Mapping Epistemic Priors of Hyperscanning Psychotherapy: The Asymmetry and Reciprocity Blindspots

Authors

Nicolás Hinrichs[1,2*], Irene Senatore [3], Nara Figueiredo[4], Elena Cuffari[5], Alejandro Fábregas-Tejeda[6]

Affiliations

1 Research Group Cognition and Plasticity, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany
2 Embodied Cognitive Science Unit, Okinawa Institute of Science and Technology Graduate University, Okinawa, Japan
3 Berlin School of Mind and Brain, Humboldt Universität zu Berlin, Berlin, Germany
4 Department of Philosophy, Federal University of Santa Maria, Santa Maria, Brazil
5 Department of Psychology, Franklin & Marshall College, Lancaster, USA
6 Centre for Logic and Philosophy of Science, Institute of Philosophy, KU Leuven, Leuven, Belgium
* Corresponding author: hinrichsn@cbs.mpg.de

Abstract

Hyperscanning has been increasingly used to quantify the quality of social relationships by tracking the neural correlates of interpersonal interactions.This paper critically examines the use of hyperscanning to track the neural correlates of psychotherapeutic change, e.g., the patient-therapist relationship. First, we motivate our project by diagnosing a lack of complex models at the mesoscale in this domain and, consequently, a polarization of the analysis at the micro and macroscales. Looking for the causes of this issue, we highlight the epistemic blindspots of current methodologies that prioritize neural synchrony as a marker of therapeutic success. Drawing on empirical studies and theoretical frameworks, we identify an asymmetry between the neural and behavioral conceptual toolkits, with the latter remaining underdeveloped. We argue that this imbalance stems from two key issues: the underdetermined qualitative interpretation of brain data and the neglect of strong reciprocity in neuroscientific second-person paradigms. In light of our critical analysis, we suggest that further research could address the complexity of reciprocal, dynamic interactions in therapeutic contexts. Specifically, drawing on enactivism, we highlight that the autonomy of interactions is one of the factors that undermines the synchrony paradigm. This approach emphasizes the co-construction of meaning and shared experiences through embodied, reciprocal interactions, offering a more integrative understanding of therapeutic change that moves beyond static neural measures to account for the emergent and dynamic nature of social cognition.

Keywords

Hyperscanning, Neural Synchrony, Intersubjective Alliance, Philosophy of Neuroscience, Psychotherapy, Radical Enactivism, Second-person Neuroscience

1 - Introduction

The relationship between neural dynamics and interpersonal behavioral synchronization has been increasingly explored, ever since the idea of simultaneously recording several subjects' haemodynamic or neuroelectric activity involved in social interactions was proposed (Montague, 2002; Balconi and Molteni, 2015). Scientists working in disciplines such as developmental psychology (Nadel, 1999), social neuroscience (Dumas et al., 2010), cognitive neuroscience (Stephens et al., 2010), and educational neuroscience (Bevilacqua et al., 2019) have considered the central nervous system as a distributed network, further incorporating this perspective in behavioral hyperscanning paradigms. Inter-brain synchronization is inspired by the understanding of intra-brain synchronization, wherein coordinated neural oscillations allow for efficient communication across different brain areas. Similarly, inter-brain synchronization is thought to reflect the neural coupling between individuals during social interaction, allowing for shared understanding and coordinated behavior (Varela et al., 2001). To this day, there seems to be a consensus on the importance of investigating interactive phenomena on the basis of synchrony (Dumas, 2011; Schilbach et al., 2013; Konvalinka & Roepstorff, 2012). Hyperscanning holds appeal for researchers who study joint action, i.e., the coordination of actions across multiple individuals towards a shared goal (Sebanz et al., 2006), because it can address research questions regarding neural processes that happen not only 'within' individual group members (i.e., intra-brain processes) but also 'across' group members (i.e., inter-brain processes). In recent years, hyperscanning has expanded from cognitive science and social neuroscience into psychotherapy research, aiming to track how neural synchrony between a therapist and a patient may serve as an indicator of therapeutic success.

This paper seeks to critically assess the hypothesis according to which neural synchrony predicts more successful social interactions. First, we spell out and examine the *epistemic priors* that seem to guide hyperscanning research. After that, we identify two epistemic blindspots in the general hyperscanning literature which are fostered by the previously identified priors: (i) asymmetry between behavioral and neural toolkits and (ii) neglect of strong reciprocity. Second, the paper zooms in hyperscanning paradigms used to evaluate the quality of psychotherapeutic relationships. Here, it is hypothesized that repeated brain synchrony may correspond to a stronger therapeutic alliance and better mental health outcomes. We scrutinize such a hypothesis, by examining how the *epistemic priors* discussed in the first part (and their related blindspots) are specifically at play in the context of hyperscanning psychotherapy.

In Section 2, we introduce the method of hyperscanning, exploring how it has been applied in social neuroscience and specifically in patient-therapist relation research. We review empirical studies that support the relationship between inter-brain synchrony and therapeutic alliance, and then we motivate the necessity of mapping the *epistemic priors* of hyperscanning research. In particular, we acknowledge that mesoscale models remain underdeveloped if not totally neglected in this domain. To understand the reasons behind this neglect, we argue, we need to map the *epistemic priors* that are at play in this context and that likely steer research towards microscale and macroscale analysis.

In Section 3, we delve into the concept of *epistemic priors*, characterizing them as implicit assumptions that guide research without being directly acknowledged. We argue that the prioritization of neural synchrony when analyzing the data that has been collected stems from a bias toward symmetry in brain patterns, which is assumed to be necessary for coordinated social behavior to emerge and, moreover, regarded as sufficient to yield a biologically realistic model of it. However, so we argue, this focus on symmetry neglects the importance of asymmetry, divergence, and realignment in social interactions, especially in therapeutic contexts where patient and therapist may experience moments of tension or disconnection that are of paramount importance for growth and change. We then organise *epistemic priors* according to their relative contribution towards the etiological, experimental, epistemic, and engineering considerations relevant to hyperscanning.

Section 4 addresses the epistemic blindspots that arise as an outcome of the *epistemic priors* mapped in Section 3. In particular, we discuss : (1) the imbalance between neural and behavioral models and (2) the neglect of strong reciprocity in second-person neuroscience paradigms. Relating brain activity to psychological interpretations of behavior is an ever-standing problem in cognitive neuroscience research (see Boone & Piccinini, 2016; Egan, 2017; Gessell et al. 2021; Shapiro, 2017). Here, we aim to describe its specific instantiation and implications in hyperscanning research during psychotherapy sessions and introduce concepts such as meaning co-construction and dynamic interaction. On the one hand, the focus on synchronicity in retrieved neural patterns often leads to the underappreciation of other marks of behavioral and experiential dynamics that are equally crucial for understanding therapeutic change. On the other hand, the assumption that neural synchrony alone ensures successful interaction neglects the co-constructed and emergent nature of therapeutic relationships, which involve both alignment and misalignment.

Section 5 articulates the consequences of neglecting strong reciprocity in hyperscanning methodologies. We propose a specific characterization of reciprocity which, we argue, should be taken into account by future hyperscanning paradigms. Finally, we advocate for a shift toward enactive neuropsychology, a framework that highlights the role of embodied, reciprocal interaction in the co-construction of meaning. In contrast to static models centered on synchrony, enactive approaches account for the emergent and dynamic nature of social cognition. This section proposes that future research should integrate both neural and behavioral data to foster a more comprehensive understanding of therapeutic change, moving beyond neural synchrony to embrace the complexities of real-world interactions.

2 - Hyperscanning

Hyperscanning is an experimental paradigm used in cognitive science to simultaneously scan the brains of two or more participants as they interact in settings that are as naturalistic as possible. Techniques such as electroencephalography (EEG), functional near-infrared spectroscopy (fNIRS), and functional magnetic resonance imaging (fMRI) are employed to measure inter-brain coupling—the similarity in neural patterns between participants during specific tasks (Dikker et al., 2017; Liu et al., 2018).

Among the most widely used measures are phase wavelet coherence, which examines the alignment of wave spectrograms at specific fNIRS channels in two participants, and signal correlation, which measures how brain regions across participants co-vary in time (Jiang et al., 2015). These tools allow researchers to capture neural synchronization during dynamic social interactions. EEG is frequently used for its high temporal resolution, capturing rapid changes in brain activity (Pan et al., 2022), while fNIRS provides insights into hemodynamic responses by measuring oxygenated and deoxygenated hemoglobin concentrations (Liu et al., 2018). fMRI hyperscanning is employed to capture high-resolution brain activity and functional connectivity, though its constrained environment limits the naturalness of interactions (Cui et al., 2020). These neural data are complemented by tools such as eye-tracking and video recording to provide additional behavioral data (Yun et al., 2020). Eye-tracking can capture participants' gaze patterns and joint attention, while video recordings of facial expressions, gestures, and body language help to link neural activity to specific sequences of social behaviors during interactions. Recent technological advancements, such as the development of open-source Python libraries like HyPyP (Barraza et al., 2019), have made it easier to implement EEG-based hyperscanning and analyze inter-brain connectivity. These tools enable advanced statistical analysis of neural synchrony and offer visualization tools to map inter-brain interactions. Statistical techniques such as phase coherence, wavelet coherence, and cross-correlation analysis further enhance the precision of these studies, allowing for the exploration of how brain signals between participants synchronize over time (Hove & Risen, 2009).

The combination of these tools has opened up new avenues for investigating social interactions in naturalistic settings, including psychotherapy. Recently, hyperscanning has been applied in therapy session settings, where both a therapist and a patient are scanned during their interactions (Costa-Cordella et al., 2024). This approach explores the neural dynamics underlying the therapeutic process, with the hypothesis that inter-brain coupling could serve as a biomarker for therapeutic alliance and predict treatment outcomes. Video recordings and eye-tracking in such settings further allow researchers to examine how neural synchrony relates to gestures, facial expressions, and other non-verbal cues during therapy.

The rationale behind these studies stems from the fact that inter-brain coupling has generally been shown to predict the success of social interactions in other studies (Fishburn et al. 2018). Building on this evidence, the hypothesis tested in hyperscanning during psychotherapy is whether repeated inter-brain coupling *predicts* a stronger therapeutic intersubjective alliance (Sened et al. 2025; Zhang et al. 2018). In turn, therapeutic alliance has been shown to predict symptom reduction in anxiety and depression cases when assessed using baseline and follow-up test anxiety and satisfaction questionnaires (Sened et al., 2025). Specifically, inter-brain synchrony has been linked to enhanced social bonding in psychotherapy (Koike et al., 2016), increased empathy and social bonding during real-time social interactions (Kinreich et al., 2017), improved social cognition and understanding during face-to-face interactions (Reindl et al., 2018), and cooperative behavior and positive social outcomes in broader social contexts (Cui et al., 2012), further supporting the hypothesis that repeated inter-brain coupling may predict a stronger therapeutic intersubjective alliance (Zhang et al., 2018). Even though researchers have been careful in establishing causality links between interbrain coupling and therapeutic success, stronger hypotheses on the connection between neurobiological underpinnings and behavioral changes have been proposed. In particular, since difficulties in interpersonal relationships have been claimed to be one of the crucial symptoms in psychopathologies (Girard et al. 2017), the capacity of individuals to synchronize with other brains during social interaction has been argued to be crucial in psychotherapy-induced behavioral change (Sened et al. 2022b). In general, the literature on this topic crucially taps second-person interaction psychological and philosophical frameworks to evaluate and qualitatively interpret empirical data (Schilbach, 2013, 2024) in relation to their potential of being applied in therapeutic contexts (see Figure 1 below).

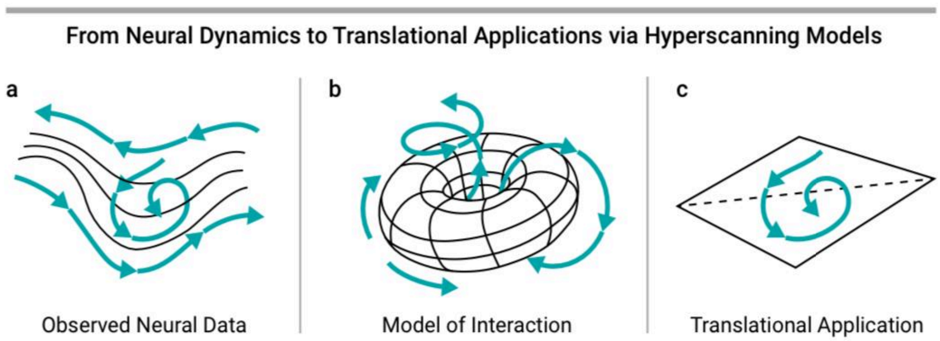

Figure 1. Different steps of research in hyperscanning: (a) observed neural data yield an instantaneous inter-connectivity state, which (b) undergoes coarse-grained, sequential mapping, guided by *epistemic priors*, which effectively link neural dynamics to interpretative models. Subsequently, these dynamics (c) are applied in translational praxis, such as clinical-behavioral diagnostics. Arrows represent information flow at each stage.

When being translated into clinical practice, hyperscanning research may face challenges that arise because of "epistemic messiness," as Scott-Fordsmand and Tybjerg (2023) have recently analyzed. In the context of hyperscanning, given the variety of concepts that are often applied in a somewhat imprecise and inconsistent manner (e.g., shared intentionality, interagency, mutual prediction theory, interpersonal synchrony, subject-subject relationship, among the most popular), it is crucial to remain mindful of researchers' epistemic assumptions and data analysis choices, particularly when drawing scientific and clinical inferences from statistical modelling of brain data (see also Zimmerman et al, 2024).[1] This is especially pertinent in hyperscanning research, where interpretations of inter-brain coupling are likely to be heavily influenced by the theoretical frameworks one decides to employ.

To systematically categorize the diverse contributions in the hyperscanning literature, we propose a framework organized around (1) Etiological, (2) Experimental, (3) Epistemic, and (4) Engineering research fields. This framework is based on two intersecting spectra (see Figure 2 below). The first spectrum spans from Etiological considerations, referring to studies with clinical diagnostic implications, to Experimental considerations, focusing on empirical, lab-based testing. The second spectrum ranges from Epistemic considerations, which addresses theoretical and conceptual considerations, to Engineering considerations, emphasizing technical implementations and advancements. This structure reflects the complex problem space that hyperscanning studies navigate, bridging clinical applications, empirical testing, theoretical reflections, and technical developments.

[1] For a critical discussion of other relevant issues related to hyperscanning that fall outside the purview of this article, see Hamilton (2021).

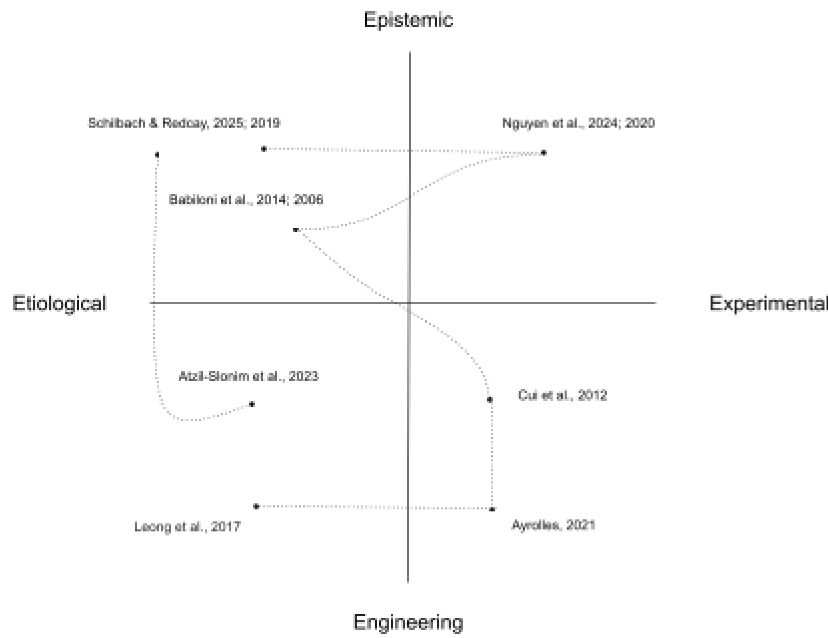

Figure 2. Categorizing contributions of hyperscanning into quadrants formed by intersecting spectra ranging from Etiological (clinical diagnostics) and Experimental (empirical lab-based testing) to Epistemic (theoretical considerations) to Engineering (technical implementations) research fields. Lines depict citation relationships.

1. Etiological studies emphasize the clinical diagnostic applications of hyperscanning, particularly in understanding interpersonal relationships in therapeutic contexts. These studies explore how inter-brain synchronization may serve as a marker for diagnosing or evaluating therapeutic progress, like Atzil-Slonim et al. (2023).

2. Experimental studies are primarily focused on lab-based testing, using hyperscanning to investigate the neural mechanisms underlying social interactions through empirical research, like Nguyen et al. (2024).

3. Epistemic studies delve into the theoretical underpinnings of hyperscanning, offering insights into how inter-brain synchrony informs broader theories of social cognition, interaction, and neuroscience, like Schilbach & Redcay (2019).

4. Engineering studies concentrate on the technical development, implementation, and refinement of hyperscanning techniques, providing tools for more accurate and reliable data collection and analysis, like Ayrolles et al. (2021).

In the next subsection, we discuss the notion of *epistemic priors*, so as to enhance the granularity on which we examine the contributions towards hyperscanning past their mere categorisation, and seek to motivate the use of such a concept to critically analyze state-of-the-art hyperscanning scientific frameworks. In particular, we highlight how mesoscale dynamics and its models are underdeveloped in hyperscanning paradigms. This very fact calls for an investigation of such neglect, which we undertake in Section 3 by mapping and explaining the consequences of specific *epistemic priors* in hyperscanning research.

2.1 - The Mesoscale

The current epistemic messiness in hyperscanning research crucially contributes to a polarization in scale association, favoring the micro and macro scales while marginalizing the mesoscale—a critical domain for capturing nuanced interactional dynamics between human agents. Overemphasis on microscalar neural synchrony and macroscalar clinical outcomes obscures the mesoscale processes where neural activity and behavior coalesce into adaptive, co-regulatory patterns (e.g., shared gaze, turn-taking, and affective mirroring). Far from being merely intermediate, these processes are crucial for understanding the emergent, reciprocal nature of social phenomena, particularly in therapeutic contexts. Neglecting the mesoscale undermines efforts to build integrative models capable of addressing the complexity inherent in such interactions.

To overcome this limitation, a multiscale framework is essential (see Table 1 below), one that examines interactions across momentary neural synchrony at the microscale, adaptive behavioral coordination at the mesoscale, and extended clinical and socio-contextual influences at the macroscale. This framework positions the mesoscale as the central bridge linking neural events to broader socio-clinical contexts. At the microscale, the focus is on localized neural synchrony, rapid oscillations, and spike-timing precision, capturing immediate neural responses that are foundational but insufficient for explaining broader adaptive behaviors. In contrast, the mesoscale emphasizes co-regulatory dynamics like shared gaze and turn-taking, which are critical for understanding patient-therapist interactions either (1) remain underdeveloped or (2) are overly tied to theory-driven observer perspectives. Finally, the macroscale accounts for extended contexts, such as therapeutic history and cultural influences, which both shape and are shaped by mesoscale dynamics, providing a holistic understanding of social interaction.

Scale	Correlates	Boundaries
Micro	Localized neural synchrony (e.g., in the prefrontal cortex), oscillations (e.g., high-frequency gamma), spike-timing precision (e.g., hippocampus)	Rapid, fine-grained neural interactions reflecting immediate responses; foundational but limited for explaining broader behavioral adaptations.
Meso	Behavioral and cognitive dynamics (e.g., shared gaze, turn-taking, affective mirroring, coordinated action patterns, mid-term neural signal epochs)	Central bridge where neural processes coalesce into observable behavior; regulated by feedback loops and rhythms over seconds to minutes, capturing adaptive social interactions.

Macro	Clinical and socioetiological profiles (e.g., extended interaction history, societal and cultural factors)	Represents extended social, clinical, and cultural contexts. Involves long-term adjustments (minutes to tens of minutes) that influence outcomes, grounded by mesoscale coordination and relevant for shaping adaptation within societal frameworks.

Table 1. A multiscale framework for hyperscanning studies, detailing the micro, meso, and macro scales of interaction dynamics. It emphasizes the mesoscale as the critical bridge linking localized neural events to broader behavioral and clinical contexts, capturing co-regulatory processes essential for therapeutic interactions.

This scalar polarization stems from *epistemic priors* that implicitly guide the design and interpretation of hyperscanning studies, shaping what is modeled, measured, and ultimately deemed significant. To critically address this issue, we must map these priors, exposing how they frame the blindspots that influence both methodology and the broader conceptual landscape of hyperscanning in the next section. While this work does not claim to be a metastudy—an incrementally performed exercise in the field of hyperscanning—and it positions itself in the broader field of philosophy of (neuro-)science, a comprehensive synthesis of said priors across different kinds of studies (i.e., epistemic, etiological, experimental, and engineering sources) will be necessary in order to elucidate sharper definitions for the field by cutting through terminological ambiguities and conceptual overlaps that often obscure progress. Also, although we are not directly exploring explanatory questions of neural mechanisms, this remains a complementary avenue for a nascent discipline like hyperscanning, especially as we underscore its translational potential.[2] The following section undertakes this task, providing a detailed analysis of the *epistemic priors* that underwrite current approaches and their implications for advancing the field.

3 - Epistemic Priors of Hyperscanning

In this section, we first characterize our notion of *epistemic priors*, specifically how it is similar and how it is distinct from other accounts in philosophy of science and, specifically, in philosophy of the cognitive sciences. After that, we identify four *epistemic priors* in the context of hyperscanning and exemplify their use by pointing to key studies in the field:

1. Specific frameworks of second-person perspective neuroscience, often centered around solipsistic mental reasoning or subpersonal brain processes, are directly assumed;

2. Diverse types of collaboration in social interactions are equally assumed to be underpinned by neural synchrony;

3. Inter-brain synchrony is modelled in analogy with intra-brain synchrony;

[2] By rethinking understanding not just as factual knowledge (*know-what*) but as practical, embodied skill (*know-how*), we can better grasp the potential of neural synchrony as something that arises in shared, real-time interactions. This perspective emphasizes the relational and emergent nature of brain coordination, offering a more dynamic framework for how we study and use neural synchrony in mental health care.

4. Different measures of inter-brain correlation (IBC), and therefore synchrony, are mapped to different conceptions about the behavioral significance of this very neural phenomenon.

Finally, we offer a mapping of how these *epistemic priors* are at play in the different disciplines involved in the field of hyperscanning (from the etiological to the experimental spectrum, and from the theoretical and the engineering one) and how these intersect in the scientific literature. This mapping allows us to yield an overview of the underlying *epistemic priors* of the field and their scopes.

3.1 - Characterizing Epistemic Priors

We take *epistemic priors* to be core theoretical assumptions of a research program that nevertheless remain in the background in daily scientific practice and are thus not directly made explicit by practitioners and consequently discussed and contested. *Epistemic priors* can take the form of guiding-analogies for characterizing phenomena in particular ways or serve as heuristic signposts for setting the standards of what is taken to be adequate scientific work. Our concept of epistemic prior is closely related (although not equivalent) to (1) the Lakatosian definition of hard core or fixed background assumptions in a research program; and (2) Lakoff and Johnson's idea of life-structuring metaphors.

Similar to Lakatosian core assumptions, *epistemic priors* are not challenged from within the research program itself and not abandoned if not at the cost of rejecting the entire research program (Lakatos, 1978). Echoing Lakoffian and Johnsonian metaphors, *epistemic priors* have the crucial feature of showing and hiding at the same time. In fact, while *epistemic priors* may bring to light specific aspects of a target phenomenon, they automatically obscure other elements that may well be as relevant as the ones they highlight. As in embodied cognitive life, the analogies credit value to *epistemic priors* acting as guides: they are compasses that the researcher follows to frame a natural phenomenon from a certain specific and limited perspective (see Lakoff & Johnson, 1980, Chapter 3, 25, 26; 1999).

Our concept of *epistemic priors* merges these particular features from the broader frameworks of Lakatos and Lakoff and Johnson and will be then used to specifically analyze the epistemic space of the hyperscanning technique in cognitive neuroscience.[3] We illustrate it with an example in what follows.

The brain is using efficient optimization techniques to carry out intelligent behavior (explicitly discussed in Doerig et al. 2024; Cao & Yamins 2024) is an epistemic prior expressed in the form of a guiding-analogy, which is very common across the cognitive sciences. In this case, the analogy usually concerns the source domain of computational tools (built to optimize different processes) and the target domain of living organisms (such as humans and their brains). Moreover, this specific epistemic

[3] The concept of "prior" is perhaps better known from its deployment in Bayesian frameworks and in the clinical literature, specifically in psychedelic-assisted psychotherapy (see Friston 2012; Villinger 2022). Here, a prior is generally defined as an assumption on the distribution of data that is continuously refined as new observations are collected. In our paper, we repurpose this term with a slightly different meaning. Crucial differences in our use of the term include: (1) no continuous refinement of *epistemic priors* as new data comes in, but rather upholding of them until the dismissal of an entire research program; and (2) a more specific application of term "prior" to practices related to scientific inquiry, that is, epistemically relevant for scientific knowledge production.

prior—expressed in the form of the guiding-analogy just mentioned—is credited in virtue of the very brain-computer analogy itself. As the rationale goes, if both living organisms and computers manage to efficiently face worldly challenges, then it is plausible to assume that the human brain works following computational principles similar to the ones of artificial systems.

Epistemic interests are necessary components of useful *epistemic priors*. This means that in the vast space of possible theoretical assumptions, scientists tend to focus on the ones that promise to bear fruit in a very pragmatic sense. For example, in the case of the instantiations of the brain-computer analogy presented above, assuming that what is to be looked for are *efficient coding strategies* allows scientists to reduce the search space for mechanisms underlying cognition, thereby making it possible to postulate a difference between relevant and irrelevant details. This is a particularly useful strategy in the case of the scientific investigation of the brain, an organ so complex to be inscrutable without a great deal of abstractions and idealizations to set off inquiry (Chirimuuta, 2024). As Chirimuuta (2024) aptly noted: "Computationalism *permits* a distinction between the functional ("information processing") aspects of neural anatomy and physiology and what is merely background support, thereby justifying the neglect of countless layers of biological complexity" (italics added).

In a similar manner to Lakoffian and Johnsonian metaphors, *epistemic priors* can be said to both enhance and limit scientific insight into a specific phenomenon (Hinrichs & Guzmán, 2024). On the one hand, they enhance it by allowing researchers to look at the target phenomenon through the manageable lens of an *ideal pattern* (Chirimuuta, 2024); on the other hand, *epistemic priors* necessarily entail blindspots, precisely in the form of features of the phenomenon that fall outside the adopted lenses. A very interesting situation where this phenomenon shows up is in the framework of computational metaphors of the human brain. As Chirimuuta (2019) has shown, different mathematical models (i.e., those construed under representationalist v. dynamical views) of the neuronal patterns of the motor cortex cannot be cross-validated by means of qualitative interpretations. Further, we argue that it is precisely the different *epistemic priors* (dynamical systems v. the vector representation ones in this case) that *shape* the analysis of the empirical data in one direction or another, thereby leading to different scientific paths that can potentially highlight and obscure specific aspects of the phenomenon, respectively.[4] From our perspective, this crucially entails that mapping the *epistemic priors* of a scientific practice is not only useful for qualitative, meta-aspectual philosophical interpretations of scientific results, but also for science practitioners themselves as they go about using different *epistemic priors* to define their research interests, goals and procedures.

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[4]As the authors of the case study discuss in their paper: "Given a set of properties of interest, the dynamics of our model agent uniquely determines the information that any subset of its components carry about those properties. The converse, however, is false; The informational explanation in general underdetermines the dynamical one in this model. *For example, different transient manifolds of states may produce the same informational quantities.* Moreover, the dynamics does not by itself determine the properties of informational interest; these are externally imposed by the questions we ask about the system. [...] When both dynamical and informational descriptions abstract over the underlying causal mechanisms, neither may uniquely determine the other" (Beer and Williams, 2015, pp. 30-31, emphasis added).

For all of these reasons, we take it to be extremely useful to map the space of both strengths and blindspots of scientific *epistemic priors* in the context of hyperscanning in psychotherapeutic research to not unwarrantedly overrely on them. The following analysis is not supposed to be exhaustive by any means, but rather serves the objective of this paper by highlighting what we believe to be the most crucial and underestimated *epistemic priors* in the field of hyperscanning and how they are cross-referenced by different disciplines and areas (viz. etiology, epistemology, experimental cognitive science, and engineering).

3.2 - Identifying and Mapping Epistemic Priors

The most common scientific hypothesis to be tested in hyperscanning paradigms is whether interbrain synchrony predicts better social relationship quality in different settings (e.g., therapy sessions, collaborative games). To this respect, a specific framework of second-person perspective taking is adopted. This is generally interpreted as the capacity of adequately predicting the other's behavior in order to successfully coordinate with them during an interaction (Schilbach et al. 2013). Schilbach and colleagues have proposed that the presence of at least two criteria, namely real-time interaction and engagement, makes a study's target *social interaction* rather than mere *social observation* (2019).

While we recognize this as a significant step towards addressing dynamic social interactions, in the vast majority of these studies, even if participants are investigated while engaging in a real-time social interaction, the hypothesised mechanisms that are taken to mediate the interaction seem to be related either to sequential and solipsistic mental reasoning or to subpersonal processes centered on brain activity. For these reasons, these studies are still missing the target of real-time, dynamic social interactions (*see* Fishburn et al. 2018; Hoehl et al. 2021). In the broader context of social neuroscience frameworks, it is important to remark that experiments are centered around concepts such as "simulating" or "theorizing." For example, this is the case in theory of mind (TOM) frameworks that construe second-person perspective taking as the ability of a subject to either theorize (according to theory-theory, TT) or simulate (in simulation theory, ST) other subjects' mental states in order to predict them and successfully act upon these predictions (Goldman, 2006; Newen & Schlicht, 2009).

When adopting these frameworks, the properties that are considered relevant for the subjects in question to successfully interact with others by taking a second-person stance are generally abstract, disembodied, and purely cognitive: in sum, the ones of a detached observer who is reasoning on other's mental states to develop the best strategy to interact with them. This has two major consequences. First, there is a shift in focus to the more theoretical—what is often referred to as "abstract"—aspect of social interaction, without a proper justification of it being more crucial to the interaction itself than other aspects of it. Second, diverse types of collaborations are mapped onto the same quantitative measure: *synchrony*. This is because a correct inference of others' mental states is often taken to be brought about by the subject's brain activity synchronization. This assumption guides the analysis by steering it away from anti-correlated brain patterns and brings the researchers to focus more on synchronized time frames and brain regions, thereby enabling them to yield a manageable idealized pattern to work with. In this sense, it could be said to act in a similar fashion as computationalism does according to Chirimuuta (2024). As computationalism helps scientists to discard countless layers of biological complexity as irrelevant or not significantly relevant, the focus on synchrony as the relevant variable of neural scale for social interaction allows scientists to classify as *noise* timeframes of brain activity that are not significantly synchronized or perhaps even asynchronous. What is at stake here is that this epistemic prior, while highlighting an idealized pattern, might, at the same time, obscure countless of other potentially phenomenon-relevant patterns without any sound justification.

Third, inter-brain synchrony is modeled in analogy with intra-brain synchrony. That is, effective communication between individuals is analogically compared to effective information processing between different regions of a single brain's network. This is useful for researchers to operationalize measures of coupled-experience, yet it could dangerously obscure the difference between personal and subpersonal processes. That is to say that, since neuronal information processing is very different—from the medium used and the variables involved—in interpersonal communication, using the same operational definitions to quantify both phenomena could lead researchers to overlook some specific aspects that the two *do not* happen to share.

Fourth, different measures of inter-brain correlation (IBC) are mapped to different conceptions about the behavioral significance of this very neural phenomenon. For example, measures like correlation, which do not yield any directional information about two brain signals, pick up *different relevant features* of synchronicity compared to measures like cross-correlation GLM, where one participant's brain activity is modeled in terms of a number of *additional* factors, including the other participant's brain activity.

Nevertheless, both quantifications of synchronicity yielded using GLM or correlation statistics are mapped onto different instances of what is generally defined as a "successful social interaction". As Hakim and colleagues concluded after analyzing 27 different measures of IBC, the interplay between different metrics and how their interpretation relates to different notions of synchrony remains unclear (2023, p.15). Moreover, three very different forms of synchronicity (all three equally considered markers of a successful social interaction in most cases) are enumerated in the literature: trend, concurrent and lagged synchronicity (Sened et al., 2022b). Trend synchronicity (synchronicity in a longer time frame) is generally neglected in the literature, as the research focuses on moment-to-moment interaction. Despite this fact, researchers have been hypothesizing that *prolonged* IBC may lead to stronger benefits of psychotherapy (Sened et al. 2022b). This hypothesis seems to require taking into account exactly trend synchronicity, though.

Here we present an illustration of how the four key *epistemic priors* we identified in the context of hyperscanning are at play (Table 2). Moreover, we depict the different disciplines and research areas that make use of them and how they cross-reference each other.

Epistemic prior	Exemplificative quotes (emphases added)
Observer-centered second-perspective frameworks	“Owing to the balanced nature of the design (e.g. each participant performed all conditions/roles), the position of each subject within the connectivity model was arbitrary. Therefore, **any asymmetries in connectivity would not be interpretable** (e.g. the presence of connectivity between the channel X of subject A to channel Y of subject B but not vice versa has no clear meaning).” (Fishburn et al. 2018, p. 844) “Synchronizing benefits arise from an **increased predictability** of incoming signals and include many positive outcomes ranging from **basic information processing** at the individual level to the bonding of dyads and larger groups.” (Hoehl et al. 2021, p. 5)
Inter-brain synchrony as a measure of different successful social interactions	“The review suggests that therapy improves patients’ ability to achieve such synchrony through inter-brain plasticity—a process by which **recurring exposure to high inter-brain synchrony** leads to lasting change in a person’s overall ability to synchronize.” (Sened et al. 2022b, p.1) “We operationalized shared intentionality as joint attention to the stimulus with a **mutual goal of problem-solving** through interaction.” (Fishburn et al. 2018, p. 843) “These results suggest that **inter-brain synchrony** can be informative in understanding **collective performance** among **teams** where self-report measures may fail to capture behavior.” (Reinero et al. 2021, p. 43) “**Neural synchrony was found for couples**, but not for strangers, localized to temporal-parietal structures and expressed in gamma rhythms [...] Among couples, neural synchrony was anchored in **moments of social gaze and positive affect**, whereas among strangers, **longer durations of social gaze** and positive affect correlated with greater neural synchrony.” (Kinreich et al. 2017, p. 1)
Analogy between inter- and intra-brain synchrony	“[...] the concept of inter-brain plasticity posits that **in a manner similar to regions in the same brain**, when regions in two brains are activated in close succession, as is the case in inter-brain synchrony, synchrony between them will grow stronger.” (Sened et al. 2022, pp. 05-06) “In addition, we hypothesized that **alpha and beta bands,** which have been consistently found when describing the neurophysiological correlates of social interaction behaviors, **would be responsible for intra- and inter-brain synchronization**.” (Vicente et al. 2023, p. 2)

Different forms of neural synchronicity mapped onto successful social interactions (without further specifications)	"[...] inter-brain synchrony has been shown to correlate **with a range of personal and social characteristics and behaviors**, underscoring its relevance in understanding naturalistic social interactions." (Chen et al. 2021, p. 9) "We suggest that IBS between what we deem the "mutual social attention systems" of interacting partners—that is, the **coupling between participants' temporoparietal junctions and/or prefrontal cortices** - facilitates and enhances the ability to tune in to the specific interaction, its participants and its goals. We propose that this process is linked to **social alignment,** reinforcing one another to facilitate **successful** and **lucrative** social interactions." (Gvirts et al. 2020, p. 108)

Table 2. A selection of significant quotes from hyperscanning literature show at work the four *epistemic priors* characterized in Subsection 3.2. The quotes are organized according to the *epistemic priors* they exemplify.

All the described *epistemic priors* and prior considerations should raise concerns about the possibility that the different types of synchronicity (measured either through different statistical models or in different timeframes) are instantiations of perhaps related, but still *different phenomena*. While mapping nuanced aspects of second-person relationships onto the same neuronal correlates (namely, *synchronicity*) can be useful in reducing the complex variable space of social behaviors, it could also lead to underrating the weight of the blindspots it inevitably introduces in the experimental paradigm and the consequent data analysis.

4 - Neural and behavioral scales: an asymmetry problem

We suggest that there is a fundamental asymmetry in hyperscanning research between the psychological phenomena and the supposedly "underlying neural mechanisms" of these very behavioral attitudes. This is the first epistemic blindspot that we identify in hyperscanning paradigms, as a consequence of adopting the previously discussed *epistemic priors.* This blindspot raises both epistemic and moral issues, especially when neuroscientific research is used to inform clinical practice in psychiatry and psychotherapy. We will focus on the epistemic issues here (see Lacroix, 2023 for a discussion on normative problems).

A clear instantiation of the asymmetry blindspot concerns distinguishing between *synchronized* and *coordinated* actions. Synchronized actions refer to the performance of the same actions in a synchronous manner by two or more individuals, for example, people playing guitar or singing together (Przyrembel et al. 2012, p. 10). Coordinated actions refer to the performance of collaborative actions in order to reach a shared goal, for example, two individuals collaborating in order to win in a basketball match perform coordinated but *different* actions in order to score two or three-point field goals.

In the scientific literature, both synchronized and coordinated actions are often mapped out onto similarity or synchronicity of neural patterns (Schilbach et al. 2013; Hakim et al. 2023). Moreover, both the performance of synchronized and coordinated actions are imputed to different behaviors involved in second-person perspective taking during social interactions, where *social alignment* and *social* *understanding* are not further distinguished. The extent to which someone is able to imitate the actions performed by peers—social alignment—does not necessarily entail a form of dynamic and complementary interaction (see Fusaroli et al. 2014; Galbusera et al. 2019). As Sened and colleagues acknowledge in their review, in-phase and anti-phase synchrony (i.e., when people are performing the same actions at the same time vs. when they are performing opposite actions a the same time) are usually aggregated in the analysis, as it is hard to mark the difference in the data. This precludes scientists from distinguishing between features of neural signals related to these very different situations. This issue can be considered an instantiation of the epistemic messiness in hyperscanning and, more generally, social neuroscience research (see Scott-Fordsmand and Tybjerg, 2023).

Here it is crucial to notice that this qualitative interpretation of neural data clearly *underdetermines* both the observed overt behaviors and the cognitive capacities thought to account for these very behaviors. How would the similarity of neural patterns be justifiably inferred to be the underlying mechanism of different but coordinated actions vs. synchronous and identical actions? In this case, it seems that looking at the entire sequence of neural patterns (*whether similar or not*) could allow researchers to infer the neurobiological processes involved in more complex behaviors than just performing the same actions at the same time, as it is the case when individuals are performing coordinated actions, which seems to be the target of research in the domain of patient-therapist investigations (see Sened et al. 2022b). However, such a nuanced qualitative interpretation that could link models of neural data to models of overt complex behaviors seems to be missing here. In fact, here is exactly where the blindspot we are characterizing arises: we identify an asymmetry between the neuroscientific conceptual and experimental toolkit and the psychological/etiological one. The former models are underdeveloped to successfully account for phenomena analyzed using the latter ones. To sum up, a single relevant variable picked up from the interpretation of neural data (i.e., synchrony) is directly linked to a *variety* of overt behaviors that can be defined as "successful." In particular, we suggest that this blindspot may be a direct consequence of the second epistemic prior. That is, different types of social interactions and related overt behaviors are equally assumed to be underpinned by one neural signature, namely moment-to-moment synchronicity.

The forms this gap can take may be multiple. Here we just presented an example of the problem to illustrate it concisely. As we hope to have shown with the example of coordinated vs. synchronized actions, the upshot of our analysis is: neural analyses centered on synchrony underdetermine the complexity of different while closely related behavioral phenomena they are supposed to explain, thereby pointing to an underdeveloped interpretation of neural signal.

A second crucial blindspot that follows from the *epistemic priors* mapped above is the neglect of the role of reciprocity in social interactions in current neuroscientific paradigms. Before tackling this issue, we zoom into the specific consequences of the asymmetry blindspot in the context of hyperscanning used to assess mental health interventions.

4.1 - Hyperscanning in Mental Health Intervention

In this subsection, we outline specific challenges related to the context of hyperscanning psychotherapy. Specifically, we discuss how the concept of "intersubjective alliance" is affected by the *epistemic priors* defined in section 3.

During psychotherapy, it seems that what matters for a successful patient-therapist relation as well as therapeutic outcome is the *reflexive* (or personal) nature of second-person perspectives. This means that both the patient and the therapist are *consciously* starting a gradual joint process of meaning co-construction. As Fuchs has argued, the role of the second-person perspective in psychiatry is aimed at "the co-construction of narratives and interpretations regarding the patient's self-concept, relationships and conflicts" (2007). This process of co-construction of meaning—what we could also call *intersubjective alliance*—has two main features: (1) it follows a developmental trajectory; and (2) it has to do with the patient and therapist *as persons*. Persons as such, on an enactive view, are incomplete, in becoming, fundamentally unfinished (Di Paolo et al., 2018), and therefore not exhaustible in terms of biomarkers or any single, synchronous measure.

Psychotherapy has a developmental trajectory because it is not given from the first session. Rather, it develops in complex and unpredictable ways over the course of repeated interactions and advancements in meaning construction. It has to do with the patient as a person, because it concerns what De Haan would call the *existential dimension* (2020) of the patient's life. It has to do with the meaning that the patient consciously attributes to contexts and events in her very own life. In this sense, it is distinguished from the subpersonal level, which concerns all the processes that go on in the patient's brain and body, which they are generally not in direct control or aware of. Adopting the third epistemic prior makes it smoother to neglect the differences between personal and sub-personal processes.

The first feature of intersubjective alliance is often neglected by current hyperscanning paradigms as (1) changes in brain synchrony are generally not measured on a long-range base[5] (Carollo & Esposito, 2024); and (2) the developmental and processual changes are only compared in a binary standardised way (e.g., more or less synchronicity), instead of being investigated in their complex unfolding trajectories. The second feature is neglected in a more subtle sense. We suspect that the talk about "underlying mechanisms" obscures the reflective, personal nature of second-perspective, intersubjective interactions. Let us illustrate this with a brief thought experiment.

Imagine that a therapist and a patient report to be in the process of co-constructing a shared meaning of the patient's lifeworld, but the neural analysis signals an average asynchronicity between the two brains.[6] How would current hyperscanning frameworks interpret this situation by building on the notion of *underlying mechanisms*? They would probably point at the fact that in this case there must be a *different* underlying mechanism for this event to happen, which could realistically be the case. However, by crossing out the notion of "underlying" and just talking about processes that make it statistically probable

[5] The inter-brain plasticity framework is trying to address this issue at least on a theoretical scale (see Sened et al. 2022b).

[6] A somewhat similar situation has been reported already (see Paulick et al. 2018).

for a certain phenomenon (e.g., a shared co-construction of meaning) to develop with a certain trajectory rather than another, scientists could better bring the focus back to the *existential nature* of psychological conditions. If we adopt this suggestion, neural activity becomes one of the elements in the bigger picture of unfolding therapeutic processes, which doesn't have a causal priority over other components of the phenomenon. Moreover, direct mappings between brain and behavior are very likely to unjustifiably simplify complex psychological interactions rather than make them more intelligible (for example, see "Neuroscientific evidence for multiple systems underlying social cognition", in Przyrembel et al. 2012) .

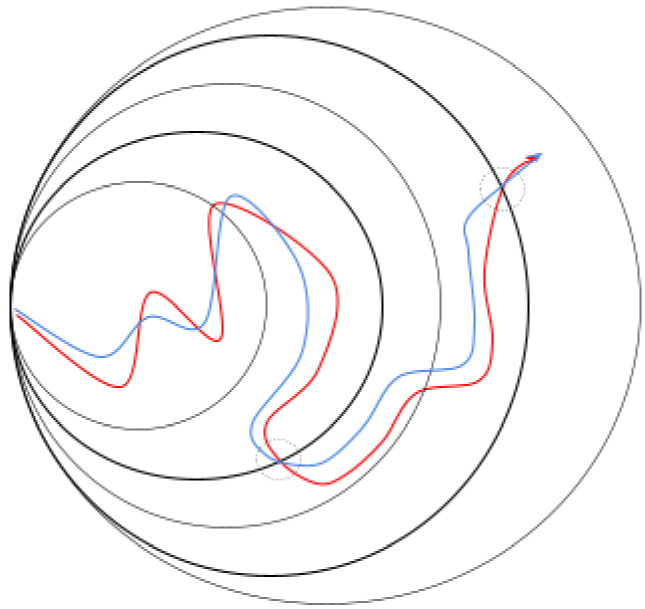

Figure 3. A depiction of a dyadic interaction of two human agents over time, focusing on when their brain signals are in sync or not. Arrows represent each person's data stream, with circles marking key measurement points. Dashed circles highlight when synchrony or asynchrony lines up with meaningful moments in their interaction. The figure contrasts ongoing dynamics with isolated moments of synchrony. Some longer data periods remain uninterpreted due to noise or lack of clear synchrony.

Therein lies the crux of hyperscanning in psychotherapy: the success of therapy relies on an empathic rapport built within an interactive, intersubjective state-system unique to the therapist-client dyad. A heuristic perspective on psychotherapy demands a naturalistic, multiscale, and multimodal paradigm, one that includes a broader range of biomarkers as potential predictors of positive outcomes. While neurobiological factors have been extensively explored, the psychosocial components—especially at the mesoscale, which captures the emergent, relational aspects of behavior—remain largely underrepresented. Recognizing mesoscale biomarkers shall enable an integrative experimental paradigm that considers reciprocal influences as continuous, rather than compartmentalized. This will provide a richer and more comprehensive model, as therapeutic success in the form of an "intersubjective alliance" is shaped not only by static measures of synchrony but by fluid, interactive processes that unfold within the therapeutic setting.

An effective model in psychotherapy accounts for the interactive dimensions of mutual communication, fostering an open-ended process in which the therapist takes on the responsibility of guiding the client toward a positive outcome. This interaction is one of reciprocal perturbations (see Figure 3 above), where shifts in the interactional state foster a shared understanding of desired personal change.

The asymmetry blindspot in hyperscanning research, with its overemphasis on specific interpretations of moment-to-moment synchronicity of the neural signal (i.e. microscale phenomena) at the expense of nuanced modelling at the mesoscale (as the one outlined below in Figure 4), has contributed to overlooking the important role of patient-therapist *reciprocity* in psychotherapeutic contexts. We turn our attention to this issue next.

5 - In favor of strong reciprocity

Reciprocity is central to understanding the complexity of interactions in hyperscanning studies, particularly when examining therapeutic and interpersonal settings. For instance, Baedke et al. (2021) describe reciprocal causation as a framework where two interacting, yet separate entities (e.g., an organism and its environment) shape one another, establishing causal feedback loops that extend diachronically. In the context of hyperscanning, this reciprocal causation must go beyond simple neural synchrony to account for the reciprocity between participants.

In second-person neuroscience, researchers aim to study how individuals partake in dyadic social interactions that are reciprocal – meaning each participant's actions directly affect the other during their exchange. These dyadic reciprocal interactions require social partners to take on complementary and alternating roles throughout the course of their engagement. Recent studies in this field have investigated how partners establish joint attention, how information flows between sender and receiver, and how previous interactions influence subsequent ones (for an overview, see Schilbach & Reedcay 2025). The value of these investigations notwithstanding, we believe that a much stronger construal of reciprocity is needed for hyperscanning studies, specially in psychotherapeutic contexts, in order to avoid shortcomings in experimental designs. An absence of strong reciprocity risks overlooking the nuanced, bi-directional interactions that occur in real-world social engagements. For example, in their seminal study, Fishburn et al. (2018) mention in the methods section that "*any asymmetries in connectivity would not be interpretable* (e.g. the presence of connectivity between the channel X[7] of subject A to channel Y of subject B but not vice versa has no clear meaning)" (emphasis added). In fact, in this study symmetry was imposed post-hoc. Thus, in a paradigm as such, reciprocity in the neural signal cannot be meaningfully extracted, but has to be surreptitiously presupposed. We would interpret this as a significant drawback of the study, since a crucial hallmark of subject-subject interaction (i.e., bi-directionality of the social interaction) becomes inherently uninterpretable. The neglect of strong reciprocity we identify in this case pervades many hyperscanning paradigms and is a direct consequence of the epistemic priors discussed in Section 3.2, specifically of the epistemic prior of the observer-centeredness of second-person perspective neuroscience frameworks.

[7] In EEG research, a *channel* refers to the recording from a specific electrode placed on the scalp, capturing electrical activity from a particular brain region. In dual-EEG (or hyperscanning) setups, each participant has multiple such channels, allowing researchers to analyze brain activity and potential synchrony across individuals at specific electrode sites.

Different correlation measures of neural synchronicity have one thing in common: they are taken as relevant neural signal sequences insofar as they match, predict or are similar to the one of another subject, remaining uninformative regarding the direction of the signal[8]. Nevertheless, they are taken to be directional at the macroscale; for instance, in claims about the ability of a therapist or a teacher to "change people's ability to synchronize" (Sened et al. 2022b, p. 07; Sun et al. 2020). These conclusions are epistemically unwarranted and likely fostered by loose assumptions about the stronger predictive ability of one subject of the other's mental states (LaCroix, 2023). These assumptions are also at the core of the first epistemic prior, as detailed in the first section of this paper. Even when the directionality of IBC is not unwarrantedly claimed, the dynamic influence between participants in these paradigms seems to remain unaddressed entirely, albeit being recurrently referred to as "studies on interaction." In fact, rather than analyzing the interplay between the two (or more) neural signatures, these paradigms seem to track the moment-to-moment sequential way these converge to synchrony. This does not help to shed light on the dynamics of a real-time reciprocal interaction, as defined above.

Strong reciprocity is likely to be neglected because of the fact that traditional measurements are informed by unidirectional theories of social interaction. For example, in ST the subject is supposed to simulate with her brain the other's actions and therefore, it should be possible to measure a similarity between her brain's activations and the ones of the partner. Similarly, according to TT, when we are reasoning about others' mental states, we are able to understand them. While it is less clear how TT should relate to similarity in brain patterns compared to ST (Przyrembel et al. 2012, pp. 6-7), both perspectives seem to address a form of unidirectional empathy rather than a stronger manifestation of "constitutively interrelated experiential perspectives" (Zahavi, 2023, p. 95). Using Zahavi's example, we suspect that hyperscanning measurements and mind-prediction theories are describing a couple dancing rumba as A is dancing rumba with B and B is doing the same with A, thereby failing to address the situation as a couple jointly performing a dance together (p. 94). Moreover, as de Haan and colleagues have emphasized, different flavours of Theory of Mind (ToM) models of social interaction—such as TT and ST—all have in common the focus on theorizing or inferring mental states about the other, either in absence of them or by avoiding direct interaction with them (2011). We suggest that hyperscanning studies aiming to capture intersubjective engagement should treat each participant's neural and behavioral responses as dynamically integrated, each influencing and reshaping the other's responses.

After having outlined the multiple faces of the reciprocity blindspot, we turn to consider some available options of construing a strong form of reciprocity, which can ameliorate the shortcomings of current hyperscanning scientific paradigms. In the scientific study of cognition, scholars have proposed various models to frame organism-environment reciprocity. Di Paolo (2020) distinguishes between three types of relationships: interaction loops, transaction loops, and constitution loops. Interaction loops represent the simplest form, characterized by bi-directional reciprocal influences—usually visually depicted as two-way arrows—between organism and environment. These loops work well when describing

[8] Various measures of neural synchrony, such as correlation, coherence, and phase synchrony, assess the degree to which neural activities between individuals are synchronized but do not inherently provide information about the directionality of these interactions. In contrast, causality measures are designed to evaluate the directional influence of one individual's neural activity on another's.

well-defined systems with stable characteristics. However, this model becomes inadequate when diachronic changes need to be taken into account. When organisms and environments undergo structural changes through their protracted engagement, the concept of interactive coupling becomes less precise and useful. As systems transform over time, variables and parameters may shift, appear, or disappear, and functional relationships may change. Dewey and Bentley (1949) articulated the concept of *transaction* to describe these fluid situations, where labels remain provisional as relationships and processes continue to transform. This is integrated by Di Paolo (2020) as *transaction loops*. Beyond these diachronic transactions, we sometimes need to understand how organisms and environments come into being in the first place. Enactivists argue that an organism's continued existence depends on an ongoing and precarious process where the individual and its environment co-create each other through relations of constitution (Di Paolo 2020). While constitution loops often involve transactions, it is important to note that not all transactions lead to constitutional relationships, as the latter specifically include both important organizational and structural changes.

We believe that, besides interaction, the other two of these loop possibilities could also be applied to the patient-therapist relationship—considering that this rationale can be applied to specific organism-environment interactions, namely subject-to-subject interactions.

Transaction loops could be a suitable framework for understanding strong reciprocity in hyperscanning research due to labeling remaining provisional in face of process transformation. Rather than treating one brain's response as merely a predictor of the other's, transaction loops in hyperscanning suggest a dual influence, where each brain's activity and behavioral response contribute to a shared, changing interaction. While transactional loops may capture the fluid dynamics of psychotherapy and the engagement between patient and therapist as agents with distinct functional roles, an enactive perspective, which we adopt in the next subsection, would suggest that constitution loops are also present in social interaction, since in the enactive literature *we* need to be understood as literally made of others and our interactions take part in how we constitute ourselves (Di Paolo et al., 2018). This means that both patient and therapist should be taken as mutually constructing each other by means of the transformations we undertake in our constant becoming. In hyperscanning, this could mean that variables should not only have provisional labels, but also take into account changes that patient and therapist undergo during treatment. The form that this methodology can take is yet to be developed. Nevertheless, Baedke et al. (2021) propose a model for distinguishing between different types of reciprocal processes without collapsing the distinct identities of each interacting entity. Applied to hyperscanning, this approach calls for methodologies that explicitly measure both physical (eg., neural synchrony) and experiential (e.g., subjective responses) dimensions of the transactions at stake, acknowledging that synchrony is not the sole indicator of effective communication. In fact, measuring symmetry in both directions—each participant influencing the other in real time—provides a more authentic picture of intersubjective processes in a therapeutic setting.

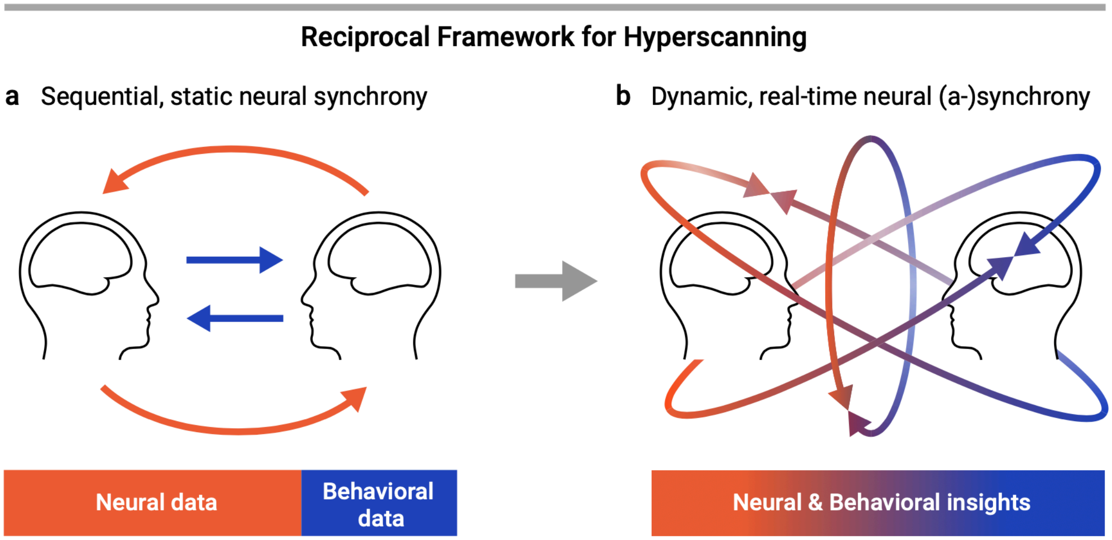

Figure 4. Suggested framework shift in hyperscanning-based research, from (a) static neural synchrony, characterized by distinct, sequential neural and behavioral data streams, to (b) dynamic, real-time, and reciprocal neural-behavioral processes, where asynchrony emerges as a potential marker of meaningful interaction at mesoscale.

Based on these considerations, we suggest focusing more on how subjects relating through a second-perspective attitude do so in a reciprocal, transactional and constitutive way,[9] both for theoretical considerations and for further developments in neuroscientific paradigms (see Figure 4 above). For this, we offer the general contours of an enactive neuropsychology that could aid hyperscanning research by foregrounding the reciprocity between patients and therapists.

5.1 - Enactive Neuropsychology

Enactivism suggests that cognition is always interactive, whether through engagements with environments or distributed across individuals through social interactions. As we mentioned above, while a transactional-loop relationship between patient and therapist could account for the dynamical nature of reciprocity, we still need to consider the other ways participants are affected and the interactional autonomy arising in subject-subject interactions. Participants' actions also affect themselves. One's actions, the other's actions, and the interaction dynamics also keep affecting oneself in ways and at timescales that we cannot easily capture. This is why we should also acknowledge constitutive loops in interaction: because our interactive histories are a constitutive part of our identities. This alone presents a

[9] A silver lining congeals in Husserlian phenomenology, which reverses the naturalistic tendency to subordinate the subjective to the objective, where the other (subject) is treated as an empirical or theoretical derivative. Instead, it posits that consciousness of both self and others precedes and shapes the empirical, particular self and others. Phenomenologically, this suggests that intersubjective intentionality underlies and conditions objective intentionality (Hinrichs & Guzmán, 2024; Cuffari & Figueiredo, 2025). By re-centering intersubjective intentionality as the basis for, rather than a byproduct of, tools for knowledge generation, a critical dimension often overlooked in many second-person neuroscience paradigms is revealed: reciprocity.

big challenge for neuropsychology because it introduces another layer of complexity, namely the autonomy of interactions.

Autonomy is defined as “[t]he property that describes a far-from-equilibrium, precarious, operationally closed system in any domain. Autonomous systems are self-individuating and depend on their associated milieu, which nevertheless does not fully determine its states” (Di Paolo, Cuffari & De Jaegher, 2018). In social interaction, participants produce meaning together. This is captured by the concept of *participatory sense-making* (De Jaegher & Di Paolo, 2007) in the enactive literature. *Participatory sense-making* is the adaptive engagement of agents in their environment with others where the differential implications of their actions for their own form of life open and restrict possibilities for action, while they are affected by the dynamics of the interaction, its coordination patterns, breakdowns and recoveries (Di Paolo, Cuffari & De Jaegher, 2018). This means that a new domain emerges, a domain in which bodies engage in mutual coupling and regulation which is highly dependent on the situations at play, but also on the very persons in action. Peoples’ historicity not only accumulates but it also reflexively determines their agency in a constant feedback of coordination and miscoordination in which we learn to be together or break up connections. The special challenge here is that there is a sustaining dynamic that is always underdetermined by the actions of its participants, let alone by their brains, which are only parts of this whole process. While interactive dynamics is not something that can be investigated merely by looking at two brains, the big question that remains open is precisely what the role of the brain is in this process. Moreover, we should acknowledge brain plasticity in interactive encounters, since subjective experiences and actions continuously influence back the flow of interaction by inducing changes in plastic neural structures, thus altering experiences and behaviours (Fuchs, 2011).

Despite the many challenges, we do acknowledge that hyperscanning techniques can provide data to support an enactive view on cognition by showing how neural processes coordinate between interacting partners in real-time and we would like to highlight second-person neuroscience's (Schilbach 2010, Schilbach et al., 2013) employment of enactive commitments and to acknowledge the challenges it poses. As we mentioned above, the key ingredients considered in second-person neuroscience are (i) acknowledging we immediately experience others as subjects instead of merely engaging in individual inference processing; (ii) acknowledging the affective dimension of interactivity by considering feelings of engagement and emotional responses in interaction; (iii) considering reciprocal relations in social interactions in which actions and reactions are themselves perceived and reacted upon; (iv) acknowledging that interaction involves different roles or modes of participation; (v) that it involves shared intentions which may emerge from the very interaction; and (vi) that it involves historicity, and should consider past and developmental trajectories (see Schilbach et al., 2013).

It is clear that second-person neuropsychology is up to date with the key enactive concerns regarding interaction:

> [...] interaction and feedback are not only a way of gathering data about the other person, that is, observing effects one may have on the other, but rather, as De Jaegher et al. (2010) have argued persuasively, one’s knowledge of the other resides – at least in part – in the interaction dynamics “between” the agents. Thus, taking social interaction seriously suggests that there may not be an absolute epistemic gulf between self and other, which would make an

inferential detour necessary, but rather, that the dynamics of the social interaction contribute to and – at times – constitute our awareness of other minds. (Schilbach et al., 2013, p. 397)

Yet, even with the important steps taken by second-person neuroscience, an adequate understanding of the complexity of real-world interactions with integrated brain information is yet to be achieved, for the complexity of real-world interactions must be carefully considered when integrated with hyperscanning. As we have pointed out throughout this text, synchrony alone cannot offer such an understanding, and reciprocity should be considered in more transactional terms and in light of Baedke's et al. (2021) framework, which is a more enactivist friendly approach, for it takes into account how interacting entities mutually shape each other in successive iterations. Nevertheless, due to the co-constructive nature of ourselves, constitution loops should also be taken into account. In empirical research, such as hyperscanning, this first step of admitting transactional loops translates into measuring symmetry in both directions in real time and acknowledging the influence each participant plays on the other. Constitution loops, on the other hand, could translate into analysing reports that consider changes in each other's perspectives, behaviors and habits. In addition, these measurements should be integrated with other measurements and subjective reports, forming a richer picture of intersubjective experience, given that synchrony alone is not an indicator of effective communication nor of participatory sense-making.

We suggested that (i) interactions must be considered as autonomous processes—in being autonomous they present self-organizing principles that do not reduce to the sum of participants actions (see also Di Paolo & De Jaegher, 2012). We also suggested that (ii) brain activity, being one part of a system that involves the whole person, the other, and the environment, is in a complex relation with the interactive system as a whole (Froese, 2022), which makes inner-outer correlations a much too restrictive way of considering its role. Given that every science is a socio-material elaboration (Froese, 2022; Barad, 2006), a key lesson to be extracted from the idea that the brain is part of a bigger system is that we should seek a careful consideration of epistemic priors and reflect on what kind of priors we could have from an enactive perspective.

Following Di Paolo & De Jaegher (2012), we highlight that the brain is "participating in a dynamical process outside its full control" and so we should think about "explanatory strategies in terms of dynamical concepts". The authors' main point is: "interactive experience and skills play enabling roles in both the development and current function of social brain mechanisms" and "the link between coordination dynamics and social understanding can be best grasped by studying transitions between states of coordination" (p.01). Studying and measuring these transitions is important because periods of coordination—how they come to be and end—play an important role in social understanding-orienting actions and intentions and in shaping individual mechanisms (Di Paolo & De Jaegher, 2012). It is important for enaction to engage in phenomenologically guided research because it is the most promising way to bridge the supposed gap between objectivity and subjectivity or, in better words, to embrace the claim that "'reality' is made up of evolving processes that are equally physical and experiential" (Frank et al., 2019). In intersubjective research the underdetermination of the phenomenon by the neuroscientific data and the very autonomy of interaction are key features that require phenomenology for clarification and definition, once it is an important aspect of the reality of the phenomenon. Although we cannot fully develop this idea here, we are suggesting that phenomenologically-guided research can help us better understand the dynamics between people and this is how the interaction needs to be addressed due to its autonomous nature.

A more phenomenologically guided interaction, before, during and after hyperscanning could be an aid to understanding these transitions between states of coordination, for example. This potential protocol is inspired by De Jaegher et al. (2017) PRISMA methodology. PRISMA is a theoretically grounded and empirically validated tool for generating insights about what goes on during interactions at the mesoscale; it offers scientific study of the experience of participation dynamics, that is, the systematic unfolding of interactive experience. "PRISMA has three main characteristics: it uses a systematic protocol for investigating the experience of interacting, it is based on an embodied methodology and concepts, and it invites researchers to use themselves as both research instrument and subject of their own investigation" (p. 495). It calls for the need to investigate the practical phenomenology of interactive experience, by means of three modes of perception: sensing, feeling and thinking. "These bodily experiences of interacting are the stuff of understanding each other and of understanding the world together — in short, of intersubjectivity" (p. 492), considering that they are influenced by and co-created by more than one subject, constantly forming and transforming the participants.

Questions such as when and why transitions between states of coordination happen, and how did people experience them, could be answered by participants, at the mesoscale, looking back at their interactions and identifying what was most salient for them in each moment, for example. In a very preliminary way, we envision three general possibilities for informing hyperscanning research with PRISMA: (1) Hyperscanning during PRISMA: it could be possible to have PRISMA participants wear portable, non-invasive neuroimaging tools such as dual-EEG, fNIRS, or motion tracking systems synchronized with audio-video recordings. (2) Neuroscientists first work with PRISMA-experts to run a PRISMA session on a target phenomena and use results (conceptually informed at meso-scale as a consequence of their PRISMA results) to design a hyperscanning experiment. (3) In the spirit of PRISMA, in which all participants are also researchers of social interaction experience, participants look back at their own Hypercanning results in a PRISMA session, because they could jointly either frame or reframe their experimental results. We believe there are many different ways in which participants could reflect on their own data, which we cannot specify further in this paper.

This integration of hyperscanning techniques to the PRISMA protocol can be challenging methodologically, but also very promising because it would allow for the integration of introspective data, yielding more complex mesoscalar characterizations, which could thereby mitigate the risks we pointed out throughout the text. In more concrete terms, we are suggesting that synchrony could be reframed as a momentary state within a process, for example. If dynamic synchrony is recognised, it would guarantee a place for other parts of the process. Misalignment, for example, could correspond to desirable exploration, and behavioral markers could inform context (e.g., non-verbal cues, subjective reports, etc.). Thus, synchrony should be taken as one part of a larger picture where we account for operationalizing the mesoscale of investigation. The current issue with the mesoscale is that it is not very well defined for neuroscientific practices, yet the PRISMA methodology situates and operates at the mesoscale from the outset. This integration of hyperscanning with PRISMA could help to better define the mesoscale for neuroscientific theory and praxis, and subsequently guide research into integrating the micro and the macroscales towards a multiscalar framework, which, in our understanding, would be the ideal way of investigating interactive cognitive processes.

Based on the above, we highlight the following key priors of the enative view: (1) Every social interaction inaugurates a dynamical interplay not reducible to the acts of each participant but modulated by all of them, this is the autonomy of interactions. (2) The brain is a mediating organ, part of a bigger system involving the body and our world and other-relations. (3) Experience is the way we relate to the world and what makes us understand it and understand each other.

Thus, the pretension towards a meaningful empirical intervention during dyadic dynamics of interaction demands giving prominence to a socio-material milieu. We believe that the enactive, second-person framework is particularly well-suited to modeling all scales of intersubjective interaction—from the micro (immediate, moment-to-moment exchanges) to the macro (longer-term relational dynamics) scale, including scalar thresholds and feedback loops—because of its holistic approach to cognition and interaction and its emphasis on dynamic, real-time engagement and sense-making. Any neuroscientific praxis of mental health intervention—for instance, via dual-EEG—will only bear a translational potential to inform bio-psycho-social models of (clinical-behavioral) etiology if, as De Haan (2021) points out, "the interaction of the physiological, psychological, and environmental processes involved" is accounted for in an integrated manner.

6 - Concluding remarks

In this paper, we critically analyzed standard hyperscanning paradigms, their epistemic strengths and weaknesses. In particular, we focused on emerging paradigms that are aimed at tracking neural correlates of psychotherapeutic interactions. We began by characterizing current hyperscanning paradigms as focused on micro and macroscales, thereby neglecting what we have referred to as the mesoscale. Aside from technical limitations, we argued that this scalar polarization stems from epistemic priors that are widely assumed in the field. In the following sections, we defined our notion of epistemic priors, why it matters, we identified four key priors in the field of hyperscanning and exemplified their role with quotes from the relevant literature. After that, we discussed two epistemic blindspots that are a direct consequence of assuming the priors identified before and their significance for the advancement of the field. First, we argued that there is an asymmetry between the current neural and behavioral toolkits, where the latter is underdetermined by the former. Second, we highlighted how current hyperscanning paradigms crucially neglect a strong form of reciprocity, thereby failing to address the target phenomenon in its dynamic unfolding. Lastly, we proposed an enactive neuropsychological framework to address the issues we pointed at throughout the paper. Here, we outline how, by incorporating the PRISMA methodology, neuroscientific hyperscanning paradigms could be better equipped to address forms of real-time, complex interactions.

In sum, we emphasized that current models often bypass the mesoscale in favor of a coarse-grained mapping between micro- and macro-levels—an oversight that is particularly problematic in second-person neuroscience. Here, intersubjective exchanges are typically reduced to neural synchrony, with little attention paid to reciprocity or the nuanced dynamics of interaction. Frameworks that overlook these elements risk flattening the therapeutic relationship, treating the other as an object rather than a subject. In contrast, successful therapy depends not only on alignment but also on productive asymmetry. We argue that more integrative approaches—incorporating subjective experience and behavioral markers such as mutual responsiveness and emotional resonance—are needed to better capture the relational dynamics central to therapeutic alliance. We have shown that in the case of hyperscanning, that is, simultaneous recording of the neural substrate of two or more individuals, the problem of asymmetry emerges, that is, rich, dynamic social interactions are simplified to patterns of neural synchrony, leaving out the nuances of coordinated, asymmetrical behavior that often characterize authentic, real-world exchanges. Current methods often emphasize synchrony in brain patterns as the causal primary marker of successful interaction, aligning only partially with the complex, bidirectional influences inherent in meaningful social and therapeutic relationships. Hyperscanning research has traditionally emphasized recognizing shared neural states as evidence of intersubjectivity. While valuable, this approach often overlooks the dynamic, interactive processes through which individuals co-create shared intentions during real-time interactions. Drawing from phenomenological perspectives, this co-creation can be understood as a collective intentionality that emerges through directed, embodied engagement (Husserl, 1954; Donohoe, 2004).

The ongoing debate about the limitations of third-person methods in capturing subjective experience often frames these approaches as fundamentally incapable of accessing intersubjective phenomena. However, this critique overlooks the developmental trajectory of measurement techniques in other fields, which have progressed from reliance on subjective calibration to achieving independent reliability (Clark, 2015; Pauen & Haynes, 2021). For example, advancements in neuroimaging, such as fMRI, demonstrate how extrospective methods can evolve to provide increasingly objective insights into mental phenomena, moving beyond initial dependence on introspective data (Anton & Silani, 2021). Similarly, hyperscanning techniques face a comparable challenge, as they attempt to reconcile neural synchrony data with subjective reports of interaction. Critics often highlight a "standoff problem," where discrepancies between subjective and objective data are viewed as irreconcilable. Yet, evidence from empirical research—such as studies of Anton's Syndrome, where patients deny blindness despite clear physiological evidence, or placebo research, which demonstrates measurable physiological effects from subjective expectations—illustrates that such conflicts can be resolved through iterative methodological refinement and the integration of multiple evidence sources (Chang, 2007; Van Fraassen, 2008; Pauen & Haynes, 2021). Hyperscanning research can adopt a similar approach by embracing triangulation, combining neural measures, behavioral observations, and subjective self-reports to construct a more comprehensive account of intersubjectivity (Clark, 2015; Anton & Silani, 2021). This approach recognizes that the apparent limitations of third-person methods are not intrinsic but rather contingent on their current stage of methodological development. By addressing these challenges head-on and iteratively refining techniques, hyperscanning can evolve into a robust tool for exploring the dynamic interplay between neural synchrony and subjective experience.

Hyperscanning provides a unique opportunity to study how neural activity reflects and contributes to the collaborative process of social interaction, moving beyond static measurements of synchrony. By designing experiments that capture the evolving interplay between participants—such as joint problem-solving or mutual adjustment in ambiguous scenarios—researchers can investigate how shared goals and understandings emerge through interaction (Friston & Frith, 2015; Bolis & Schilbach, 2018). This shift foregrounds the generative, forward-looking aspects of intersubjectivity central to participatory sense-making and aligns with the enactive view of cognition as co-constructed within social contexts (Fotopoulou & Tsakiris, 2017; Lohmar, 2012). However, from a methodological standpoint, current hyperscanning approaches remain limited in their ability to capture truly reciprocal interactions, particularly in relation to behavioral and cognitive dynamics that extend beyond immediate neural responses. While standard measures help identify synchrony, they often fail to address the bidirectional influences that characterize co-regulated social engagement. Future advancements should thus prioritize techniques capable of analyzing dynamic, two-way neural processes alongside behavioral markers such as gaze, facial expression, and body language, especially to enhance interpretation of reciprocal exchanges in therapeutic contexts.

The mesoscale provides a valuable framework for capturing the nuanced behavioral and cognitive dynamics that emerge in bidirectional processes, which unfold over seconds to long-run adaptive interactions, offering a richer understanding of social exchanges as co-regulatory and developmental. Unlike the microscale focus on immediate neural responses, the mesoscale enables us to study these patterns as they evolve, highlighting both alignment and productive asymmetry as key factors in therapeutic engagement. This scale is essential for bridging short-term neural events with the broader, long-term implications seen at the macro scale, where clinical and socioetiological insights into therapeutic outcomes emerge. To properly ground clinical frameworks, macro-scale analysis must build on these mesoscale dynamics.

Lastly, a focus on reciprocity brings into view the active, co-constructed nature of meaning-making that is essential to second-person perspectives in therapy. Current frameworks inadequately capture this intersubjective alliance, which unfolds as a joint and evolving process over time. To address this issue, frameworks based on enactivism and dynamical systems theory may offer useful models that shift from predictive to emergent, embodied accounts of social interaction. An enactive perspective proposes a neutral, process-oriented approach to resolving the limitations discussed here, offering a promising way to understand the dynamic, reciprocal, and co-constructed nature of human interaction in therapeutic settings.

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References

Albarracin, M., Pitliya, R. J., Ramstead, M. J. D., & Yoshimi, J. (2022). Mapping Husserlian phenomenology onto active inference. arXiv. https://arxiv.org/abs/2208.09058

Anton, C., & Silani, G. (2021). The predictive brain and interoceptive inference: A review of recent advances. Neuropsychologia, 151, 107729. https://doi.org/10.1016/j.neuropsychologia.2021.107729

Atzil-Slonim, D., Soma, C. S., Zhang, X., Paz, A., & Imel, Z. E. (2023). Facilitating dyadic synchrony in psychotherapy sessions: Systematic review and meta-analysis. Psychotherapy Research, 33(7), 898–917. https://doi.org/10.1080/10503307.2023.2191803

Ayrolles, A., Brun, F., Chen, P., Djalovski, A., Beauxis, Y., Delorme, R., Bourgeron, T., Dikker, S., & Dumas, G. (2021). HyPyP: A hyperscanning Python pipeline for inter-brain connectivity analysis. Social Cognitive and Affective Neuroscience, 16(1–2), 72–83. https://doi.org/10.1093/scan/nsaa141

Babiloni, F., & Astolfi, L. (2014). Social neuroscience and hyperscanning techniques: Past, present and future. Neuroscience & Biobehavioral Reviews, 44, 76–93. https://doi.org/10.1016/j.neubiorev.2012.07.006

Babiloni F, Cincotti F, Mattia D, Mattiocco M, De Vico Fallani F, Tocci A, Bianchi L, Marciani MG, Astolfi L. Hypermethods for EEG hyperscanning. Conf Proc IEEE Eng Med Biol Soc. 2006;1:3666–9. doi: 10.1109/IEMBS.2006.260754.

Baedke, J., Fábregas-Tejeda, A. & Prieto, G.I. Unknotting reciprocal causation between organism and environment. Biol Philos 36, 48 (2021). https://doi.org/10.1007/s10539-021-09815-0

Barad, K. (2006) Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning. Duke University Press.

Beer, R. D., & Williams, P. L. (2015). Information Processing and Dynamics in Minimally Cognitive Agents. Cognitive Science, 39(1), 1–38. https://doi.org/10.1111/cogs.12142

Bevilacqua, D., Davidesco, I., Wan, L., Chaloner, K., Rowland, J., Ding, M., & Poeppel, D. (2019). Brain-to-brain synchrony and learning outcomes vary by student–teacher dynamics: Evidence from a real-world classroom electroencephalography study. Journal of Cognitive Neuroscience, 31(3), 401-411. https://doi.org/10.1162/jocn_a_01274

Bolis, D., & Schilbach, L. (2018). Beyond one Bayesian brain: Modeling intra- and inter-personal processes during social interaction. Psychoneuroendocrinology, 92, 165–174.

Bolis D, Dumas G, Schilbach L. 2023. Interpersonal attunement in social interactions: from collective psychophysiology to inter-personalized psychiatry and beyond. Philos. Trans. R. Soc. B 378(1870):20210365

Boone, Worth & Piccinini, Gualtiero (2016). The cognitive neuroscience revolution. Synthese 193 (5):1509-1534.

Cuffari, E.C., Figueiredo, N.M. (2025) Intentions in interactions: an enactive reply to expressive communication proposals. Synthese 205, 46. https://doi.org/10.1007/s11229-024-04836-0

Cui X., Bryant D.M., Reiss A.L. (2012). NIRS-based hyperscanning reveals increased interpersonal coherence in superior frontal cortex during cooperation. NeuroImage, 59, 2430–37.

Carollo, A., & Esposito, G. (2024). Hyperscanning literature after two decades of neuroscientific research: A scientometric review. Neuroscience, 551, 345-354. https://doi.org/10.1016/j.neuroscience.2024.05.045

Cao, R., & Yamins, D. (2024). Explanatory models in neuroscience, Part 2: Functional intelligibility and the contravariance principle. Cognitive Systems Research, 85, 101200. https://doi.org/10.1016/j.cogsys.2023.101200

Chang, H. (2007). Inventing Temperature: Measurement and Scientific Progress. Oxford University Press.

Chirimuuta, M. (2019). Charting the Heraclitean Brain: Perspectivism and Simplification in Models of the Motor Cortex. In Understanding Perspectivism. Routledge.

Chirimuuta, M. (2023). Haptic realism for neuroscience. Synthese, 202(3), 63. https://doi.org/10.1007/s11229-023-04295-z

Chirimuuta, M. (2024). *The Brain Abstracted: Simplification in the History and Philosophy of Neuroscience*. The MIT Press. https://doi.org/10.7551/mitpress/13804.001.0001

Clark, A. (2015). Surfing uncertainty: Prediction, action, and the embodied mind. Philosophical Transactions of the Royal Society B, 369(1655), 20130486.

Costa-Cordella, S., Grasso-Cladera, A., & Parada, F. J. (2024). The Future of Psychotherapy Research and Neuroscience: Introducing the 4E/MoBI Approach to the Study of Patient–Therapist Interaction. Review of General Psychology, 28(2), 143– 165.
https://doi.org/10.1177/10892680231224399

Cui, X., Bryant, D. M., & Reiss, A. L. (2012). NIRS-based hyperscanning reveals increased interpersonal coherence in superior frontal cortex during cooperation. NeuroImage, 59(3), 2430-2437. https://doi.org/10.1016/j.neuroimage.2011.09.003

Cui, X., Bray, S., Bryant, D. M., Glover, G. H., & Reiss, A. L. (2020). A quantitative comparison of NIRS and fMRI across multiple cognitive tasks. NeuroImage, 54(4), 2808-2821. https://doi.org/10.1016/j.neuroimage.2010.10.069

Czeszumski, A., Eustergerling, S., Gundlach, H., McMahon, K., Schnake, T., König, P., & Schilbach, L. (2020). Hyperscanning: A valid method to study neural inter-brain underpinnings of social interaction. Frontiers in Human Neuroscience, 14, 39. https://doi.org/10.3389/fnhum.2020.00039

de Haan, S. (2020). Enactive Psychiatry: Psychiatric Disorders Are Disorders of Sense-Making. In Enactive Psychiatry (pp. 194–233). chapter, Cambridge: Cambridge University Press.

de Haan, S., Jaegher, H. D., Fuchs, T., & Mayer, A. (2011). Expanding perspectives: The interactive development of perspective-taking in early childhood. In W. Tschacher & C. Bergomi (Eds.), The implications of embodiment: Cognition and communication. Exeter: Imprint Academic.

De Jaegher, H., & Di Paolo, E. (2007). Participatory sense-making: An enactive approach to social cognition. Phenomenology and the Cognitive Sciences, 6(4), 485–507. https://doi.org/10.1007/s11097-007-9076-9

De Jaegher, H., Di Paolo, E. & Gallagher, S. (2010) Can social interaction constitute social cognition? Trends in Cognitive Sciences 14(10):441–47. Available at: http://dx.doi.org/10.1016/j.tics.2010.06.009.

Dengsø, M.J. Enactive psychiatry and social integration: beyond dyadic interactions. Phenom Cogn Sci (2024).
https://doi.org/10.1007/s11097-024-09957-y

Dikker, S., Wan, L., Davidesco, I., Kaggen, L., Oostrik, M., McClintock, J., & Poeppel, D. (2017). Brain-to-brain synchrony tracks real-world dynamic group interactions in the classroom. Current Biology, 27(9), 1375-1380. https://doi.org/10.1016/j.cub.2017.04.002

De Jaegher, H., Pieper, B., Clénin, D., Fuchs, T. (2017). Grasping intersubjectivity: an invitation to embody social interaction research. Phenom Cogn Sci 16, 491–523 https://doi.org/10.1007/s11097-016-9469-8

Di Paolo, E. A. (2020) Picturing Organisms and Their Environments: Interaction, Transaction, and Constitution Loops. Front Psychol, 11, https://doi.org/10.3389/fpsyg.2020.01912

Di Paolo, E. A. ; Cuffari, E. C. & De Jaegher, H. (2018). Linguistic Bodies: The Continuity Between Life and Language. Cambridge, MA, USA: MIT Press.

Di Paolo, E., De Jaegher, H. (2012) The interactive brain hypothesis. Frontiers in Human Neuroscience, 6 https://doi.org/10.3389/fnhum.2012.00163

Di Paolo, E. A., Rohde, M., & De Jaegher, H. (2010). Horizons for the enactive mind: Values, social interaction, and play. In J. Stewart, O. Gapenne, & E. Di Paolo (Eds.), Enaction: toward a new paradigm for cognitive science (pp. 33–87). Cambridge: MIT Press.

Doerig, A., Sommers, R.P., Seeliger, K. et al. The neuroconnectionist research programme. Nat Rev Neurosci 24, 431–450 (2023). https://doi.org/10.1038/s41583-023-00705-w

Donohoe, J. (2004). Husserl on Ethics and Intersubjectivity. Prometheus Books.

Dumas, G., Nadel, J., Soussignan, R., Martinerie, J., & Garnero, L. (2010). Inter-brain synchronization during social interaction. PloS One, 5(8), e12166. https://doi.org/10.1371/journal.pone.0012166

Egan, Frances (2017). Function-Theoretic Explanation and the Search for Neural Mechanisms. In Explanation and Integration in Mind and Brain Science 145-163. Oxford, UK: pp. 145-163.

Fishburn, F. A., Murty, V. P., Hlutkowsky, C. O., MacGillivray, C. E., Bemis, L. M., Murphy, M. E., Huppert, T. J., & Perlman, S. B. (2018). Putting our heads together: Interpersonal neural synchronization as a biological mechanism for shared intentionality. Social Cognitive and Affective Neuroscience, 13(8), 841–849.
https://doi.org/10.1093/scan/nsy060

Fotopoulou, A., & Tsakiris, M. (2017). Mentalizing homeostasis: The social origins of interoceptive inference. Neuropsychoanalysis, 19(1), 3–28.

Frank, A. Gleiser, M. Thompson, E. (2019) The blindspot. Aeon. https://aeon.co/essays/the-blind-spot-of-science-is-the-neglect-of-lived-experience.

Friston, K., & Frith, C. (2015). Active inference, communication, and hermeneutics. Cortex, 68, 129–143.

Froese, T. (2022). Scientific Observation Is Socio-Materially Augmented Perception: Toward a Participatory Realism. Philosophies, 7(2), 37. https://doi.org/10.3390/philosophies7020037

Fuchs, T. (2010). Subjectivity and Intersubjectivity in Psychiatric Diagnosis. Psychopathology, 43(4), 268–274. https://doi.org/10.1159/0003151269

Fuchs, T. (2011). The Brain -- A Mediating Organ. Journal of Consciousness Studies 18(7-8):196-221

Fusaroli, R., Rączaszek-Leonardi, J., & Tylén, K. (2014). Dialog as interpersonal synergy. New Ideas in Psychology, 32, 147-157.

Galbusera, L., Finn, M. T., Tschacher, W., & Kyselo, M. (2019). Interpersonal synchrony feels good but impedes self-regulation of affect. Scientific reports, 9(1), 14691.

Gessell, B., Geib, B. & De Brigard, F. Multivariate pattern analysis and the search for neural representations. Synthese 199, 12869–12889 (2021). https://doi.org/10.1007/s11229-021-03358-3

Goldman, A. (2006) Simulating minds. The philosophy, psychology, and neuroscience of mindreading. Oxford University Press.

Hakim, U., De Felice, S., Pinti, P., Zhang, X., Noah, J. A., Ono, Y., Burgess, P. W., Hamilton, A., Hirsch, J., & Tachtsidis, I. (2023). Quantification of inter-brain coupling: A review of current methods used in haemodynamic and electrophysiological hyperscanning studies. NeuroImage, 280, 120354. https://doi.org/10.1016/j.neuroimage.2023.120354

Hamilton, A. F. de C. (2021). Hyperscanning: Beyond the Hype. Neuron, 109(3), 404–407. https://doi.org/10.1016/j.neuron.2020.11.008

Hasson, U., Ghazanfar, A. A., Galantucci, B., Garrod, S., & Keysers, C. (2012). Brain-to-brain coupling: A mechanism for creating and sharing a social world. Trends in Cognitive Sciences, 16(2), 114-121. https://doi.org/10.1016/j.tics.2011.12.007

Heiko H Schütt, Alexander D Kipnis, Jörn Diedrichsen, Nikolaus Kriegeskorte (2023) Statistical inference on representational geometries. eLife 12:e82566.

Hinrichs, N., & Guzmán, N. (2024). Radical realism. arXiv. https://arxiv.org/abs/2401.14049

Husserl, E. (1954). The Crisis of European Sciences and Transcendental Phenomenology. Northwestern University Press.

Jiang, J., Dai, B., Peng, D., Zhu, C., Liu, L., & Lu, C. (2015). Neural synchronization during face-to-face communication. Journal of Neuroscience, 35(42), 15088-15093. https://doi.org/10.1523/JNEUROSCI.2334-15.2015

Kinreich, S., Djalovski, A., Kraus, L., Louzoun, Y., & Feldman, R. (2017). Brain-to-brain synchrony during naturalistic social interactions. Scientific Reports, 7, 17060. https://doi.org/10.1038/s41598-017-17339-5

Kinreich, S., Djalovski, A., Kraus, L. et al. Brain-to-Brain Synchrony during Naturalistic Social Interactions. Sci Rep 7, 17060 (2017). https://doi.org/10.1038/s41598-017-17339-5

Konvalinka, I., & Roepstorff, A. (2012). The two-brain approach: How can mutually interacting brains teach us something about social interaction? Frontiers in Human Neuroscience, 6, 215. https://doi.org/10.3389/fnhum.2012.00215

Koike, T., Tanabe, H. C., & Sadato, N. (2016). Hyperscanning neuroimaging technique to reveal the "two-in-one" system in social interactions. Neuroscience Research, 90, 25-32. https://doi.org/10.1016/j.neures.2014.11.006

Kriegeskorte, N., & Diedrichsen, J. (2019). Peeling the Onion of Brain Representations. Annual Review of Neuroscience, 42(Volume 42, 2019), 407–432. https://doi.org/10.1146/annurev-neuro-080317-061906

LaCroix, Travis (2023) Autism and the Pseudoscience of Mind. [Preprint] URL: https://philsci-archive.pitt.edu/id/eprint/22817

Lakatos, Imre; Worrall, John; Currie, Gregory. (1978). The methodology of scientific research programmes (Philosophical Papers) in Falsification and the methodology of scientific research programmes. , 10.1017/CBO9780511621123(1), 8–101.doi:10.1017/CBO9780511621123.0

Leong V., Byrne E., Clackson K., et al. (2017). Speaker gaze increases information coupling between infant and adult brains. Proceedings of the National Academy of Sciences of the United States of America, 114, 13290–95.

Liu, T., Saito, G., & Oi, M. (2018). Role of the right inferior frontal gyrus in turn-taking during question-and-answer dialogue: A NIRS hyperscanning study. Brain and Cognition, 131, 34-40. https://doi.org/10.1016/j.bandc.2018.09.002

Lohmar, D. (2012). Mirror neurons and phenomenology of perception. In S. Gallagher & D. Zahavi (Eds.), The Oxford Handbook of Contemporary Phenomenology. Oxford University Press.

Newen, A. & Schlicht, T. (2009) Understanding other minds: A criticism of Goldman's Simulation Theory and an outline of the Person Model Theory. Grazer Philosophische Studien 79(1):209–42.

Nguyen, T., Kungl, M. T., Hoehl, S., White, L. O., & Vrtička, P. (2024). Visualizing the invisible tie: Linking parent–child neural synchrony to parents' and children's attachment representations. Developmental Science, 27, e13504. https://doi.org/10.1111/desc.13504

Nguyen T, Bánki A, Markova G, Hoehl S. 2020. Studying parent-child interaction with hyperscanning. Prog.Brain Res. 254:1–24

Pauen, M. (2012). The Second-Person Perspective. Inquiry, 55(1), 33–49. https://doi.org/10.1080/0020174X.2012.643623

Pan, Y., Novembre, G., Song, B., Li, X., & Hu, Y. (2022). Dual brain stimulation enhances interpersonal learning through spontaneous movement synchrony. Social Cognitive and Affective Neuroscience, 17(4), 349-358. https://doi.org/10.1093/scan/nsac022

Pauen, M., & Haynes, J.-D. (2021). Measuring the mental. Consciousness and Cognition, 90, 103106. https://doi.org/10.1016/j.concog.2021.103106

Paulick, J., Rubel, J. A., Deisenhofer, A. K., Schwartz, B., Thielemann, D., Altmann, U., et al. (2018). Diagnostic features of nonverbal synchrony in psychotherapy: Comparing depression and anxiety. Cogn. Ther. Res. 42, 539–551.
doi: 10.1007/s10608-018-9914-9

Przyrembel, M., Smallwood, J., Pauen, M., & Singer, T. (2012). Illuminating the dark matter of social neuroscience: Considering the problem of social interaction from philosophical, psychological, and neuroscientific perspectives. Frontiers in Human Neuroscience, 6.
https://doi.org/10.3389/fnhum.2012.00190

Redcay, E., Schilbach, L. Using second-person neuroscience to elucidate the mechanisms of social interaction. Nat Rev Neurosci 20, 495–505 (2019). https://doi.org/10.1038/s41583-019-0179-4

Reindl, V., Gerloff, C., Scharke, W., & Konrad, K. (2018). Brain-to-brain synchrony in parent-child dyads and the relationship with emotion regulation revealed by fNIRS-based hyperscanning. NeuroImage, 178, 493-502. https://doi.org/10.1016/j.neuroimage.2018.05.060

Reinero, D. A., Dikker, S., & Van Bavel, J. J. (2021). Inter-brain synchrony in teams predicts collective performance. *Social Cognitive and Affective Neuroscience, 16*(1–2), 43–57. https://doi.org/10.1093/scan/nsaa135

Schilbach, L. (2010) A second-person approach to other minds. Nature Reviews Neuroscience 11(6):449.

Schilbach, L., Timmermans, B., Reddy, V., Costall, A., Bente, G., Schlicht, T., & Vogeley, K. (2013). Toward a second-person neuroscience. The Behavioral and brain sciences, 36(4), 393–414. https://doi.org/10.1017/S0140525X12000660

Schilbach, L., & Redcay, E. (2025). Synchrony Across Brains. Annual review of psychology, 76(1), 883–911. https://doi.org/10.1146/annurev-psych-080123-101149

Scott-Fordsmand, H. & Tybjerg, K. (2023). Approaching diagnostic messiness through spiderweb strategies: Connecting epistemic practices in the clinic and the laboratory, Studies in History and Philosophy of Science,Volume 102, 12-21 https://doi.org/10.1016/j.shpsa.2023.08.006 .

Sened, H., Gorst Kaduri, K., Nathan Gamliel, H., Rafaeli, E., Zilcha-Mano, S., & Shamay-Tsoory, S. (2025). Inter-brain plasticity as a mechanism of change in psychotherapy: A proof of concept focusing on test anxiety. Psychotherapy Research, 1–15. https://doi.org/10.1080/10503307.2025.2451798

Sened, H., Zilcha-Mano, S., & Shamay-Tsoory, S. (2022b). Inter-brain plasticity as a biological mechanism of change in psychotherapy: A review and integrative model. Frontiers in Human Neuroscience, 16.
https://doi.org/10.3389/fnhum.2022.955238

Shapiro, Lawrence A. (2017). Mechanism or Bust? Explanation in Psychology. British Journal for the Philosophy of Science 68 (4):1037-1059.

Stephens, G. J., Silbert, L. J., & Hasson, U. (2010). Speaker–listener neural coupling underlies successful communication. Proceedings of the National Academy of Sciences, 107(32), 14425-14430. https://doi.org/10.1073/pnas.1008662107

Stuart, J., Gapenne, O., Di Paolo, E. (2014) Enaction Toward a New Paradigm for Cognitive Science. MIT Press.
Thompson, E. (2001). Empathy and consciousness. Journal of Consciousness Studies, 8, 1–32.

Thompson, E. (2007). Mind in life: biology, phenomenology, and the sciences of mind. Cambridge: MA, Harvard University Press.

Van Fraassen, B. (2008). Scientific Representation: Paradoxes of Perspective. Oxford University Press.

Villiger, O. (2022). How Psychedelic-Assisted Treatment Works in the Bayesian Brain

Vicente, U., Ara, A. & Marco-Pallarés, J. Intra- and inter-brain synchrony oscillations underlying social adjustment. Sci Rep 13, 11211 (2023). https://doi.org/10.1038/s41598-023-38292-6

Yun, K., Watanabe, K., & Shimojo, S. (2020). Interpersonal body and neural synchronization as a marker of implicit social interaction. Scientific Reports, 10(1), 2045. https://doi.org/10.1038/s41598-019-57335-z

Zahavi, D. (2023). Observation, Interaction, Communication: The Role of the Second Person. Aristotelian Society Supplementary Volume, 97(1), 82–103.
https://doi.org/10.1093/arisup/akad001

Zhang, Y., Meng, T., Hou, Y., Pan, Y., & Hu, Y. (2018). Interpersonal brain synchronization associated with working alliance during psychological counseling. Psychiatry Research: Neuroimaging, 282, 103-109. https://doi.org/10.1016/j.pscychresns.2018.09.007

Zimmermann, M., Schultz-Nielsen, K., Dumas, G., & Konvalinka, I. (2024). Arbitrary methodological decisions skew inter-brain synchronization estimates in hyperscanning-EEG studies. *Imaging Neuroscience, 2*, 1–19. https://doi.org/10.1162/imag_a_00350