



Toward an Enactive Conception of Productive Practices: Beyond Material Agency

Ezequiel A. Di Paolo^{1,2,3}  · Diego Lawler⁴ · Andrés Pablo Vaccari⁵

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Abstract

We examine the question of material agency as raised in material engagement theory (MET). Insofar as MET tends to highlight the causal roles played by extra-bodily material flows in human practices, the term “material agency” does not sufficiently distinguish cases in which these flows are part of an agentic engagement from cases in which they are not. We propose an operational criterion to effect such a distinction. We claim this criterion is organizational, i.e., systemic, and not causal. In the enactive account, agency requires three organizational conditions: self-individuation, interactional asymmetry, and normativity. These conditions can have organic, sensorimotor, and sociomaterial realizations. The dance of human productive practices is indeed spread between brains, bodies, and the world, as MET claims, but it is distributed in an organized manner that involves constraints and norms at various scales. We put forward a relational and non-anthropocentric perspective toward an enactive approach to productive practices. We discuss some aspects of agentic ensembles rendered more intelligible by our proposal, including incorporation, soft assembly and non-decomposability, and the grounding of teleology normative processes at multiple scales. In this manner, we seek to continue the dialog between MET and enactive theory, beginning with the view that a situated system must realize certain minimal organizational conditions to be called an *agent*.

Keywords Material agency · Enactive approach · Material engagement theory · Incorporation · Teleology · Soft assembly · Productive practices

✉ Ezequiel A. Di Paolo
ezequiel.dipaolo@ehu.es

¹ Ikerbasque, Basque Foundation for Science, Bilbao, Spain

² IAS-Research, Department of Philosophy, UPV/EHU, Donostia, Spain

³ Department of Informatics, University of Sussex, Brighton, UK

⁴ IIF-SADAF/CONICET, Buenos Aires, Argentina

⁵ CITECDE/UNRN, CONICET, Bariloche, Argentina

1 Introduction

Material engagement theory (MET) rethinks human practices by foregrounding the roles played by material processes in human action, particularly in the act of making (Malafouris, 2013, 2016, 2019). One of the key insights of MET is that non-human material processes should not be construed as providing a passive, readily available background to human intentionality and action, but that they are “functionally co-substantial component[s]” of the intentionality of the actor (Knappet & Malafouris, 2008, xiii).

MET makes use of three core theses (Malafouris, 2013, 2016, 2019):

- (a) The *extended mind* thesis: External resources (such as the physical and informational features of materials, objects, and environments) are continuous and co-extensive parts of minds in action;
- (b) The *enactive signification* thesis: Material signs *bring forth* meaning rather than simply *stand for* external things, in contrast to the representationalist account of cognition; and
- (c) The *material agency* thesis: Materiality plays an ineliminable constitutive role in human activity and in their physical and epistemic products.

Material agency seeks to phase out talk of mental representation in favor of situated and emergent aspects of materiality in action and (more specifically) artifact production. The focus is shifted from a centralized human agent toward the material drivers of action. Agency, accordingly, is not a property of humans but the result of a synergetic engagement of humans and material forces in which “minds and things, more than being merely causally linked, are constitutively interdependent” (Malafouris, 2013, 77). Malafouris (especially in 2008) focuses on the unfolding, micro-physical, real-time dimensions of production. At this level of analysis, the properties of materials and the manifold contingencies of the poietic scene have a clear central role in generating the features of the finished artifact. This aspect of technical practice is immediate and situated; it concerns material, embodied, and phenomenal facets outside the purview of intentionality, prior plans, and mental schemas.

Since these initial proposals, the idea of material agency has developed into the notion of “thinging” in order to focus on the unfinished and creative aspects of material engagement (e.g., Malafouris, 2014, 2016). Thinging attempts to capture the dynamic and non-representational cognitive, affective, and practical engagement with and through things and their effects on human becoming. It adds to the idea of material agency and underscores its enactive resonances: “I use this term to differentiate the active participatory process by which things are presented to us through acts of engagement and enactive signification, from the passive process by which things are often construed as re-presented in us by way of internalization and mental substitution” (Malafouris, 2016, 296). This shift toward thinging in relation to creativity and becoming, however, does not contradict the earlier work on material agency, which is the focus of our discussion in

this paper (e.g., thinging is used to emphasize “the vitality and agency of things in human thinking, or else, the cognitive life of things,” *ibid.*).

While these are much needed moves against intentionalist and representationalist theories of human practice, the notion of material agency can benefit from further specification. We agree with Malafouris that an adequate understanding of human productive practices depends *in some way* on an understanding of material processes, including their effects on creativity and human becoming. However, Malafouris and colleagues do not offer an adequate general answer to the question of in what specific ways and circumstances a material process may be deemed as constitutive of a particular practice. Having a more specific concept of agency at hand can help answer this question and facilitate the empirical analysis of practices to help us distinguish how, where, and when material agency is manifested (or not). MET underscores its proposal by assigning agent-like language to material processes; for example, artifacts are “engaged,” “involved,” or “participate in” human action. These metaphors are evocative but we believe more can be said to avoid trivial readings.

One such trivial reading would see the qualifier *material* before *agency* as redundant for a non-dualistic approach since *all* agency is material, and that includes mental tasks (remembering a face, meditating, and other activities without overt “physical” action) and “representation-hungry activities” (Clark & Toribio, 1994). The point is that while trivial, this reading is consistent with MET’s proposals as stated, suggesting that if something else is “obviously” meant by material agency, that something needs to be articulated further.

Our concerns are questions such as: Why is engagement with artifacts an instance of “agency”? Is it always? What distinguishes agency from other physical processes and relations? And why, in the cases that Malafouris discusses, is there always a human involved in order for “agency” to appear? Are human beings the only “producers” we should take into account? MET highlights the roles played by extra-bodily material flows in human practices by means of clear examples. But it does not give us tools to distinguish, in general, cases in which these flows are part of an agential engagement from cases in which they are not.

We subscribe to the spirit of MET and its quest to undo traditional representationalist-intentionalist accounts of human practice. And we think that in order to achieve this, key terms such as *agency* must be tethered to well-articulated technical concepts. Otherwise, they remain catch-all phrases to connote (not necessarily wrongly, but potentially imprecisely) all kinds of aspects of materiality, from activity and resistance to change, to intentionality and design.

Because we share with MET the broad objective of decentering the locus of agency from the exclusively human to find its scope in wider processes, we feel urged to provide an account of agency that will not simply equate it with spontaneous material activity, an idea that is otherwise commonplace in physics, chemistry, and biology. Agency connotes notions of positionality, identity, and normativity, even notions of responsibility, and these should not remain undertheorized.

In this article, we propose an enactive concept of agency that (1) can do the work of answering the questions we have raised above and that the notion of material

agency cannot fully answer, and (2) is, as far as we can see, fully compatible with MET.

Following enactive work, we propose that all forms of agency are characterized by requirements of *self-individuation*, *interactional asymmetry*, and *normativity*. These are all intrinsically *relational properties* and an agent itself is considered an organization of relations. This does not prevent us from speaking of “agents” as individuals in a precise sense, in a way that is fully compatible with Malafouris’ (2008, 22) remark that agency and intentionality are manifested (realized) in material engagement spanning brain, body, and culture. The enactive conception of agency is not subject to the criticisms raised by Knappett and Malafouris against other efforts to specify criteria for agency in that it is not elaborated from a “narrow anthropocentric perspective” (2008, x). Rather, it emerges from operational principles used to understand the organization of living organisms (including “simple” ones). Not only are non-human organisms clear examples of agents in this view, it is also conceivable that some artificial systems may meet some or all of the criteria for agency as well. It is also conceivable that material processes that do not fully count as agents may still approach some if not all of the operational requirements generating a form of agent-like engagement (resistance, spontaneity, directionality, etc.). Such processes may be very much experienced as agencies by other participants. In this sense, our conception agrees with the spirit of considering “agency non-anthropocentrically, as a situated process in which material culture is entangled” (ibid.) According to our view, the dance of human practices is indeed causally spread between brains, bodies, and the world, as MET claims, but is distributed in an organized manner that involves constraints and norms at various scales. These organizational criteria allow us to claim, despite the causal spread, that some processes are the result of agencies at play, while other processes (regardless of how “active”) are not. In this manner, we seek to incorporate core insights from enactive theory into MET, beginning with the view that a situated system must realize certain organizational conditions to be called an “agent.”

In the next section, we discuss the question of material agency and try to offer a more precise meaning. We then present the enactive concept of agency and lay the foundations for a new, enactive concept of *productive practices*.

2 MET’s Criticism of Hylomorphism

The material agency thesis presents an alternative to the Aristotelian hylomorphic model of human action in the transformation of reality and production of artifacts. Throughout the course of Western thought, the hylomorphic model has provided the paradigmatic basis for understanding human agency and intentionality. Beth Preston (2013) has termed this model the “centralized control model of action.” This model has two main features: an emphasis on individual action and planning, and a reliance on a model of production in which forms are impressed on matter.

In the hylomorphic-intentionalist account, an agent is a subject who acts intentionally, guided by a representation, precise or vague, of what she intends to do. The resulting picture of artifact production goes as follows: An agent sets off to act with

some intention in mind, and this intention has a supervisory role over the course of action. In this manner, technical action is an aspect of practical reason: the deliberation on means and ends. The intentionalist view implies some commitment to representationalism. Representations, whether traditional (internal, offline) or action-based, provide eidetic guides that act normatively over the course of production, weaving out the characteristic teleological texture of technical agency. According to a vigorous intentionalist view such as Thomasson's, for example, an artifact "must be the product of a controlled process of making," and this involves "imposing a number of intended features on the object ..." (Thomasson 2007, 58–59). The intention to make a thing of an artifactual kind K "must thus involve a substantive (and substantively correct) concept of what a K is, including an understanding of what sorts of properties are K-relevant and an intention to realized many of them in the object created" (59). The producer applies schemas that are cognitively fixed and causally prior to the act of making. As Malafouris points out, representationalism is intimately allied with hylomorphism. For Malafouris, a common fallacy is assuming that form (organic or artificial) pre-exists the processes that give rise to it; that is, we wrongly think of the process of making as the transcription of a pre-existent form realised in some abstract domain (genetic, mental, or cultural) to the material domain of the physical world (Malafouris, 2014, 152).

A similar criticism of hylomorphism (and substantialism) can be found in the work of philosopher Gilbert Simondon (2020) with its proposed shift to an ontogenetic perspective focused on the principle of individuation and not on its finished products (the concretized individuals and associated milieus). The uptake of Simondon's work by enactivists (e.g., Di Paolo, 2021; Di Paolo et al., 2018) signals similar concerns with hylomorphic thinking.

We should note that there are two different claims in the critique of hylomorphism: That a form pre-exists the process of making, and that the process of making consists in the transcription of this form. Matter ("materiality," or "materials") is largely inert, unshaped and pliable, a source of resistances or affordances, but lacking agency and intentionality.

In this manner, human productive practices can be understood in terms of a dualism between the intentional active subject and formless passive matter. The contributions of intentional agency can be identified and isolated from the contributions of the body, the materials that the action transforms, and the techniques employed for its transformation. This assumes that the contributions of the mind can be isolated from the contributions of the body, the materials, and techniques. Therefore, if we can factor out the respective contributions of each side (mind and matter), we can reconstruct the scheme of their relations, following the direction of causality between cognitive-perceptual-affective processes and matter (bodies, materials, objects, and environment).

In this approach, human productive practices are composed of a network of plans (representations) followed by agents with the purpose of the controlled shaping of matter. The process of shaping is guided by a set of instrumental actions which involve the use of existing artifacts. Following such a plan is like consciously following a rule. For example, take the case of a builder who follows a set of instructions for fixing a window. The builder "represents" the actions and executes the

commands. Afterwards, she evaluates the results of her actions by judging the changes intentionally introduced and contrasting them with the representations previously itemized in the instructions.

3 Material Agency: What Is It?

Agency is a highly abstract notion, like that of substance and force. It is a notion traditionally anchored on the contrasts between *activity* and *passivity*: activity being associated with the notion of causing change, and passivity with being the recipient of change. According to the classical definition by Giddens (1984), the capacity of agency (or action) “depends upon the capability of the individual to ‘make a difference’ to a pre-existing state of affairs or course of events” (14). An agent is seemingly characterized by an active causal power—and not just any power but one that is exerted in view of intentional aims. Traditionally, materiality has been placed on the passive side of the equation and mind on the active side. We should note, however, that passivity is not the same as indifference or lack of resistance; it may be predicated about agents themselves, as we discuss later. In fact, it is best understood in this context as an *aspect* of agency that describes the ability and willingness to submit to change. Agency, then, comprises both active and passive aspects. This is implicit in MET as it highlights the activity of matter and the passivity of human agents, who can be receptive to the material properties and forces that unfold in the space of practice.

Malafouris (2008) takes the case of pottery making as a model to argue that fundamental aspects of manufacturing take place at levels outside conscious awareness and the grasp of mental representations. The actions of the potter require close feedback loops between perception and action in which the minute pressures and motions of the fingers occur “with a minimal need of storage and internal processing” (22). The action begins with a grasping of the clay in which the hand adapts to the affordances of the material, in a “dynamic coupling” between “equal partners” (24–25). Intentionality is an emergent aspect of material engagement that takes place involving brains, bodies, and artifacts. These distributed components act as “dynamic attractors” that mold “the field of action” and shape, to an extent, the intentions of the craftsperson (28).

Such processes of making can be explained without appealing to representations in the minds of agents, and by approaching the components involved as a field of forces. The complementary metaphor of a *dance* characterizes the interaction between the agent’s work and the material conditions of production. Malafouris contends that agency is about causal events in the physical world rather than a “natural atemporal property of human beings” or a function of representational states in the mind (25). While bringing agency down to Earth, it also follows that in this view agency is primarily about *causality*: “the problem of agency is essentially about who or what is the cause of the doing” (23). Agency belongs to the system, the “compound of brain, body and resource” (32) in which the contribution of the potter is considered from the same ontological vantage point as any other component.

Human productive practices (i.e., practices aimed at the transformation of material processes and resources into some product of value; see Lawler, 2018) constitute a seamless warp of intentionality-in-action, materials, bodies, agencies, and techniques. These practices are interlinked by processes of “thinging,” i.e. “processes of thinking with and through things” (Malafouris, 2019, 7). Analyzing human productive practices means apprehending them in their ecological niches, where this seamless web is generated. Thus, for example,

“When we look to a stone tool we don’t simply see the externalization of form, skill or memory; rather we observe how the affordances of stone make possible for human bodies to learn and to remember skills, to sense causality, or to enact intention (...) stone tools bring forth and constrain the organism’s possibilities for action and imagination” (Malafouris, 2019, 3).

Much of the thrust behind MET derives from advances in embodied cognitive sciences, notably not only the enactive language expressed in the last quote but also the extended functionalism of Andy Clark (2008), Michael Wheeler (2010), and others (e.g., Rowlands, 2009; Rupert, 2009). According to the latter, brain, body, and world are engaged in a symmetrical dance where complex couplings realize the functionality of action, perception, and cognition, without entailing a privileged role for the human brain or the human body, an image we have already seen in the MET literature.

4 An Enactive Perspective on Agency

If we mix enactive and extended functionalist versions of embodied cognition, we may encounter problems. Enactivists have criticized extended functionalism precisely for ignoring the autonomy and agency of the cognizer (Di Paolo, 2009; Thompson & Stapleton, 2009). These criticisms center on the need to acknowledge an asymmetry between agents and environment, given by the ongoing and precarious processes of bodily self-individuation. This asymmetry does not imply a *causal* separation between bodily and environmental processes; as we shall see, it is built on the ongoing coupling between these processes and their mutually determining relations. Worldly processes are *always* involved in the agent’s self-individuation and become sedimented in a history of becoming. The enactive perspective thus distances itself from a functionalist/representationalist account by underlining the materiality *and* open-endedness of bodily processes. An agent is not a given individual but an unfinished process of becoming (Di Paolo, 2021; Malafouris, 2016). To establish this claim, the enactive perspective addresses questions that lie at the blind spot of functionalism, such as, what is an organism? What is sense-making? These questions are approached in operational terms, avoiding vicious circularities. All of this, interestingly, does not negate that processes of sense-making are realized through the coupling of bodily and non-bodily processes; on the contrary, the enactive approach offers tools to explain how this happens.

Despite its direct inspiration in embodied cognitive science, the material engagement perspective has not engaged with the enactive theory of agency in much depth.

MET has indeed attended to other aspects such as enactive signification and its emphasis on embodied activity (e.g., Froese, 2019; Malafouris, 2013, 2016, 2019, Overmann, 2019; Parisi, 2019; Prezioso & Alessandroni, 2022; Poulsen, 2019; Walls, 2019; Woodward, 2019). One exception is Ransom (2019) who briefly discusses the dynamic and asymmetrical relationality of agency and the self-constitution of bodies in the enactive literature, and highlights the potential of MET further engaging these and other ideas in 4E approaches. Another exception is Iliopoulos (2019) who examines the resonances and complementarities between pragmatism (in the works of Peirce, Dewey, and Mead) and both MET and enactive perspectives on agency and semiosis (see also Di Paolo et al., 2017; Gallagher, 2017).

5 A World-Involving, Organizational, MET-Compatible Theory of Agency

The enactive concept of agency has been the subject of an ongoing theoretical elaboration for at least two decades (Barandiaran et al., 2009; Di Paolo, 2005, 2009; Di Paolo et al., 2017, 2018; Varela, 1997) with similar ideas being currently discussed in philosophy of biology (Moreno, 2018; Walsh, 2015). This section and the next introduce some of the technical vocabulary necessary to describe the conditions of agency.

We should clarify that our focus on this particular branch of enactive work in no way denies the potential of other enactivists to further engage with MET; we think that work by Shaun Gallagher (2017, 2020) and by Alva Noë (2015) is particularly relevant and complement the points we develop here. See also the ecological-enactive framework developed by Erik Rietveld and colleagues (e.g., Rietveld et al., 2018).

The enactive approach is a non-reductionist naturalism that regards the properties of living and cognitive systems as part of a continuum (conceptually as well as ontologically; e.g., Thompson, 2007), without erasing qualitative differences. Enaction emphasizes the role of embodied experience in affect and cognition, the autonomy of the cognizer, and its relation of co-determination with its world. In the context of our argument, enactivists propose a set of minimal conditions for defining agency. A broad constraint on these conditions is epistemic: A definition of agency should be operational, that is, based on what can be explained about a concrete instance without appealing to historical or contextual knowledge beyond the concrete current situation (Di Paolo, 2009; Varela, 1979).

The three key conditions that characterize the agency of organisms are *self-individuation*, *interactional asymmetry*, and *normativity*. These are proposed as the basic requirements for *minimal* agency. More complex forms of agency, such as sensorimotor, social, or linguistic agency, satisfy these three and additional conditions.

Within the context of the sciences of mind and the human sciences, we generally conceive of agents as identifiable individuals that engage in attempts to alter their relations to the environment and other agents; they do so to achieve some goal, or follow a norm. These intuitive requirements are given operational synthesis in enactive theory.

Self-individuation in organisms is described through *autopoiesis*, the organizational condition stating that the identity of an organism is continuously produced by its own operation. In other words, identity arises from the organism's own processes of self-production and self-distinction:

“An autopoietic system is organised (defined as unity) as a network of processes of production (synthesis and destruction) of components such that these components: (i) continuously regenerate and realised the network that produces them, and (ii) constitute the system as a distinguishable unity in the domain in which they exist” (Varela, 1997, 75).

Autopoiesis is the continuous material regeneration of a (i) self-producing and (ii) self-distinguishing network of molecular transformations in a far-from-equilibrium situation. Autopoiesis draws an *organizational*¹ (rather than *physical*, *statistical*, or *causal*) boundary around the organism. Autopoietic organizations are energetically and materially open, and they can sustain a certain range of perturbations and internal changes. The concept of autopoiesis can be broadened to other forms of self-individuation in systems beyond the biomolecular domain through the idea of *autonomy* (Varela, 1979).

Organisms are autonomous because they follow “laws” set down by their own activity (Di Paolo, 2003, 24). Identity, in this basic sense of the term, is generated when a network of dynamical processes becomes operationally closed under precarious conditions. Operational closure means that, for any given process that forms part of the system, we can always find among its enabling conditions other processes that make up the system. Processual precariousness (Beer & Di Paolo, 2023; Di Paolo, 2009) means that in the absence of the rest of the operationally closed network, any constituent process will tend to run down and stop. It follows that, at some level of description, the conditions that sustain any given process in such a network always include those conditions provided by the operation of the other processes in the network. The result of their global activity is an identifiable unity in the same domain or level of description (Di Paolo, 2009; Di Paolo & Thompson, 2014).

Self-individuation entails an ongoing coupling with environmental processes that involve exchanges of all kinds; it is an inherently relational concept. This coupling may be conceived, in a broad sense, as *symmetric* in general, meaning that influences between systems flow in all directions. Agents, however, often engage in *modulations* of this coupling; that is, they change its conditions, as when they displace themselves to an area that is more sheltered to avoid harsh weather, or when they pluck an apple from a tree branch. These modulatory engagements are *asymmetric* (Di Paolo et al., 2017). In dynamical systems terms, this means that agents induce changes (in parameters, constraints, variable sets, etc.) in the ongoing flow

¹ In the current context, the terms *organization* and *organizational* express the adoption of a system-theoretic perspective whereby a system is studied not so much in terms of specific causal processes but in terms of how processes relate in multiple ways (including causal as well as other forms of conditioning). This stance is a well-known feature of autopoietic theory and other current approaches to biological organization (e.g., Moreno 2018). The term organization should not be confused with exclusively human, social, or institutional meanings.

of influences between themselves and their environment. This is a key idea for the enactive account because it simultaneously acknowledges the inherent connection between agent and environment while recognizing a difference between them. Difference does not entail separation or dichotomy.

Asymmetric modulations are not random; they often are, in fact, *regulations*; i.e., they follow some vital sense, sensorimotor norm, or social value. The notion of *normativity*, broadly understood as entailing a situated non-indifference, applies beyond the human and implies that organisms cast a web of significance on their world, establishing their own perspective on it, narrowing down all possible interactions to just a few meaningful ones. In short, organisms are invested in what happens to them, they *care*. This is proposed as the definitional property of any minded system: the creation and appreciation of meaning, or *sense-making* (Di Paolo, 2009). Sense-making is the core shared aspect of all mental life, before further distinctions between action, perception, emotion, and cognition are introduced. Sense-making is active non-indifference—or *caring*—given by the adaptive relation that an organism holds with respect to the viability boundaries introduced by its self-individuation. The action of organisms *generates* meaning as well as being guided by it; organisms *enact* a world. They do so by the material traces left by their engagement with their surroundings, by selecting between alternatives and triggering other effects, in short, by tracing a historical trajectory co-defined with their environments. In this manner, a broad sense of value is an aspect of all sense-making, defined as the evaluation of the material consequences of interaction with the world by the sense-maker. Inherent in all this is an inextricable affective component (Colombetti, 2014). Value refers to the extent to which a situation affects the viability of a self-sustaining and precarious process that generates an identity.

The three requirements for minimal agency are synthesized by a set of internal relations. Vital or acquired norms are grounded in the conditions of ongoing and precarious self-individuation, which relies on asymmetric interventions in environmental flows that adaptively tend to conserve a way of life and cast the environment into a *world* or *Umwelt* for the organism. Agential regulations become sedimented into incorporated relations passing from a behavioral domain to a domain of organismic constitution, as in many cases of “externalized” physiology, such as insects that use air bubbles as external “lungs” to breathe underwater (Turner 2000). It is therefore the synthesis of these requirements, and not merely a list of three items, that is proposed as the definition of *minimal agency* (individually or in partial combinations, these conditions may be found in other systems too, Di Paolo et al., 2017).

The enactive conception of agency is grounded in operational definitions (of autonomy, adaptivity, sense-making, etc.) that, in turn, are based on system-theoretic concepts. It is a definition focused on *organization* (topological and temporal enabling relations between constituent processes) and not on *causality*. It is a non-circular definition in which agency is *not* defined as, say, the capacity “to act,” or in traditional terms of intentionality (e.g., Davidson, 1963). It is less restricted than an intentionalist account and more specific than a causal account in which an agent is defined as effecting changes in the world, like so many natural processes do. The minimal organization that a situated system must realize to be called an agent may be realized in different ways, and may involve extra-bodily processes (as in the case

of incorporation in sensorimotor agency discussed in Sect. 7, Di Paolo et al., 2017); but not just *any* extra-bodily process.

As we commented for the case of MET, minimal agency does not depend on ideas of activity or passivity. Agents may adaptively submit to external changes induced by environmental processes, such as birds that soar and control their flight by the subtle regulation of the relation between body and wind. An agent may not be the source of all relevant regulations, nor is it required to continuously engage in action. Activity and passivity are *aspects* of agency. They do not describe a dichotomy or even a single spectrum of possibilities (Bermejo et al., 2020). For example, I may actively inhibit my habitual reactions so as to let my arm be moved passively by a physiotherapist.

In the enactive view, the dance of human practices is indeed spread between brains, bodies, and world, but spread in an organized manner, involving constraints and norms at many scales, and in this spread some processes are the result of the agencies at play, while other processes, no matter how “active,” are not, according to the proposed criteria.

6 Sensorimotor Agency

Human practices, linguistic agency, and the human socialization are grounded on sensorimotor agency shaped by the context of material, social, and historical processes. To provide better links with MET, we must move from minimal agency to the organization of practices and how they emerge in the context of sensorimotor networks.

Enaction was first introduced by Varela and colleagues (1991) in terms of sensorimotor networks that describe how bodies are organized and embedded in webs of regulation (Thompson & Varela, 2001). Examining the idea of mastery in action and perception, Di Paolo and colleagues (2017) elaborate a formalization of Piaget’s equilibration theory and describe an agent’s sensorimotor repertoire in terms of precarious, operationally closed networks of *sensorimotor schemes*. These schemes are the components of action and perception and are always already constituted by a coupling of bodily and environmental flows. Sensorimotor schemes are “reusable, interlocking, organised sets of coordination patterns between body and environment” (Di Paolo et al., 2017, 81). They are organized sets of coordination patterns, mutually adjusted in timing, intensity, speed, precision, and etc., and these coordination patterns always emerge from a transaction between body and world. Grabbing a glass of water is a sensorimotor scheme composed of several coordination patterns, such as displacing the hand to the right location with an appropriate speed profile, orienting the hand and opening it, adjusting the position slightly, closing the fingers around the glass with the right amount of force, and lifting the glass. Schemes are shaped by experience via processes of assimilation and accommodation, responding to breakdowns with plastic recoveries. Moreover, schemes relate to each other, forming networks of dependence, priming, inhibition, or simply structural consequences (in body and environment) that affect other sensorimotor schemes (the scheme of drinking water is often enabled by a scheme of grabbing a glass of water and inhibited by a scheme for producing speech).

Schemes can form self-sustaining patterns, such as *habits* (schemes that sediment their history of structural and functional relations in such a way that they promote their re-enactment, which in turn reaffirms the same set of relations).

As the properties of habits already suggest (e.g., persistence, directed regulation, normativity), networks of sensorimotor schemes can form regional autonomous bundles of mutually related activity, the logic of which is underdetermined by biological constraints. It is possible to postulate a form of agency emerging in this way, a sensorimotor agency. A self-sustaining network of equilibrating relations among sensorimotor schemes (a “bundle of habits” to use William James’, 1890 term) can fulfill the three requirements for agency: it can become a self-individuated autonomous system, regularly inducing asymmetric regulations of the coupling with the environment, regulations that follow norms that correspond to the viability of the sensorimotor network itself.

Sensorimotor bodies are not just organic bodies. They are made up of networks of relations between precariously equilibrated sensorimotor schemes; they are organized patterns of enactments, powers, and sensitivities involving bodily and environmental processes. Sensorimotor norms establish how well a given act coheres with other acts, with the current situation, with other agents and artifacts, and overall, with the particular, historically developed sensorimotor style of the agent. It is the acts themselves that constitute a sensorimotor body as an ongoing, open-ended process. Bodies are therefore not just centers of active engagement with the world, they are, in a very strict sense, composed by the traces produced by enactments themselves, traces in our own body, in other bodies, and in the world. Bodies are not fully individuated givens; we literally enact them (see, e.g., Mol & Law, 2004).

Human sensorimotor bodies are constantly becoming in relation to environmental processes and other sensorimotor bodies. Repertoires develop and grow together, in particular in the regulation of interactions with others, from which patterns of interactions, social norms, forms of co-operative activities, languaging, and social practices emerge (Di Paolo et al., 2018). These paths lead to understanding aspects of human agency beyond the sensorimotor realm, such as, for instance, linguistic agency, the origin of ideality and objectification, labor, and the social roles and relations that develop as part of, and in the context of, sociomaterial historical processes. In turn, these reflections also help us establish some conceptual grounds for a theory of practice.

7 Toward an Enactive Conception of Productive Practices

As we have noticed throughout the previous sections, the enactive concept of agency does not contradict any of MET’s tenets. It is a relational concept, it is not anthropocentric, and it thematizes the deep entanglement of material processes (bodily and environmental). It is explicitly about ongoing becoming and avoids hylomorphism. And it offers a non-intentionalist set of operational criteria to answer questions about the agencies at play in a given situation, as well as the roles of non-agentive processes, regardless of their apparent activity or passivity. This delivers our central goal for this paper. The enactive concept of agency does not contradict MET, it

arises from similar philosophical sensitivities, but it does empower researchers to ask and answer questions beyond the recognition of causal spread.

To see that this is not merely an academic exercise, in this section we push the enactive position toward a MET-compatible approach to productive practices, focusing of questions of scale, decomposability, and teleology that showcase how the idea of agency might be deployed in concrete studies.

We want to show that the enactive concept of agency can be used to better articulate questions concerning the ensembles and multiple scales involved in productive practices. Through it we arrive at a similar conclusion as MET: Materiality *can* play constitutive roles in human productive practices (and practices in general), though it may not always do so. And when it does, it may or may not be an instance of non-human agency.

To fully achieve this articulation is beyond the scope of this paper, but it is possible to sketch at least a few relevant observations, as well as the questions they open up. Our first observation is that concrete situations demand situated epistemic decisions. A theoretical framework based on a version of MET incorporating enactive agency may offer general tools, but each case will be different from the next. This being said, the general proposal involves a methodological corollary: A useful notion of productive practice has to be able to function as a “unit” of analysis. It should provide a scale in which agents and non-agent processes as well as their relations can be meaningfully distinguished using the criteria for agency. In this sense, while formulated abstractly, enactive ideas are always to find their meaning and drive for further development within the study of what Hutchins calls “cognitive ecologies” (Hutchins, 2010). Having the enactive concept of agency at our disposal, it is possible to elaborate a non-hylomorphic idea of productive practice as processes within such ecologies by clarifying how we approach the questions of integration, scale, and teleology of agentive ensembles.

To illustrate this, we consider a couple of examples. A productive practice involving a clear case of non-human agency can be found in the tradition of building bridges across forest streams by guiding the aerial roots of living trees (Fig. 1). One of the best studied cases is practiced by the Khasi people in Meghalaya, in the north of India (Ludwig et al., 2019). Roots are manipulated to encourage growth in the desired direction. Different roots may combine by growing into a stronger natural “grafting” and the whole structure “stimulated” to grow stronger where needed by placing stones to induce tension. The bridge remains part of a living organism, with its natural defenses against parasites and rot and its ongoing self-renewal and strengthening in accordance to use. The bridge as such fulfills the organizational criteria for agency and demands a more interactive or participatory stance on the part of human “builders” and users. It constrains design decisions not just by its materiality but by the contingent and adaptive ways it would literally *react* to their implementation. The living bridge dictates its own temporality (taking years to form and lasting potentially for hundreds of years) entailing a particular relation to the social organization and traditions of the people who use them and their interaction with environmental and geological processes (Middleton et al., 2020). The productive practice in this case is defined by circular mutual specifications between all agents and other environmental



Fig. 1 Living root bridge in Cherrapunji in North-East India. (Photo by Arindam Das, CC BY-SA 4.0 <<https://creativecommons.org/licenses/by-sa/4.0/>>, via Wikimedia Commons)

processes involved, determining different phases of production that reduce in intensity but do not entirely stop when the bridge begins to be used regularly.

A contrasting case is the traditional production of lime mortar for use in conservation of historical buildings (e.g., Balksten, 2007). Material processes in this case are also very active and constrain human action, but they are not agents themselves. Appropriate limestone must be slow-burned for several hours to induce calcification. Adding water to the baked lime produces slaking and results, after several more hours of exothermic reaction, in lime putty deposits with a thick consistency. Other methods for slaking include mixing dry lime with wet soil. In these artisanal methods, the human agent is involved at specific stages in the process, setting up the conditions for material (thermal and chemical) processes to “do the work.” The productive practice is defined by a series of punctuated and relatively rapid interventions separated by longer stretches of material activity. Nevertheless, these material processes, active as they are, are not organized as agents. The skills involved lie mostly on the human side and consist in knowing the conditions well and adapting the process in case of any deviation.

While these two examples are relatively clear, we expect many real-world cases to be complex and depend on situated epistemic decisions, such as the scale of observation. This is particularly the case if we consider that the enactive concept of agency recognizes the plasticity of unfinished bodies and their boundaries, as well as the complexities of interventions involving the sense-making activities of multiple agents (Di Paolo et al., 2017, 2018). An important technical notion likely to play a role in more complex scenarios is that of *incorporation*, i.e., an

engagement between agent and material processes that moves beyond contextual or enabling relations, to *co-constitutive* ones.

Typical examples of incorporation are the skillful uses of tools and artifacts that progressively transform the way of life of an agent, and even her bodily constitution in all of its organic, sensorimotor, and social dimensions. Incorporation can be articulated in operational terms (for instance in terms of co-dependent participation in sensorimotor networks, Di Paolo et al., 2017, 175; Di Paolo et al., 2018, 29, 192ff, 330) and is manifested by certain phenomenological markers, such as a sense of empowerment, dependence, or extension of the lived body. Merleau-Ponty's classical example of incorporation is the blind person's cane. Here, the skillful use of the artifact reaches a point where lived experience resides not in the hand that holds the cane but at its tip (Merleau-Ponty, 2012, 144–45). Incorporation can take place in time-bounded situations, delimited by the normativity of a particular activity. Mutual incorporation may also take place fleetingly as a result of participatory sense-making (De Jaegher & Di Paolo, 2007; Fuchs & De Jaegher, 2009). When one or several agents *co-operate* (Goodwin, 2018), the boundaries of the agentive ensembles may be put in question. Actions and interventions may sometimes be attributable to a system composed of several agents, artifacts, and other material flows. The important point is that this is not always the case. It may or may not occur, or it may occur to certain and determinable degrees, and a theory of productive practices must have the tools at its disposal to tell the difference.

An agent is always heterogeneously constituted by the coordination of bodily and extra-bodily processes. How then can we identify incorporation in practice? Apart from the organizational and phenomenological criteria just mentioned, incorporation may be empirically investigated by specifying the conditions in which a set of processes behaves as a *decomposable* or *non-decomposable* system (Simon, 1969). In a decomposable system, different processes may be “factored out” in that their operation is (1) not strongly dependent on the concrete relations with other parts of the system and (2) neither is the operation of the rest of the system strongly affected. This cannot be done in a non-decomposable system. Also, some systems may be *partially* decomposable. Again, it is important to clarify we are not talking about causal relations, but relations of constitution; to operate as a part of a system requires certain interactions with other parts; if these relations do not affect the way the part operates but only the result of the operation, then these relations are merely causal and the part is ultimately decomposable. An integrated circuit in a computer will perform different computations, but the way it works remains unaffected by these differences. If the circuit overheats, in contrast, its operation is affected, and an explanation of this malfunction involves the effect of non-decomposable relations.

Studies on soft assembly in embodied cognitive tasks show that incorporations are not a given but vary with experience (e.g., Dotov et al., 2010; Anderson et al., 2012; Baber et al. 2019). These studies show that the dynamic signature of skill development, for instance, of a phenomenological transition from readiness-to-hand to presence-at-hand in tool use, is marked by *scale-free correlations across multiple timescales*. Such dynamical measures can be used to track the formation and transformations of agentive ensembles where agents fluidly relate to tools, objects, and other processes.

As we have said, these concerns will be more or less relevant according to the scope or focus of the investigation of concrete practices. The choice of scope (in temporal and spatial terms) leaves room for more than one relevant perspective, depending on the research question. In some cases, for example, the practice should be analyzed with particular attention to its material-cultural niche as well, in which it is found entangled with other practices of material engagement (Monterroza-Ríos & Gutiérrez-Aguilar, 2022). This by no means implies that the relations of agency and incorporation will be equally manifested at *any* arbitrary scale. Some perspectival choices will simply miss the relevant phenomena.

A relevant issue concerning the building of a MET-compatible enactive approach to productive practices is the worry that the enactive approach to agency might be too “individualistic” for the concerns of MET. While the order of ideas that serves our presentation follow the path of the single biological individual, later a sensorimotor agent, and then a social agent, it should also be clear from our exposition that this order is not a statement of how agency itself is produced. On the contrary, becoming an agent is always a result of an existing ecology and historical community of agents and environmental processes. Enaction explicitly investigates the way agency is enabled, shaped, honed, and constrained by sociomaterial processes (Di Paolo et al. 2017, 2018). Agency in real life, particularly human agency, must be understood as a collectively instituted category, even if manifested in individuals. Moreover, it is through participation in processes of collective individuation that the individual agent is further individualized, e.g., in adopting the stylistics of a profession, of an age group and gender, of a political affiliation, etc. (see Simondon, 2020; Virno, 2015).

One may also worry about whether the enactive concept of agency, in distinguishing agents from non-agents based on their organization, promotes a distancing between agents and the rest of nature? Do we not risk continuing to cast nature as means and resource by furnishing ourselves with a renewed theoretical justification? MET researchers would not look at such a split sympathetically (e.g., Alessandrini & Malafouris, 2022). This is an important point and the response goes along the same lines as our comments on agency as the products of sociomaterial ecologies. An agent does not confront mere separate materiality that may be consigned to particular functions within the agent’s design or discarded otherwise. An enactive agent confronts a world that is involved in the making and transformation of its own self. This is an explicitly transactional account (in the sense of Dewey & Bentley, 1946; see Di Paolo et al., 2018, 60). The agent emerges from a world that is valued and the target of moral concern, whether agencies are manifested in it or not. Again, we have an organizational distinction that does not entail a causal or processual separation; quite the opposite.

In this view, it is possible to state that agentive ensembles constitute productive practices together with other material flows that do not act as agents themselves, but which are partially sustained and sometimes constituted by the activity of the whole agentive ensemble. Incorporation and transactions may take place and manifest themselves as softly assembled systems correlating at multiple scales. Agents and non-agents can consequently develop complex historical relations of co-definition. Such would be the case of a *place* and other entangled enduring relations (e.g., Sepúlveda-Pedro, 2023).

In the study of a specific practice, what counts as agentic factors are the non-decomposable ensembles that fulfill (on the whole, and not merely derivatively) the requirements for agency. For instance, if we focus on the timescale of productive operations, we expect the skillful use of a tool by an expert worker to be less decomposable than the process of learning to use a tool by a novice. Insofar as the locus of agency is concerned, the ensemble of worker-and-tool is a system that operates as an “extended agent.” However, at the timescale of the social reproduction of a practice, the articulation of productive practice and apprenticeship may not admit an easy decomposition as in cases where training and production are separate activities. An organization that articulates production, training, and exchange may operate as an “agency” in ways that are not necessarily under the control of any individual human agent participating in it, either centrally or peripherally (Lave & Wegner 1991; Lave, 2011). This tends to be the case with complex institutions. The goals and norms that guide the global activity of production and reproduction are not even necessarily available in a complete or partial form to any individual consciousness (on the contrary, a collective enactment of *consciousness raising* is often required to become aware of these patterns).

The important point here, which deserves further research, is that while scales of observation may be chosen according to the particular interest of the researcher, the mark of non-decomposability implies internal relations *across* scales. This means that, already at the scale of production, operations have multiple normative constraints, some of which originate at other scales, e.g., training. Productive “virtues” (such as efficiency, safety, teachability, and sustainability) reflect dimensions of a productive practice involving several different scales that act concurrently, and which are realized in concrete processes.

This suggests that an enactive conception of productive practices will be concerned with the kind and degree of situatedness of a practice and the scales at which a practice remains non-decomposable. The systemic outlook complements similar approaches, such as Ian Hodder’s concept of “entanglement,” broadly conceived as sets of interlinked dependencies between humans and things (Hodder, 2012). These entanglements may be localized and partially instantiated; they might be unfinished or in a process of becoming. The enactive perspective turns intuitive notions such as “interlinked dependencies” into operational categories. Not just *any* relation between humans and things, or between things and things, will form part of an entanglement in general, or an agentic ensemble in particular.

The enactive idea of productive practices we are sketching here entails a historicity that places certain demands when accounting for normativity and teleology. Why follow certain designs or styles and not others that are equally efficacious? Why follow certain ways of making rather than others? Why train by doing instead of separating teaching and production? The advantage of combining MET’s approach to signification with enactive perspective is that normativity and teleology are inherent in the concepts of sense-making and agency, as we have seen. They do not require additional explanations, nor are they separate from sense-making activity. There is no need of a mental-intentional realm

imposing independent constraints on productive operations. There is rather the possibility of a mental realm *emerging* from productive practices (Sohn-Rethel, 1978; Stewart, 2014). In those representation-hungry practices where “mental” operations (planning, design, etc.) are dominant, the latter are also seen as the embodied activity of agentic ensembles, often executed via gestures, diagrams, material arrangements, measuring devices, computers, and other epistemic tools.

From this, it should be clear that we do not propose to consign the origins of novelty, flexibility, and creativity of productive ensembles solely to the agents themselves. This is a concern that drives Malafouris’s more recent work. What is novel, normative, flexible, or effective does not unquestioningly reside in just one kind of process (agents) and not in others. Novelty and creativity originate in historicity, i.e., situations in which dynamical changes, precariousness, and variability conspire to take on the shape of a novel activity, which itself may posit its own framework of normativity, sometimes retroactively (e.g., discovering a particularly pleasant sound by playfully striking a stone may lead to a search for similar stones to make music). All of this can happen with or without an agent’s intentions or motivations playing a part. Enactivists sometimes call this the emergence of a new “microworld” (see Di Paolo et al., 2017; Varela, 1995; and the discussion on historicity in Di Paolo et al., 2022). Since all the dancing partners, agents or not, affect these historical processes, creativity cannot be solely attributed to agents themselves, very much in tune with Malafouris’s (2014) concept of *thinging*. This should allay worries about the enactive perspective devolving such virtues to the human domain simply because it posits a differentiation between agents and non-agents (cf., Alessandrini & Malafouris, 2022). We hope that the misinterpretation that enactive theory proposes an *independence* between agents and materiality (ibid.) has been sufficiently discouraged by all of the foregoing.

Clarifying the difference between agency and non-agency, however, does not ipso facto resolve all of these questions. Put differently, the naturalized take on teleology and the generalized sources of novelty beyond the agent, while advantageous, do not fully answer all questions concerning the historical creativity and stability of particular traditions of production. Such questions require historical and situated explanations. These explanations we owe. Recent work on an analogous question concerning language (Di Paolo et al., 2018) may help us sketch how norms and spontaneous activity become sedimented in the recurrent interactions between communities and their environment, including other communities and the other-than-human world.

8 Conclusion

We have articulated an enactive theory of agency that, to our minds, fits well within the general orientation of MET and resolves several outstanding questions. The enactive framework theorizes agency from an organizational perspective and develops this idea in an operational definition. The definition serves the purpose of supplying MET with tools to clarify the scope of agency in concrete situations of production. As with any definition, it may be revised and improved.

We have also sketched some initial building blocks for a MET-compatible enactive conception of productive practices, which is the empirical field in which the enactive notion of agency should be applied and its usefulness tested. We have discussed some aspects (incorporation, integration, decomposability, scale, historicity, and teleology of agentive ensembles) that can furnish an enactive analysis of human productive practices.

We have dealt exclusively with the epistemic advantages of our proposal but we should also mention that a strong theory of agency has important ethical implications that demand further exploration (see, e.g., Di Paolo & De Jaegher, 2022; Pescador Canales & Mojica, 2022; van Grunsven, 2018). Questions of empowerment and alienation, of responsibility, of the erosion or regimentation of human agency by economic and technological power, and many others, are only conceivable if predicated of agents (or more specific categories, such as “persons”). Counting with a rigorous, yet flexible, concept of agency renders us capable of thinking about, say, alienation and liberation in many of its forms.

In encouraging the growth of a living bridge between MET, enaction, and other perspectives and practices, we hope to have contributed to a better understanding of these open scientific and ethical questions.

Abbreviation MET: Material engagement theory

Data availability Not applicable.

Declarations

Ethical Approval and Consent to Participate Not applicable.

Consent for Publication Not applicable.

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