# Hybrid Participatory Sense-Making in Human-Robot Social Interaction: An Enactive Account of Hybrid Relational Organization

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**Abstract.** Social robots increasingly participate in forms of coordination with humans despite fundamental differences in the organization of their respective activities. This organizational heterogeneity poses a specific challenge to enactive approaches to social cognition, particularly Participatory Sense-Making (PSM), whose canonical architecture involves coordination among autonomous sense-makers and the possible emergence of interactional autonomy**.** Building on current debates concerning the application of PSM to human–machine interaction, this paper takes a complementary, unexplored direction. It asks, with specific reference to social robots, what becomes of this architecture when not all participants can be assumed to instantiate autonomy and sense-making. Rather than making the cognitive status of the artificial participant a prerequisite for analysing human–robot interaction, we return to Varela's foundations of enaction—specifically, his theory of autonomous organization—to explore the organization that heterogeneous coordination itself may acquire. We introduce two concepts. The first is *Hybrid Conversational Unit* (HCU), designating the possible emergence of autonomous relational organization through recurrent coordination between human and robotic participants. The second is *Hybrid Participatory Sense-Making* (HPSM), designating the participatory transformation of human sense-making through such an organization. Their distinction supports our central proposal: *being a sense-maker and participating in the organization of sense-making need not coincide*. Together, HCU and HPSM ground a *conversational approach to hybrid participation* that shifts inquiry from the isolated properties of artificial systems to the relational organizations in which their capacities participate, opening a comparative and design-oriented research program concerned with the sustainability of emerging hybrid social ecologies.

**Keywords:** Enaction, Hybrid Conversational Unit, Hybrid Participatory Sense-Making, Sustainable Social Robotics.

## 1 Introduction

Social robots are artificial systems designed to interact with humans through social signals compatible with those involved in human social interaction [e.g., 1-3]. Gaze, gesture, vocal and temporal patterns, movement and proxemic behaviour can enable human and robotic participants to enter into processes of social coordination despite fundamental differences in the mechanisms through which their respective activities

are generated. Social robotics therefore confronts us with a distinctive form of social interaction: coordination between organizationally heterogeneous systems [4-5].

Understanding this heterogeneity becomes increasingly important as social robots enter human processes of communication, coordination, learning and socialization. Their significance concerns not only what robotic systems can do, but what forms of social relation human–robot interaction can generate, how these relations participate in shaping human activity and sense-making, and with what consequences for the sustainability of human cognitive and social life. Here, sustainability refers specifically to the conditions under which hybrid interactions support or constrain human agency, social relationships and sense-making within evolving cognitive and social ecologies.

Accordingly, addressing these questions requires complementing the analysis of the individual participants with an exploration of the organization of their interaction.

The enactive notion of *Participatory Sense-Making* (PSM) provides an important resource for this shift. Rather than reducing social cognition to the capacities of individual agents, PSM investigates how the coordination of human agents, construed as autonomous cognitive systems, can acquire its own dynamics. More specifically, the interaction can acquire a degree of autonomy and, in turn, contribute to transforming their cognitive activity—sense-making. Importantly, the application of PSM to human–machine interaction raises a specific problem. *What becomes of this enactive architecture when not all participants can be assumed to be autonomous sense-makers?* This question has begun to emerge in PSM-based approaches to human–machine interaction and intersects with current debate concerning the possibility of "artificial sense-making".

In this paper, we contribute to PSM-related research on human–machine interaction by exploring a direction complementary to ongoing inquiries. Specifically, rather than making the cognitive status of the artificial participant a prerequisite for examining the interaction, we ask what organizational form human–robot coordination can acquire under conditions of organizational heterogeneity, and how such relational organization can participate in human sense-making.

To address these questions, we return to Varela's foundations of enaction—in particular, to his theory of autonomous organization. Our theoretical proposal is articulated in two concepts: *Hybrid Conversational Unit* (HCU) and *Hybrid Participatory Sense-Making* (HPSM). HCU identifies the conditions under which coordination among organizationally heterogeneous participants—specifically, humans and social robots—may acquire relational autonomy. HPSM identifies the further possibility that such a hybrid relational organization participates in shaping and transforming human sense-making. Together, HCU and HPSM ground what we propose as a *conversational approach to hybrid participation*: an approach that shifts inquiry from the isolated properties of human and artificial systems to the forms of relational organization in which their different capacities can participate. This provides a basis for investigating, comparing and developing heterogeneous forms of human–artificial participation from the standpoint of their implications for the sustainability of human cognitive and social ecologies.

The paper proceeds in five steps. *Section 2* identifies the conceptual resources for our proposal by reconstructing the development of the enactive relation between autonomy, sense-making and PSM. *Section 3* examines how these resources have been brought into human–machine interaction and defines the problem posed by organizational

heterogeneity. *Section 4* establishes the organizational basis for addressing this problem by returning to Varela's generic model of autonomous organization—the conversational unit. *Section 5* and *Section 6* develop, respectively, the concepts of HCU and HPSM. *Section 7* draws together the resulting framework as the basis of a conversational approach to hybrid participation and outlines its implications for the investigation and development of sustainable hybrid social ecologies.

## 2 The Evolution of Sense-Making

### 2.1 Autonomy and Sense-Making

Francisco Varela's enactive approach to cognition took shape within a line of research originating in Warren McCulloch's cybernetic program of *experimental epistemology* [6]. McCulloch's modelling of neuronal activity, developed with Walter Pitts, contributed decisively to the foundations of computationalism and to the development of the digital computer as a model for understanding cognition. Yet, within the same research direction, McCulloch and Pitts came to recognize the computational approach as an oversimplification of the organization of natural cognitive systems [7-8]. Their work thus contributed to a research tradition increasingly concerned with the limitations of the computer metaphor. By describing cognition through an *input–processing–output* architecture, this metaphor obscures a fundamental organizational difference between biological systems and engineered computational devices. Living systems are autonomous, not heteronomous systems: they are not specified from the outside but constitute and maintain themselves through their own activity [9].

Within experimental epistemology, this recognition opened a double research problem concerning the kind of organization that supports the autonomy of living systems and the kind of cognition that autonomous organization makes possible. Varela developed this problem through a research trajectory connecting the McCullochian tradition of experimental epistemology, second-order cybernetics [10], autopoiesis [11] and the broader scientific investigation of self-organization. The enactive approach emerged from this trajectory by connecting the organizational autonomy of living systems with the distinctive form of cognition that such autonomy makes possible [12].

This approach builds on the idea that, organizationally, the autonomy of biological cognitive systems—their capacity to constitute and maintain their own identity—is realized through a closed network of mutually dependent component-level processes. Through their recursive interdependence, these processes generate the dynamics of self-constitution through which the system maintains its identity while remaining structurally coupled with its environment, on which it continuously depends for matter and energy. Closure therefore does not mean isolation; it has a crucial epistemological implication [13-15]. Environmental events do not specify the system's activity from the outside but perturb a system whose possible changes are determined by its own structure and regulated within its autonomous organization. Structural coupling thus describes an ongoing history of reciprocal changes in which the autonomous system responds to environmental perturbations through its own self-regulatory dynamics while maintaining its organizational identity [10-12].

The relation between autonomous identity and environmental coupling, developed through Varela's 1970s work with Humberto Maturana on autopoiesis [11] and his independent work on autonomy [12], provides the organizational basis for his notion of *sense-making*. In a 1981 lecture entitled *Living Ways of Sense-Making*, Varela describes living beings as "making sense" in ways through which they can be said to have a world [16].[1] In later formulations, the same organizational logic is articulated as the emergence of an identity that constitutes a point of reference for a domain of interactions, since environmental events acquire significance in relation to the system's own organization and continued existence. Cognition, in this sense, is not the internal representation of an externally pregiven world, but the activity through which an autonomous system brings forth a meaningful world of reference for its interactions [e.g., 17].

## 2.2 Participatory Sense-Making

The theory of *Participatory Sense-Making* (PSM), originally developed by Hanne De Jaegher & Ezequiel Di Paolo, extends this organizational conception of cognition to social interaction [18]. Its central move, far from simply placing individual sense-makers in interaction, is to recognize the interaction process as a distinct level of organization that can acquire a degree of autonomy of its own. Through recurrent coordination, patterns can emerge that are not under the unilateral control of either participant and that contribute to maintaining and regulating the interaction itself. When this occurs, the interaction constitutes an emergent autonomous organization in the relational domain. Individual sense-making and interactional dynamics consequently constitute distinct but interdependent levels of organization. The participants remain autonomous sense-makers, while their sense-making activities become coordinated and reciprocally constrained; in turn, the dynamics of interaction can modulate, regulate and, under some conditions, constitute aspects of individual sense-making.

Later developments of PSM make the organizational relation between these levels particularly explicit. In *Linguistic Bodies*, Di Paolo and De Jaegher, with Elena Cuffari, distinguish "individual autonomy" from the "interactional" or "relational autonomy" of the interaction pattern [19]. The latter is not an autonomy anchored in the bodies of either participant, but one that emerges from the relations between their bodies and activities.

Crucially, relational autonomy does not replace individual autonomy. Enactive social interaction requires the coexistence of both: an autonomous organization emerging in the domain of relational dynamics and the continued autonomy of the agents involved. The autonomy of the interaction is therefore a complementary organizational level, not an alternative to the autonomy of its participants.

This point places an important constraint on the architecture of PSM. The interaction can acquire dynamics of its own and can in turn transform individual sense-making, but the participants entering this interaction are themselves autonomous agents and sense-

[1] The title Living Ways of Sense-Making originates from a lecture delivered by Francisco Varela at the 1981 Stanford International Symposium on Disorder and Order. Evan Thompson (2011) subsequently adopted the title for his own article, explicitly acknowledging its Varelian origin [16].

makers. In this canonical configuration, individual autonomy, interactional autonomy and PSM are distinct but structurally connected. PSM emerges through the coordination of autonomous sense-makers within an interaction characterized by relational autonomy. This raises a specific problem when PSM is extended to human–artificial interaction: *what becomes of this architecture when the participants entering the interaction cannot be assumed to instantiate individual autonomy and sense-making symmetrically?*

# 3 The Challenge of Heterogeneous Participation

## 3.1 Participatory Sense-Making in Human–Machine Interaction

This question has become increasingly salient as PSM has been brought into the study of interaction with artificial systems.

In social robotics, Valentina Fantasia, Ingar Brinck and Christian Balkenius (2022) propose PSM as both a theoretical framework and a methodological resource for Human-Robot Interaction (HRI) [20]. Their proposal entails a significant shift in the unit of analysis. Rather than grounding human–robot social interaction exclusively in the cognitive capacities of the individual participants considered separately, they place joint action and interaction dynamics at the centre of analysis. Human and robot can thus be investigated in terms of what they produce through coordination and as participants that, in their formulation, can "act together as a system". On this view, PSM directs attention to the sequential and situated processes through which social engagement and meaning are negotiated and transformed online.

This key relational shift, as realized in the field of HRI, exposes a critical theoretical question. Fantasia et al. adopt the canonical enactive framework, in which PSM involves the coordination and transformation of the participants' processes of sense-making. When transferring this framework to HRI, they do not independently establish that the robotic participant satisfies the organizational conditions associated with individual enactive sense-making. However, their discussion eventually refers to the successful coordination of sense-makers "be they humans or machines". The move from individual cognition to joint action therefore does not by itself resolve the question of the organizational and cognitive status of the heterogeneous participants whose coordination constitutes the interaction.

A related possibility emerges in Frank Förster's enactive analysis of robotic language acquisition [21]. Förster explicitly denies that the robotic system under investigation qualifies as autonomous in the enactive sense, while nevertheless considering the interaction to which it contributes as a potentially distinct emergent identity. His experiments further indicate that human–robot conversational dynamics can generate interaction-level constraints that modulate the activity of the participants. Although the system examined by Förster does not generate the conditions required for interactional autonomy, his analysis points toward an important possibility for the present argument. The absence of individual enactive autonomy in the robotic participant does not preclude investigating autonomy and constraint at the relational level.

This problem becomes an explicit object of investigation in the work of Robin Zebrowski and Eli McGraw. In their analysis of PSM and artificial minds [22], they

emphasize that PSM identifies a further level of autonomous organization in the interaction itself. Drawing on [18], they describe interaction as installing a relational domain with its own properties, capable of constraining and modulating individual behaviour. This provides conceptual resources for investigating human–machine interaction without reducing the analysis to the properties of the artificial system considered in isolation. However, their subsequent work [23] makes explicit a difficulty involved in extending this framework to human–machine interaction: the assumed symmetry of participants in standard accounts of PSM. Interactions involving living and artificial systems may instead instantiate forms of asymmetrical sociality. Zebrowski and McGraw address this problem by combining PSM with the notion of *sociomorphing* developed by Seibt et al. [24]. Sociomorphing shifts the analysis from the projection of human capacities onto non-human systems to the perception of their actual social capacities, allowing social capacities to be understood as asymmetrically distributed across different kinds of participants. In this way, it provides a finer-grained vocabulary for describing participation in human–robot interaction without presupposing human-like social or cognitive capacities on the artificial side.

Considered together, these PSM-based approaches provide crucial resources for extending PSM to human–machine interaction. Fantasia et al. show how PSM can reorient social robotics from the isolated capacities of human and robotic participants toward joint action and the dynamics generated through their coordination. Förster shows that interaction-level emergence and constraint can become analytically relevant even when the robotic participant does not satisfy the conditions of individual enactive autonomy. Zebrowski and McGraw further show that the extension of PSM to human–artificial interaction cannot simply presuppose symmetry between living and artificial participants, and explicitly develop conceptual resources for addressing asymmetrical forms of social participation.

The relevance of organizational heterogeneity also emerges from complementary perspectives on human–robot interaction. Hannah Pelikan and colleagues [25] investigate robotic agency as a situated and transient interactional achievement, including configurations of hybrid agency emerging through coordinated human and robotic contributions. Tom Ziemke [26, 27], drawing on the distinction between biological and artificial autonomy, examines how humans interpret robotic systems whose perceptual organization differs from their own, introducing the observer's grounding problem. These contributions illuminate distinct aspects of interaction under conditions of heterogeneity, without equating interactionally achieved agency or attributed intentionality with organizational autonomy.

Despite their different theoretical orientations, the approaches analyzed here highlight the central importance of relational dynamics and heterogeneity in human–robot interaction. Building on their insights, we extend the inquiry to the organizational level and address a new question. *What organizational form, if any, can coordination acquire when it involves a human and a social robot—that is, systems heterogeneous with respect to autonomy and sense-making?*

The relevance of this question becomes even clearer when considering that the social robots currently entering human social environments are predominantly developed within the "weak approach" to social robotics. From this perspective, organizational heterogeneity is not merely a temporary limitation to be overcome through the development of more sophisticated artificial systems, but a structural consequence of

the design strategy of weak social robotics [28]. Weak social robots are designed to reproduce aspects of the phenomenology and dynamics of human social coordination through artificial mechanisms that do not attempt to replicate the biological organization underlying human—or other living—social behaviour [4-5, 28]. Human and social robots can therefore enter recurrent processes of social coordination through compatible interactional signals while remaining fundamentally different in their modes of organization.

This point is decisive from an enactive perspective. A human participant is an autonomous sense-maker. The capacity of a robotic system to generate context-sensitive behaviour, regulate aspects of its activity or contribute effectively to social coordination does not, by itself, establish individual autonomy or sense-making in the enactive sense. Participation in social coordination and sense-making therefore cannot simply be assumed to coincide. Human–robot interaction may display precisely the kinds of coordination dynamics that motivate a relational analysis while the autonomy and sense-making of its participants remain organizationally asymmetric.

## 3.2 Artificial Sense-Making or Hybrid Relational Organization?

One possible response is to reconsider whether artificial systems themselves may instantiate forms of sense-making.

Recent developments in artificial intelligence have made this possibility increasingly contested. Focusing specifically on Large Language Models, Tom Froese formulates an "AI dilemma" [29]. Either the linguistic competence displayed by frontier LLMs can occur without sense-making, or sense-making itself must be reconsidered beyond its traditional grounding in biological embodiment. He argues for the latter possibility, proposing that contemporary LLMs may instantiate a novel non-biological form of sense-making grounded in technologically mediated embodiment.

Although Froese's argument concerns LLMs rather than social robots, the theoretical challenge it raises is directly relevant here. It questions whether biological constitutive autonomy should remain a necessary condition for every possible form of sense-making and thereby identifies one route through the problem exposed by human–machine interaction: reconsider the conditions under which the artificial participant itself can qualify as a sense-maker. Its relevance to social robotics may become still more direct as language-model-based capacities begin to be integrated into embodied interactive systems.

However, our argument explores a complementary route. We neither exclude the possibility of artificial sense-making nor need to decide it in advance. Instead, we ask whether two dimensions that largely coincide in the canonical architecture of PSM must necessarily coincide in every participatory configuration: being a sense-maker and participating in the organization of a process through which sense-making is shaped and transformed. This distinction shifts the inquiry from the cognitive status of the artificial participant to the organizational status of the interaction, returning us to the question raised above: *what form of autonomous organization, if any, can emerge through coordination between participants heterogeneous with respect to autonomy and sense-making?* This organizational question opens onto a further one: *what becomes of participatory sense-making when being a sense-maker and participating in the organization of sense-making no longer necessarily coincide across participants?*

The organizational question brings us back to a problem that played a formative role in the research tradition from which enaction emerged: the organizational distinction between natural cognitive systems and artificial machines.

## 4 Back to the Origins: the Conversational Unit

The difficulty identified in the previous section is not whether interaction can acquire an autonomy of its own. PSM already provides a positive answer to this question through the notion of interactional or relational autonomy. The difficulty concerns instead the organizational conditions under which such autonomy can emerge when the coordination involves systems heterogeneous with respect to autonomy and sense-making. In the canonical architecture of PSM, an autonomous interaction is constituted through the coordination of participants that are themselves autonomous sense-makers [18-19]. Human–robot interaction therefore requires us to ask whether this condition exhausts the organizational possibilities of relational autonomy.

To address this question, we go back to the characterization of autonomy that Varela placed at the foundations of the enactive approach. Varela's investigation of the organization supporting autonomy was not limited to the specific modelling of minimal biological organization developed with Maturana within autopoietic biology. In *Principles of Biological Autonomy* (1979), he developed a generic model of autonomous organization—"the conversational unit"—intended to be specified in relation to different domains and organizational levels [12; 30]. At its core is the notion of *organizational closure*: the processes constituting an autonomous system "depend recursively on each other in the generation and implementation of the processes themselves" and, through this recursive interdependence, "constitute the system as a recognizable unit" in the domain in which they occur. Crucially for the generic character of the model, Varela emphasizes that "the processes that specify a closed organization can be of any type" [12].

From the perspective of our argument, the interest of this formulation is that it shifts the criterion of autonomy from the nature of the participating processes to the organization of their interdependence. Closure does not require a prescribed material substrate or a predefined class of components. What matters is whether the processes involved become recursively interdependent in such a way as to constitute and maintain a recognizable unity. Moreover, the resulting unity can itself enter into further relations of interdependence, whose closure may generate another autonomous organization at a different level [12; e.g., 31-33]. Autonomy can therefore be investigated across organizational levels without assuming that the processes entering into a higher-order unity must themselves instantiate the same form of organization.

Varela explicitly explores the possibility of higher-order autonomous organization at multiple levels, including that of social interaction. At these higher levels of integration, the model of the conversational unit provides conceptual resources for examining interaction itself as a possible autonomous relational organization. In this respect, the relational architecture developed by Varela can be regarded as a strong conceptual antecedent of PSM. The latter subsequently develops this architecture explicitly in terms of the coordination and transformation of the participants' processes of sense-making.

The organizational core of Varela's model lies in recursion. Processes of social interaction can themselves enter into organizational closure. Through recurrent coordination, the activities of the participants may become recursively interdependent such that their social interaction acquires an organization that cannot be reduced to their separate trajectories. Its closure can be "transient and mobile" [12], yet the interactive process may constitute "an autonomous entity in itself", emerging at a higher level of interdependence among the participating systems [12].

Importantly, however, Varela's criterion does not prescribe organizational homogeneity among the processes entering the closure. His statement that the constitutive processes of a closed organization can be "of any type" does not establish that arbitrary heterogeneous processes will form an autonomous unity, nor does it imply that human–robot coordination is organizationally closed. It makes a different and more limited possibility theoretically available. Relational autonomy can therefore be investigated without making organizational symmetry between the participating systems a starting assumption.

This possibility allows us to reformulate the problem raised by human–robot interaction. Relational autonomy need not be made conceptually dependent on first establishing autonomy and sense-making in the artificial participant. The organizational question is instead whether recurrent coordination between an autonomous human sense-maker and an organizationally different artificial system can develop recursive interdependencies through which their interaction constitutes and regulates an autonomous relational unity of its own.

The proposed extension thus preserves the organizational criterion of relational autonomy. An interaction must still constitute a recursively organized network of interdependencies capable of contributing to its own regulation and maintenance. What is reconsidered is the canonical PSM assumption that the participants whose coordination constitutes an autonomous interaction are themselves autonomous sense-makers. Varela's generic model allows us to distinguish the organizational conditions for autonomy at the relational level from the organizational properties of the systems whose activities enter into that relation. This distinction does not establish that hybrid relational autonomy occurs in human–robot interaction; it makes its possibility available for theoretical formulation and empirical investigation.

We develop this organizational hypothesis through the concept of the *Hybrid Conversational Unit*.

## 5 Hybrid Conversational Units

The Varelian model allows us to formulate the organizational hypothesis at the core of our proposal. If autonomy at the relational level depends on the recursive organization of interdependencies rather than on the organizational homogeneity of the processes involved, recurrent coordination between a human sense-maker and an artificial system can be investigated as a possible site of autonomous relational organization.

We introduce the concept of *Hybrid Conversational Unit* (HCU) to designate this possibility. An HCU is an autonomous relational organization that may emerge when recurrent coordination between organizationally heterogeneous participants—specifically, humans and social robots—develops recursive interdependencies through

which the interaction contributes to the regulation and maintenance of its own organization. Importantly, its hybrid character does not refer to a convergence between human and robotic forms of organization. On the contrary, it designates a relational unity constituted through their difference. Hybridization concerns the organization of the relation, not the organizational or cognitive equivalence of its participants.

This distinction shifts the analysis from the similarity of the participants to the organization of their coordination. A social robot need not reproduce the biological organization underlying human cognitive and social activity in order to participate in such an organization. Its movements, timing, linguistic production or other socially relevant activities can enter into recurrent dependencies with human activity. Robotic activity constrains the trajectories available to the human participant, while human activity constrains the subsequent trajectories of the artificial system.

However, reciprocal influence alone is not sufficient to constitute an HCU. Following the conversational unit model, the stronger condition is that these local dependencies become recursively organized so that the relational pattern they generate in turn constrains the processes through which it is maintained.

The HCU hypothesis therefore distinguishes coordination from relational autonomy. Not every successful or sustained human–robot interaction constitutes an HCU. Repeated responsiveness, behavioural adaptation or engagement may remain explainable through the separate regulatory architectures of the participants. Relational autonomy becomes a relevant hypothesis when coordination develops interaction-generated constraints that contribute to its own continuation and regulation, producing an organizational level that cannot be reduced to either participant considered independently. In this sense, the proposed progression is *recurrent coordination; recursive interdependence; interaction-generated constraints; organizational closure; relational autonomy.*[2] For an illustration, see *Table 1*.

***Table 1.*** *A hypothetical human–robot conversational repair scenario illustrating the distinctions between recurrent coordination, HCU and HPSM*

| Analytical level | Hypothetical scenario | Distinguishing criterion |
|---|---|---|
| *Recurrent coordination* | A human signals a misunderstanding; the robot requests clarification; the human reformulates; the robot adjusts its response. | Reciprocal responsiveness, potentially explainable through the participants' separate regulatory architectures. |
| *Hybrid Conversational Unit (HCU)* | Through successive repairs, a relational pattern develops in which locally generated constraints regulate subsequent contributions, while the enactment of these contributions recursively regenerates the conditions sustaining the pattern itself. | Recursive interdependence and interaction-generated constraints contributing to the regulation and maintenance of an autonomous relational organization. |
| *Hybrid Participatory* | Through participation in this relational organization, the human progressively reinterprets | Relationally mediated transformation of human sense- |

[2] Empirically, this progression raises the question of what interactional evidence would allow us to distinguish recurrent coordination from the emergence of an autonomous relational organization. Relevant indicators would need to concern not simply reciprocal responsiveness, but interaction-generated constraints through which the ongoing relational dynamics contribute to regulating their own continuation.

| | | |
|---|---|---|
| *Sense-Making (HPSM)* | ambiguous responses as opportunities for clarification, transforming how conversational difficulties acquire significance and which possibilities of action become available. | making, beyond behavioural adaptation alone. |

This formulation re-specifies Varela's generic organizational model for the case of human–robot interaction, while also preserving the relational insight subsequently developed by PSM. In the canonical configuration of PSM, interactional autonomy emerges through the coordination of participants that are themselves autonomous sense-makers. The HCU hypothesis extends the organizational inquiry to interactions in which this condition cannot be assumed for all participants. The robotic participant is not thereby redescribed as biologically autonomous or as a sense-maker. What is attributed autonomy is the relational organization emerging through coordination. Human–robot interaction can therefore be analysed simultaneously at distinct organizational levels: autonomy and sense-making at the level of the human participant, artificial regulation at the level of the robotic participant, and—when the required organizational conditions are met—relational autonomy at the level of their coordination.

This multilevel organization also clarifies what we mean by robotic participation. Participation in an HCU does not require identical contributions from the human and artificial systems, nor does it imply equivalent agency or cognition. It requires that processes generated by both participants become relevant to the recursive organization of the relational unity. Their contributions may therefore remain radically asymmetric while becoming organizationally interdependent**.** Organizational heterogeneity is preserved within, rather than eliminated by, the emergent relational organization.

The HCU hypothesis therefore leaves open the question of artificial sense-making raised in Section 3. Its claim is more limited: relational autonomy can be investigated without first attributing sense-making to the robotic participant. At the same time, the HCU hypothesis allows us to return, in organizational terms, to the second question formulated there. *If a robotic system becomes organizationally involved in a relational unity that recursively constrains the activity of a human sense-maker, what role does it thereby acquire in the organization of human sense-making?*

The issue is no longer whether the robot itself makes sense of the interaction, but whether it participates in the relational organization through which human sense-making is shaped and transformed. This is the distinction between being a sense-maker and participating in the organization of sense-making that we develop in the next section through the concept of *Hybrid Participatory Sense-Making*.

## 6 Hybrid Participatory Sense-Making

The concept of the HCU addresses the organizational question raised by human–robot interaction, but it does not yet resolve its cognitive implications. An HCU may describe a relational organization emerging through the coordination of heterogeneous participants without requiring that both participants instantiate canonical sense-making. However, PSM concerns more than relational autonomy. It concerns the ways in which interaction participates in the generation and transformation of sense-making. The

question is therefore what becomes of this participatory dimension when not all participants in the relational organization can be assumed to be sense-makers.

A useful point of comparison is provided by recent enactive analyses of human interaction with Large Language Models. Barandiaran and Almendros [34] resist the attribution of autonomous agency to LLMs while examining how recurrent human–LLM coupling can nevertheless reorganize human activity. Their notion of *midtended agency* shifts attention from the artificial system considered in isolation to forms of human–LLM coupling in which machine operations intervene recursively in the ongoing activity of the human agent, becoming integrated into what they describe as a "unifying intentional process". In this respect, their proposal is particularly relevant to our argument. The absence of autonomous artificial agency does not imply the cognitive irrelevance of the artificial participant to the coupled process. Artificial systems can enter into interactional dynamics that alter the organization and trajectory of human agency without thereby becoming autonomous agents equivalent to their human partners.

Our proposal develops this relational possibility specifically in terms of sense-making and relational organization. If an artificial system participates in an HCU, its activity does not merely provide external stimuli to which the human sense-maker independently responds. It becomes part of the recursive network of dependencies through which the interaction is organized. Because this relational organization in turn constrains the human participant's activity, processes generated by the robotic system can contribute to shaping the conditions under which human sense-making unfolds. The relevant participation is therefore neither the transmission of meanings already generated by the robot, nor necessarily a joint production of meaning by two sense-makers. It is participation in a relational organization through which the participants' activities become mutually constrained and which, in turn, can modulate, redirect and potentially transform the human participant's sense-making.

This suggests a distinction that becomes necessary under conditions of organizational heterogeneity. *Being a sense-maker and participating in the organization of sense-making need not coincide.* In the canonical configuration of PSM, these dimensions largely overlap because the participants whose activities constitute the interaction are themselves autonomous sense-makers. In hybrid interaction they can come apart. The human participant remains the locus of enactive sense-making, while the robotic participant contributes processes that become organizationally involved in the relational dynamics through which that sense-making is organized. The asymmetry is therefore not an obstacle to be eliminated by attributing equivalent cognitive properties to both participants; it becomes a defining feature of the hybrid configuration.

We propose the concept of *Hybrid Participatory Sense-Making* (HPSM) for this configuration. HPSM designates the participatory organization and transformation of human sense-making within a relationally autonomous process constituted through the coordination of organizationally heterogeneous participants—specifically, humans and social robots. The robotic participant is not assumed to generate a meaningful world of reference comparable to that of a living sense-maker. Its contribution lies instead in participating in the recursive organization of a relational domain that constrains and transforms the human participant's possibilities of action, interpretation and meaning generation. The hybrid character of sense-making therefore concerns the organization

of its relational conditions, rather than the attribution of equivalent sense-making capacities to human and robotic participants.

HPSM consequently avoids two reductions: treating the robot as a mere external source of perturbation and requiring it to be treated as an individual sense-maker equivalent to the human participant. In the first case, the relational organization through which robotic activity becomes involved in human sense-making disappears from the analysis; in the second, organizational heterogeneity is dissolved by extending the same cognitive category to both participants. Sense-making may remain a capacity of the human participant while participation in its relational organization is distributed across heterogeneous human and artificial processes. This preserves the enactive grounding of human sense-making in individual autonomy while recognizing that its concrete unfolding can become dependent on relational organizations that include artificial processes.

This proposal also clarifies the relation between HCU and HPSM. The two concepts refer to different descriptive levels and should not be conflated. HCU characterizes the emergence of relational autonomy through recursive coordination among heterogeneous participants; HPSM characterizes the cognitive significance that such relational organization may acquire when it participates in shaping the sense-making of the human participant. An HCU therefore provides a possible organizational condition for HPSM, but does not by itself constitute HPSM. Identifying relational closure does not by itself establish that the resulting organization significantly participates in sense-making. This second claim requires showing how the relational dynamics constrain and transform the human participant's processes of meaning generation.

The relevant distinction is not simply whether the human participant changes behaviour, but whether the relational organization participates in transforming what becomes meaningful, how the situation is interpreted, and which possibilities of action become available. In the hypothetical repair scenario illustrated in Table 1, this would involve conversational difficulties acquiring a different meaning for the human participant through participation in the relational organization, rather than merely through exposure to individual robotic responses. Neither successful repair nor behavioural adaptation alone would establish HPSM.

The proposed architecture can be summarized as follows. The human participant remains the locus of enactive sense-making: significance emerges through the coupling of an autonomous system with its environment in relation to the maintenance of its own identity. However, the relational conditions through which such sense-making unfolds need not be constituted at the level of both participants. Within an HCU, these conditions can emerge through the coordination of heterogeneous human and robotic processes. Relational autonomy characterizes this hybrid organization, while HPSM characterizes the participatory transformation of human sense-making within it. This framework leaves open the possibility that some artificial systems may independently satisfy stronger criteria for autonomy or sense-making, as proposed in other approaches. Its purpose is to show that such an attribution is *not a prerequisite* for investigating how artificial systems can participate in relational processes that shape and transform human sense-making.

Building on the relational shift already introduced into social robotics by PSM-based approaches, HPSM specifies a further research question. *How do different artificial capacities enable different forms of participation in relational organization, what kinds*

*of hybrid relational dynamics emerge, and under what conditions do these dynamics participate in transforming human sense-making?* This opens an empirical research program in which different classes of social robots and, more broadly, artificial systems capable of social or communicative interaction can be compared in terms of their capacities for participation, the forms of relational organization these capacities enable, and the corresponding configurations of HCU and HPSM.

## 7 Grounding a Conversational Approach to Sustainable Hybrid Participation

Social robotics confronts enactive approaches to social cognition with a distinctive problem: social coordination can occur between systems that are organizationally heterogeneous with respect to autonomy and sense-making. Rather than making the cognitive status of the artificial participant a prerequisite for analysing such interactions, we have asked what organization human–artificial coordination itself can acquire and what role such organization may play in human sense-making.

Our proposal distinguishes two related possibilities. HCU designates the possible emergence of autonomous relational organization through recurrent coordination between organizationally heterogeneous participants—specifically, humans and social robots. HPSM designates the participatory transformation of human sense-making through such an organization. Their distinction allows us to separate being a sense-maker from participating in the relational organization of sense-making, without requiring equivalent cognitive or organizational properties on the human and artificial sides.

Together, HCU and HPSM provide the foundations for what we propose as a *conversational approach to hybrid participation*. The term *conversational* is intended here in a double Varelian sense. It refers, first, to the possibility that interaction itself acquires an autonomous relational organization. At the same time, it points to the *epistemology of participation* within which Varela situated the study of autonomous systems. An epistemology in which systems are identified and understood through situated, observer-related processes of interaction and distinction rather than from an assumed position of epistemic exteriority [12]. Applied to hybrid participation, this orientation redirects inquiry in two related ways. On the one hand, it shifts attention from what human and artificial systems are assumed to be in isolation to how their specific capacities participate in the constitution of relational organizations. On the other, it makes explicit the situated perspective of the observer-community from which these relational configurations are distinguished and investigated, and relative to which particular questions and interests become relevant [30]. In our case, this means making explicit an interest in the sustainability of the human cognitive and social ecologies in which robotic and other artificial systems are increasingly embedded.

The conversational approach is not limited to the analysis and comparison of existing configurations. It also provides an organizational perspective for exploring and developing different forms of hybrid participation. This becomes particularly relevant as previously distinct forms of artificial interaction increasingly combine within shared hybrid ecologies. Different robotic, linguistic, virtual and other artificial capacities may enter into new configurations of participation, making the relevant unit of inquiry not

simply a particular class of artificial system, but the relational organizations to which different combinations of capacities contribute. HCU and HPSM can thus support a research and design program concerned with both understanding emerging forms of hybrid participation and exploring the organizational conditions under which socially sustainable configurations can be developed. Such a program would compare how different artificial capacities contribute to recurrent coordination, whether and how interaction-generated constraints support autonomous relational organization, and under what conditions these dynamics participate in transforming human meaning generation. From a design perspective, the question is not simply how to sustain interaction, but how to develop relational configurations that support human agency, meaningful participation and the continuity of human social relationships.

From this standpoint, social sustainability concerns more than the persistence or effectiveness of human–artificial interaction. Relational autonomy and social sustainability are distinct dimensions. An HCU may maintain its own organization while constraining human agency or undermining human–human relationships; HPSM may transform human sense-making in ways that are not necessarily beneficial. Mixed social ecologies are already taking shape through interactions in which artificial processes participate in the relational organization of human activity and sense-making, and their increasing diversification and integration may transform the broader social ecologies in which human–human relations develop. The sustainability of hybrid participation therefore also concerns the forms of human agency, sociality and sense-making that different relational configurations enable, constrain or transform.

From a conversational perspective, the key sustainability-relevant question raised by increasingly interactive artificial systems is not so much whether artificial systems make sense of the world as we do, but how systems that are different from us can participate in organizing the relational processes through which we make sense of the world—and with what consequences for the sustainability of human social and cognitive life.

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