003, p. 93); (2) formalism, "the commitment to explicitly specifiable rules of thought [...] to govern the transformation from one cognitive state to another" (Anderson, 2003, p. 94); (3) computationalism, "the endorsement of the view that cognition is information-processing" (Gomila and Calvo, 2008, p. 4); (4) disembodiment, "the detachment of central cognitive processes from the perceptual and motor systems" (Gomila and Calvo, 2008, p. 4); and (5) solipsism, the tendency "to draw the boundaries of *cognition* at the same place that a computer scientist might draw the boundaries of *computation*—at the points of interface with the world" (Shapiro, 2019, p. 28).

Insofar as embodied cognition disputes this version of cognitivism and ascribes it to Chomsky, it is worth asking, for our purposes, whether his perspective on cognition indeed aligns with any of these five defining aspects. The current section addresses (1), (2), and (3), while the next one will consider whether these imply or require (4) and/or (5).

It is clear from the beginning that Chomsky advocates for (1), especially when it comes to accounting for language cognition. His rationale is straightforward (Chomsky, 1994, 2000): invoking "mental representations" in scientific psychology and cognitive science is simply to abstract away from the brain's physical states in order to make them empirically tractable and to allow these fields to strive for explanatory power over their own data. In Neto's words (2011, p. 97, translation ours), these representations are "formal objects of the theoretical construct that correspond to the 'things' of the modeled reality." Put differently, it is a matter of formalizing brain states in a language that represents them. Chomsky's representationalism, therefore, stems chiefly from a methodological commitment to

ensure that linguistics, in addressing cognition, can seek explanatory adequacy. If we were to reformulate Anderson's (2003) statement to better fit Chomsky's perspective, we would say that explaining cognition centrally involves representation, in the sense we are now set to detail.

For Chomsky, both (2) and (3) naturally follow from (1), at least regarding the domain of grammatical competence. Nonetheless, it should be emphasized that this implication remains exclusively methodological. With respect to (2), the reasoning seems to be that the mind, as a biological system and part of the human organism, is bound by natural limits that shape its capacities. To analyze this system's functioning, Chomsky (1980, p. 48) argues that its physical states must be abstracted into "mental" ones, and the limitations imposed by their physical realization understood as rule-like constraints. Even more crucial is to grasp, also at the level of abstraction, that these rules are embedded in the development of cognitive capacities and govern the structuring of the knowledge underlying each of them; in linguistic inquiry, these would correspond to "the genetically determined principles of the language faculty" (Chomsky, 2003, p. 15).

He explicitly frames this as an idealization (1980, p. 28), acknowledging the difficulty in asserting that the biological system that is the mind, with limits such as those imposed by genetics, is the same for every individual. In any case, Chomsky (1980, p. 28) insists that cognitive theories aspiring to axiomatic rigor must adopt this method, as he illustrates in his linguistic work: the term "universal grammar" refers to the set of properties of human biological endowment that are "biologically necessary", although not "logically necessary", in linguistic matters. Thus, the very notion of universal grammar as an object of scientific study is epistemically accessible only because we adopt a level of abstraction that enables us to formulate general laws about the faculty of language, beyond individual neurophysiological variability.

As for (3), his adherence is strictly mathematical: the computational rules are not processing algorithms in the sense of what is programmed into an artifact, but rather formal descriptions of the generative procedure abstracted from the biological system. This is a fundamental distinction for Chomsky (1994, p. 207): "[a]rtifacts pose questions that do not arise in the case of natural objects", because the former are analyzed through the lens of their intended design, whereas the latter are simply endowed with capacities that we must observe, describe, and explain. Furthermore, Chomsky (2000, pp. 24-25) holds that this primary requirement of observation, on which the other two clearly depend, is most effectively met by computational-representational theories, precisely because the interpretation of abstract data, such as mental states and their generative processes, has proven far more significant in granting autonomy to the study of language and mind than the mere collection of neurophysiological or behavioral evidence. But this matters to Chomsky, of course, only because he considers the most significant

empirical claim in linguistics to be that a speaker-hearer can produce and understand a potentially infinite number of sentences, with recursion serving as a more appropriate evidential cornerstone for such a theoretical framework.

What we have seen thus far then is that, for Chomsky, (1), (2), and (3) are methodologically significant abstractions, especially within the domain of linguistics, though arguably relevant to a range of other internal competences as well. The next step is to clarify the scope of competences to which such a level of abstraction applies, and to assess whether the previously examined triad necessarily entails the alleged (4) and/or (5) attacked by embodied cognition theorists.

2.2 The sensorimotor system and externalization

Well known is Chomsky's (1965, p. 4) differentiation in *Aspects of the Theory of Syntax* between "*competence* (the speaker-hearer's knowledge of his language) and *performance* (the actual use of language in concrete situations)." But what does it mean to say that a competence is internal, and that the abstractions outlined above are methodologically relevant to its explanation? To the best of our knowledge, Chomsky never uses the expression "internal competence" literally; rather, he consistently refers to "internal structure" (1964, p. 29; 2007c, p. 44-45), "internal representation" (1964, p. 35; 1980, p. 52; 1984, p. 10), "internal computation" (1965, p. 187; Berwick and Chomsky, 2016, p. 11) or "program" (1994, p. 207), and, of course, "internalized grammar" (1964, p. 10, 112; 1980, p. 118, 2007c, p. 165). Chomsky's review of *Verbal Behavior* offers a valuable clue to the meaning of this internalism, as he notes that

> prediction of the behavior of a complex organism (or machine) would require, in addition to information about external stimulation, knowledge of the internal structure of the organism, the ways in which it processes input information and organizes its own behavior. (Chomsky, 2008 [1959], p. 2).

In effect, every time Chomsky applies the term "internal" to mental representations, computational procedures, or grammatical principles, he is referring to the biological basis of some cognitive capacity, specifically those for which he takes such a basis to be both necessary and sufficient to constitute an autonomous mental faculty, or a well-defined "mental organ". It is in this sense that, for Chomsky, internal competences may be said to exist insofar as they arise from latent structures within the organism, which develop under appropriate stimulation, yet whose operation does not depend on other systems (circulatory, respiratory, digestive etc.) as sufficient conditions. This is exactly the nature of the faculty of language in the narrow sense, as defined in Hauser *et al.* (2002, p. 1571): a competence whose syntactic

and semantic systems can generate representations without necessarily responding to any internal or external stimuli from the organism's other systems.

Now, it does not follow from Chomsky's recognition of internal competences that he assumes they can be exercised without the involvement of bodily functions. What Chomsky in fact emphasizes is that competences like language map their outputs—in this case, discrete expressions—onto systems such as the sensorimotor during their real-time processing and use. However, modeling such a competence to explain how it generates its outputs does not require capturing the interface with these other systems, since its generative procedure is purely internal. This, of course, assuming that speaking of competences is itself an idealization, serving methodological purposes similar to other such constructs intended to attain explanatory adequacy in the study of the mind.

That said, we argue that, for Chomsky, (1), (2), and (3) imply (4) only with regard to internal competences, and only in terms of their theoretical modeling, never in their actual exercise beyond the abstraction required to study them. It is obvious to Chomsky (2000, p. 113) that any cognitive capacity can only be exercised by a person who possesses a body and operates within a physical world, subject to the limitations inherent to any biological organism: "More cautiously, we may say that in appropriate circumstances *people* think, not their brains, which do not, though their brains provide the mechanisms of thought." Still, he believes that integrating all such complexities is not the preferable strategy for scientifically elucidating internal competences. Treating them as embodied, in this context, amounts to little more than a trivial observation that adds nothing to the explanatory power of a theory concerning them.

Lastly, assigning (5) to Chomsky should be approached with considerable care. In the first place, as previously discussed, cognition, in his view, can be called computational only in the sense of being an abstraction from the biological structure it arises from. In the second, the exclusion of the "interface with the world" from a theoretical account reflects his understanding that internal computation alone suffices to explain the competence in question. Above all, one must not overlook Chomsky's (2010, 2012) insistence on the "externalization problem", which concerns the theoretical challenge of understanding how internal systems are connected to sensorimotor mechanisms for purposes of public expression. He regards this as a legitimate, though extremely difficult, problem in the study of cognitive capacities, though he does not equate it with the problem of modeling internal competences.

This outlines Chomsky's conception of cognition and, if one wishes, his position as a cognitivist, at least in the sense intended by the theorists previously mentioned. (1), (2), and (3) are abstract principles relevant to securing the autonomy of the study of mind as a biological system of cognitive faculties that

generate mental representations. (4) and (5), if relevant, serve merely as theoretical tools in the modeling of internal competences with explanatory aims. Let us now examine whether and in what ways this position contrasts with the approaches advanced under the label of embodied cognition.

3 Embodied cognition

We do not intend to provide a thorough mapping of embodied cognition research or to organize it into a taxonomic classification (see Wilson, 2002; Shapiro, 2007; Goldman and De Vignemont, 2009; Goldinger *et al.*, 2016; Farina, 2021). For the sake of coherence in our investigation, we will rely exclusively on the three principles to which Goldinger *et al.* (2016) reduce embodied cognition. This is not, for us, an arbitrary choice, but rather an attempt to characterize embodied cognition, first, as offering proposals that diverge meaningfully from classical cognitivism, and second, as being capable of making nontrivial claims. We now turn to a succinct account of each principle, before turning to a comparative discussion of how they relate to, or differ from, the Chomskyan perspective on cognition.

The first principle states that "cognition is influenced by the body, including its potential actions" (Goldinger *et al.*, 2016, p. 963). Earlier, the authors clarify this influence by stating: "When a person processes information [...] her body is involved in some nontrivial way, as a constraint or bias on processing" (Goldinger *et al.*, 2016, p. 963).

The second principle holds that "cognition is influenced by the environment, including off-loading" (Goldinger *et al.*, 2016, p. 963), with off-loading referring to the practice of "leaving information out there in the world to be accessed as needed, rather than taking time to fully encode it" (Wilson, 2002, p. 628).

Finally, the third and arguably most controversial principle is that "cognition may not require internal representation" (Goldinger *et al.*, 2016, p. 963), in the sense that the sensorimotor system's functions could, by themselves, constitute both necessary and sufficient conditions for certain, if not all, cognitive processes.

Let us borrow Farina's (2021) terminology, albeit detached from its original context and theoretical implications, and refer to each of these principles, respectively, as minimal embodiment (ME), full embodiment (FE), and radical embodiment (RE).The only reason this classification may not be fully arbitrary lies in the gradation of claims: the first represents the minimal requirement for any theory of embodied cognition; the second builds upon it by seeking to incorporate the surrounding environment into the explanation of cognition; and the third is evidently the most radical. Still, these principles are not mutually exclusive and may well coexist within a single embodied cognition perspective. If the reader

remains unconvinced by the chosen terminology, it may be understood as serving no more than another expository convenience.

Before engaging with the question of how Chomsky's conception of cognition relates to those three principles, something fundamental in his thought deserves to be emphasized. Since at least the 1980s, Chomsky (1984, 1986, 2003 [1988]) has often emphasized that scientific psychology and cognitive science appear to lack any coherent and theoretically significant concept of what a body is. What he means by this is that, whereas Cartesian psychology once relied on a highly explanatory conception of the body drawn from mechanistic philosophy, such a framework is no longer tenable for any psychological theory aligned with post-Newtonian natural science, in which the explanatory power of reducing the physical world to mere extension and motion has been rendered obsolete. From his perspective, it is not that no conception of the body has emerged since then, for example, in fields like mechanics or biochemistry, but rather that none has been theoretically compelling enough for psychology to adopt without sacrificing its autonomy and gaining any genuine explanatory power over the phenomena it seeks to understand.

We take this to express his conviction that the concept of body, in each of the natural sciences, is fundamentally a theoretical and methodological construct. It would be mistaken to suppose that a single, universally shared concept of body exists across all natural sciences just because they agree in addressing phenomena from the physical natural world. Given that each discipline seeks to explain its own specific phenomena, there is no justification for mechanics to employ the same theoretical constructs as histology, among others. The same applies to what counts as an explanatorily meaningful concept of body: there is no reason for a mechanical or kinematic problem to consider the cellular composition of organic tissues, even when dealing with the movement of an organism.

In this sense, unless the study of the mind develops an abstraction of embodiment that proves equally useful and allows for substantial, nontrivial claims concerning its own empirical domain, appeals to the body will continue to offer little to cognitive theorizing. This may represent Chomsky's most enduring challenge to theories of embodied cognition. We shall keep this in mind moving forward, as we return to the three principles outlined above, this time considering what Chomsky may have, at any point, endorsed or rejected regarding their underlying assumptions, constituent parts, and broader implications.

We can only assume that Chomsky's possible objections to ME would concern, first, the specific concept of body in which this principle might be grounded, and second, the competencies one might be attempting to model as influenced by the body. Another more explicit but less relevant objection lies in Chomsky's (2000, p. 72) skepticism that anyone today can confidently define what constitutes an action

or maintain that it is "caused" by anything, including the agent's body. It soon becomes clear that ME, the least radical and bold among the three principles, not only assumes a type of computationalism but also easily accommodates the notion that bodily influences produce mental representations that are, to some extent, rule-based and formally describable. That is to say, ME's only potential conflict with Chomsky an perspective on cognition concerns features (4) and (5), depending on the concept of body it manages to construct and the competencies it aims to capture. To avoid triviality or, so to speak, being dismissed by Chomsky's razor, ME would need to preserve the autonomy of psychological explanation by precisely characterizing what it means to be influenced by the body, and which specific competencies are subject to such an influence.

In the case of FE, these two aforementioned tensions are joined by Chomsky's classical poverty of stimulus (POS) arguments, which introduce an additional and significantly more insurmountable layer of incompatibility. Setting aside the trivial observation that certain capacities (such as vision) require external objects to operate on, FE seems to touch a turning point in Chomsky's account of the "four typically interacting factors" essential to any acquisition theory: "(1) Innate, domain-specific factors; (2) Innate, domain-general factors; (3) External stimuli [...]; (4) Natural law" (Berwick *et al.*, 2011, p. 1209).Chomsky's objection would certainly not amount to a mere denial that the body receives environmental stimuli, or that such stimulation plays some role in the development of latent cognitive structures. Rather, it would concern the logical and empirical justification for treating such environmental stimuli as equally or even more important than innate factors in explaining how a given competence is fully acquired, particularly in view of its scope of uses. The case of grammatical competence as Chomsky conceives it serves as a crucial counterexample to FE, given its nonlinear hierarchical structure, which he argues must be innate and domain-specific (Berwick *et al.*, 2011), along with the absence of an external referent that he believes characterizes much of the lexicon used by any speaker-listener of a natural language. And this would undoubtedly be a point of contention for any other cognitive capacity whose acquisition is as rapid and uniform as that of language.

For its part, RE appears early on as fundamentally at odds with nearly everything stated about Chomsky so far, or even with all of it if we consider that approaches taking this principle seriously have progressively moved away from computationalism (Hutto and Myin, 2017; Shapiro, 2019). It is largely irrelevant to our aims whether a non-representational computationalism is feasible or what its precise nature might be. As we hope is already clear by now, it seems inconceivable to Chomsky that the autonomy of scientific psychology and cognitive science can be preserved without the methodological abstraction of mental representations. And on the more specific terrain of grammatical competence, the

aspects of Chomsky's thought that clash with RE center on two major questions. The first concerns the difficulty of explaining how the sensorimotor system alone could provide the necessary and sufficient conditions for humans to possess cognitive capacities such as apprehending lexical items or full sentences that carry amodal concepts. The second asks how that same system could account for the ability to recognize grammaticality, or indeed to be responsive to the long-range dependencies that typify natural languages. Not to mention, of course, the concept of body that RE would need to rely on to remain coherent, one that, we imagine, Chomsky would deem nearly indefensible, as it would have to be both explanatory and nontrivial across such a vast range of phenomena that it becomes theoretically unviable, overly broad, or hopelessly generic.

Hence, this appears to be the overall depiction of Chomsky's relation to those three principles of embodied cognition. ME might raise concerns for him depending on the nature of the competence it seeks to model and on the concept of body it formulates for that purpose. FE largely draws on POS arguments, and he might find it inadequate for grounding theories of the acquisition of cognitive capacities, surely one of its most substantial applications. RE, ultimately, may strike him as problematic on all fronts, from its degree of representational rejection to its attribution of full explanatory force to the sensorimotor system.

Heading toward a conclusion, we intend to step beyond a solely interpretative reading of Chomsky's ideas, demonstrating how his epistemological views not only reflect his distinct conception of cognition but can also, in our judgment, contribute to sharpening the heuristic of embodied cognition, considering all that has been discussed so far.

4 Methodological naturalism and biological "truism"

On the rare occasions when Chomsky (1994, 2000) chooses to name his epistemological approach to the study of the mind, he terms it "methodological naturalism". If we were to interpret the meaning of this expression, we could say it encapsulates the first three features of Chomsky's perspective on cognition as applied to cognitive capacities broadly, along with the remaining two insofar as the focus is on internal mental structures. (1), (2), and (3) may be viewed as foundational methodological commitments for research into the mind that envisions unification with the natural sciences; in turn, (4) and (5) arise as methodological implications of this naturalism in the analysis of internal competences, as would be the case, for Chomsky, with grammatical competence.

He (1994, p. 182) sets this stance against what he calls "methodological dualism": "the view that we must abandon scientific rationality when we study humans 'above the neck' [...] imposing arbitrary

stipulations and a priori demands of a sort that would never be contemplated in the sciences". In saying this, he targets what he regards as a detrimental demand placed upon scientific psychology and cognitive science—namely, the restriction against working with theoretical abstractions and idealized models, or formulating central hypotheses and determining the most appropriate kind of evidence to test them, as has always been standard practice in the natural sciences. We see this as positioning him almost completely against eliminative materialism (Churchland, 1981; Churchland, 1986), which seems to anticipate that psychology will eventually be discarded alongside now-discredited fields such as alchemy or demonology, solely due to its engagement with abstract entities; in contrast, Chomsky holds that it is precisely the use of abstraction as a methodological tool that, when properly managed, offers a promising future to the sciences of the mind.

Nevertheless, Chomsky cannot be described as an outright optimist regarding his own field of inquiry.In fact, he is known to argue for a differentiation within this domain between two categories of issues: problems, defined as "approaches and concepts that are moderately well understood", and mysteries, those other approaches and concepts "that remain as obscure to us today as when they were originally formulated" (Chomsky, 2007c, p. 137). Chomsky seems aware that there is something inherently subjective in the formulation and use of this distinction, but what concerns us most here is his view that the existence of genuine mysteries is entirely natural within any theoretical-scientific pursuit. According to Chomsky (2018), asserting their existence is nothing more than a "truism", since concept formation and the construction of explanatory theories are themselves cognitive capacities, thus subject to the same kind of biological limitations that affect any other capacity and inherently constrained in scope and applicability. Consequently, for him (2007c, p. 24-25), there is no guarantee that the most difficult areas of scientific investigation must lie within the intersection between all true scientific theories and those reachable by human cognition; it may well be that the requisite concepts and explanations fall outside the biologically determined scope of our "science-forming capacities".

As mentioned earlier, any and all types of action serve as a prime example of this for Chomsky, though he does not claim it to be beyond dispute. This seems an appropriate moment to connect two ideas introduced in the previous section: Chomsky's skepticism toward theories of action stems from his understanding that one cannot meaningfully speak of the mind-body problem in a broader sense, nor of mental causation, without a coherent concept of body. It is not entirely clear from his remarks whether Chomsky believes that the very formulation of such a concept, within the domain of mental inquiry, exceeds the scope of human cognition; what is clear, however, is that actions appear to him more as a

mystery than as a scientifically tractable problem, particularly if one is more concerned with explaining their causes than the cognitive capacities from which they may arise (see Chomsky, 2008, p. 27).

In our reading, it is the convergence of methodological naturalism and biological "truism" that underpins Chomsky's possible criticisms of ME, FE, and RE. The former could lend support to the objection that any approach based on at least one of these principles must begin by constructing abstractions about the body and its role in cognition that can yield empirically substantive claims. From this perspective, Chomsky might interrogate ME as to whether its claims about bodily influence are anything more than self-evident; FE, as to whether its emphasis on the environment can yield explanations as predictive as those grounded in innate factors; and RE, as to whether its rejection of mental representations undermines mental inquiry's epistemic autonomy. At the same time, biological "truism" may deepen Chomsky's skepticism by implying that, even if ME, FE, and RE proved internally coherent, their explanatory viability may exceed human cognitive limits, especially if bodily influence, environmental influence and the rejection of representationalism all imply a causal, or at least causation-centered, approach to embodied cognition.

That concludes our examination of what pertains directly to Chomsky. We now proceed to our argument concerning how at least part of his epistemological outlook may contribute to the heuristic framework of embodied cognition.

5 The bodily formats approach

As might be anticipated, we believe it is of utmost importance for any research programme in embodied cognition to begin by establishing a concept of body that will serve its purposes. But even before attempting to define what that concept might be, it is necessary to dwell a bit further on what the purposes of such a programme should be. First and foremost, we contend that a variant of Chomsky's methodological naturalism may prove useful in this context: for embodied cognition to legitimately participate in the scientific study of mind, it will need to sustain itself independently through the use of abstract constructs, both inherited and newly developed, so as to keep open the possibility of eventual unification with the natural sciences. Contrary to what one might assume, this does not necessarily mean aiming to reduce the mind to something physical, such as the sensorimotor system or anything of the sort; it simply means that embodied cognition may take for granted that it is attempting to explain phenomena instantiated in the physical and natural world, yet ones that must be approached on an abstract, theoretical level. In this respect, embodied cognition can fully embrace the use of tools such as mental

representations, formalizations, and computational data without being any less embodied or simply subsumed under classical cognitivism; for that to happen, though, it needs to respond to what follows.

Given its broader purpose, a key question emerges to define its more targeted concern: which dimensions of cognition are to be understood as embodied? We interpret that scientific psychology and cognitive science can truly engage with this question only to the extent that it can be articulated into empirically tractable research problems and allow for nontrivial empirical claims. Aligned with what we have seen in Chomsky concerning FE, we find it difficult to see how embodied cognition could aim to account for the grounding of so many—if not all—amodal concepts, whose explanation would more plausibly lie either in internal competences or in social cognition. What it can reliably offer, by contrast, is insight into the ways in which these amodal concepts are enhanced or transformed by embodiment (Mahon and Caramazza, 2008). And this seems to be just one among many possible examples of empirically tractable problems in embodied cognition, once we begin with the premise that the embodied dimensions of cognition concern a subset of mental representations shaped by the body.

This moderate approach to embodied cognition (Goldman and De Vignemont, 2009; Goldman, 2012, 2014), clearly grounded in what we have called the ME principle, both expands the range of tractable empirical problems and rests on a sharply delineated notion of the body: a physical instance, excluding the brain, that becomes relevant to cognitive explanation only inasmuch as it supplies the cognizer with the full range of "bodily codes" or "formats". The terminology here reflects an analogy with the modularist idea of mental codes or formats, each consisting of "a distinctive vocabulary, syntax, and/or set of computational procedures [...] and [having] a distinctive array of contents", which, in their embodied version, are implicated in the mental representation of bodily states and bodily activity (Goldman, 2014, p. 100). One might cite the dorsal and ventral visual pathways as cases of distinct bodily coding, as they seem to process visual information at different levels (Milner and Goodale, 1995; Goodale and Milner, 2004 *in* Goldman, 2012, p. 73). Another example would involve the distinct levels of pain processing carried out by two specialized subsystems: the sensory-discriminative component, responsible for "representing the intensity of pain and its bodily location", and the affective component, which "captures the unpleasantness of a painful experience" (Goldman, 2014, p. 101). Taken together, these cases point to four distinct body-informed formats, whose tokens may exhibit similarities in terms of what bodily information they represent and the neural processing pathways they engage (Goldman and De Vignemont, 2009, p. 155). In summary, this approach maintains that certain products of cognition are initially encoded or formatted in a differentiated manner, depending on the bodily system with which they are associated.

Finally, assuming that embodied cognition's core domain is that of B-codes or B-formats, what phenomena might it aspire to explain and naturalize? It does not appear capable of dealing with the general mind-body problem or mental causation specifically. Not due to the matter being inaccessible, as Chomsky suggests, but because, and on this point we concur with him, we barely know what a cause is or in what way anything in cognition could genuinely be caused. Research into the mental aspects of the natural world cannot afford to rely solely on an answer to this one problem, nor should it wait for philosophy of mind to resolve it before turning to other relevant inquiries. Following Goldman and De Vignemont (2009, p. 155), we take it that B-formats may play a causally significant role in cognition; still, for embodied cognition, their current importance lies not in causality per se, but in methodology: they help delineate which features of the body impact cognition and therefore warrant investigation.

Among the phenomena that embodied cognition may seek to explain are embodied cognitive skills, which we will refer to here as capacities for the sake of textual unity. But what, then, are we asserting when we claim that a capacity is embodied? Within our moderate framework, the only reasonable construal is that the embodied cognitive capacity is, on the one hand, structured upon B-formats that serve as its sufficient conditions, and on the other, functionally tasked with generating bodily-informed mental representations. We have little to say regarding whether such capacities can rightly be called internal, given that this hinges first on their individuation; only then does the question arise as to whether integral modularity spans multiple B-formats or their aggregates.

The main point we would like to stress is that, in our view, a particularly fruitful and entirely plausible path to embodied cognition, in addition to Mahon and Caramazza's (2008, p. 67-68) "grounding by interaction hypothesis", is to frame embodied cognitive capacities as precisely coextensive with certain sets of B-formats. Though this idea cannot be fully developed here, we suggest that it opens the door to formulating hypotheses that are amenable to empirical scrutiny, testing whether a particular assembly of B-formats accounts for these capacities, or whether alternative assemblies do. Determining the specific subsystems of the overarching sensorimotor system that effectively shape cognition is a necessary step prior to testing both the validity and the extent of their impact. This may also represent a promising theoretical direction for interpreting the various forms of evidence typically brought forward in the study of mental phenomena: neurophysiological data, for instance, could be used to formulate and test hypotheses about the constitution of a given capacity in terms of B-formats, while computational data might support both hypotheses about bodily information processing and the development of models to capture it.

Throughout all these developments, the B-formats approach may serve to shield embodied cognition from trivialization, by ensuring that embodiment is not treated as yet another biological "truism" and instead reconfiguring it as a scientific program with coherent abstractions, an empirical field, and hypotheses open to testing. It first converts the body from a raw datum into a set of codes or formats that shape a subset of mental representations; then it narrows the scope of embodied cognition to those cognitive capacities structured by such codes; and it supports the formulation of explanatory hypotheses about the architecture of these capacities and their contribution to cognition.

These, then, seem to be some of Chomsky's preliminary contributions to embodied cognition: encouraging it to conceive of itself as both scientific and naturalistic, precisely by relying on theoretical abstractions, since it is through them that it may aspire to explanatory power over a given set of phenomena. Through its commitment to abstraction and the careful delineation of explanatory scope, Chomsky's methodological naturalism protects embodied cognition against both physicalist reductionism and empirically intractable radical assertions. In relation more directly to our endorsement of a moderate approach, he likewise brings forth several further concerns that may rightly be raised at this point, even if their resolution must remain, for now, out of reach. Which cognitive capacities can be meaningfully described as embodied? Does this entail that they are not internal in any substantive sense? What role do B-formats play in explaining the acquisition of such capacities? Can these codes be construed as generative procedures within cognitive processing? And would this require the adoption of a singular computational model, or instead a collection of models, to adequately render these processes intelligible? We regard this kind of methodological problem as central to the continued development and coherence of embodied cognition as a scientific enterprise.

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Recebido em: 01/08/2025

Aceito em: 25/08/2025