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Environment as Information

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In contemporary debates across the life sciences, cognitive science, and philosophy of technology, 'environment' and 'information' have become both unavoidable and oddly elusive. The language of information pervades discourse on life and mind: genes 'encode' traits, brains 'process' inputs, digital platforms curate 'information ecosystems', and climate models appear as informational infrastructures. Meanwhile, 'environment' has been expanded and destabilized, shifting from a Newtonian medium, to a Lamarckian set of circumstances, to ecological systems, to the 'infosphere' of our digital condition (Canguilhem, 2008; Floridi, 2010). What we mean by 'environment', and how it relates to 'information', is therefore far from obvious.

Part of the difficulty lies in the historical stratification of these concepts. In the wake of cybernetics and information theory, information has often been treated as an abstract pattern separable from any particular substrate. Norbert Wiener's claim that «information is information, not matter or energy» emblematizes a widespread tendency to treat information as a third ontological category, irreducible to physical stuff and yet more fundamental than it (Wiener, 1948, p. 132). As N. Katherine Hayles shows, this 'dematerialization' underwrites many posthumanist narratives of virtual embodiment: if information is independent of its embodiment, it can, in principle, be uploaded, downloaded, and endlessly migrated across media without remainder (Hayles, 1999).

In parallel, our ways of talking about environments have also drifted. Classical physiology and experimental psychology largely presupposed a relatively stable external world acting on an organism or subject. Twentieth-century biology and philosophy of life complicated this picture. From Jakob von Uexküll's *Umwelt* to Kurt Koffka's distinction between geographical and behavioral environments, the 'environment' of a living being came to be seen not as a neutral container but as a structured field of significance, selectively disclosed through an organism's perceptual and motor capacities (von Uexküll, 2010; Koffka, 1935). Ecological psychology and enactivist approaches further insist that organisms and environments form integrated systems of mutual determination rather than a simple subject-object dyad (Gibson, 1979; Varela, Thompson and Rosch, 1991).

The rapid development of digital media and networked infrastructures intensifies this instability. Luciano Floridi's proposal to think of our condition as 'onlife' – irreversibly immersed in an 'infosphere' where online and offline interpenetrate – has been especially influential (Floridi, 2014). Our environment becomes not only physical surroundings but also dense, layered, often opaque architectures of data flows, algorithms, and interfaces. Human beings appear as 'inforgs', informational organisms that both shape and are shaped by the infosphere (Floridi, 2010). Yet, as Hayles warns, this expansion of informational language risks re-inscribing, in new terms, the same problematic disembodiment that marked early cybernetic thinking (Hayles, 1999).

This article starts from a simple but demanding question: what if we took seriously the idea that environments themselves are informational structures – without treating information as immaterial? Rather than positing a physical environment with an informational 'layer' superimposed, I argue that we should reconceive environments as the systemic ensemble of information available to an organism at a given moment. An environment is not a mere spatial container, neutral background, or purely mental construct; it is the organized set of material structures that function as information for some organism, enabling and constraining its possible actions, perceptions, and forms of life.

To develop this claim, I draw on Italian philosopher of science Vittorio Somenzi's materialist theory of information, marginal in mainstream Anglophone debates but rich in resources for overcoming the dualism between immaterial information and brute matter. Against readings of Wiener that treat information as a quasi-spiritual substance, Somenzi insists that information is a way in which matter is organized: a functional structure with real causal efficacy that cannot be detached from its physical instantiation. This allows us to reject both naïve physicalism – reducing information to energy or mass – and an idealism of patterns in which information floats free of material constraints. Information instead appears as a specific mode of material configuration: a pattern that does something, enabling certain processes and excluding others.

From this vantage point, the convergence between 'environment' and 'information' is not a metaphorical shortcut but a substantive ontological claim. If environments are the structured conditions of possibility for an organism's activity, and if information names those material structures insofar as they guide behavior and cognition, then saying that an environment is information is not to dematerialize it but to specify how it matters. A rocky surface, a pheromone trail, a traffic light, or a social-media feed all belong to an environment in virtue of the informational roles their physical structures play for some organism or agent. They are not 'symbols in the head' nor ethereal data points, but organized material configurations that, given a particular body and set of capacities, become actionable, perceivable, or meaningful.

This reconceptualization has two immediate consequences. First, it invites us to reread classic models in the life and cognitive sciences as partial articulations of an 'environment as information' perspective, where the focus falls on how structures in the surroundings function as cues, invitations, obstacles, or resources for behavior. Second, it offers a coherent way to think about contemporary digital environments without reifying an ontological gap between 'virtual' and 'real.' Both a forest and a social-media platform qualify as environments because both are complex systems of informational structures, materially instantiated – in trees and soil, in servers and fibre-optic cables – that shape possibilities of action and experience for their inhabitants.

The aim of this article is therefore both historical-epistemological and theoretical. Historically, I reconstruct how environment and information have

been conceptualized in key moments of twentieth-century thought, paying particular attention to immaterialist understandings of information and their influence on contemporary notions of digital environments. Theoretically, I propose a materialist, non-dualist account of information, inspired by Somenzi, and use it to redescribe environments – biological, cognitive, and digital – as dynamic ensembles of informational structures. In doing so, I suggest that familiar oppositions (matter vs information, object vs representation, physical vs digital environment) can be reframed as different levels or modes of organization within a single informational ontology.

My guiding hypothesis is that environments can be rigorously defined as the systemic ensemble of information available to an organism at a given moment. This does not reduce environments to subjective experience, nor treat information as purely semantic or mental. Rather, what counts as an environment is determined by the material structures that can function as information for some organism, given its bodily capacities and situated history. By foregrounding the informational dimension of environments while insisting on the materiality of information, we can move beyond both the idealist temptation to treat environments as mere representations and the naïve realism that treats them as indifferent containers. Environments are neither simply 'out there' as neutral backgrounds nor 'in here' as private constructions; they are dynamic, materially instantiated systems of informational structures, in which organisms themselves appear as informational nodes among others.

1. *Digital environments and the infosphere*

Luciano Floridi's notion of 'onlife' is one of the most influential attempts to describe how digital technologies have reshaped our experience of the environment. The *infosphere* is, for him, the global 'informational environment' made up of all informational entities, their properties, interactions, processes, and relations (Floridi, 2010, 2014). Human beings are 'inforgs': informationally embodied organisms whose identities and lifeworlds are increasingly shaped by their position in this informational space.

Crucially, Floridi does not present the infosphere as a metaphor laid over a more 'real' physical world. It *is* the environment within which agents act, perceive, and form themselves. The online/offline distinction collapses: so-called 'online' interactions are specific regions of a broader informational environment in which we are permanently immersed. A user scrolling a social-media feed on a smartphone in a park does not inhabit two separate environments, one physical and one virtual, but a hybrid informational field in which trees, screens, wireless signals, and algorithms all participate.

Floridi also proposes a general definition of information (GDI) as data + meaning + truth under suitable semantic and epistemic conditions (Floridi, 2010). Information is thus not merely Shannon-style correlation but contentful, factive, and usable. Although sometimes criticized as too restrictive, this definition usefully emphasizes that information is never just 'stuff out there' but is bound to contexts of use, constraints, and what counts as a significant

difference. Any informational description presupposes a *level of abstraction* (LoA): a way of modeling a system that selects some features as relevant and brackets others. To speak of 'information' is always to speak from a particular LoA.

Attention to LoAs quietly destabilizes naïve realism about environments. If what counts as information depends on an agent's perspective and capacities, the environment cannot be a neutral container whose properties are simply 'given'. It appears instead as a structured field of informational relations, always already carved up, interpreted, and acted upon from within. Floridi stresses that inforgs are not passive recipients but active nodes in the infosphere, capable of modifying its structure and being modified in turn (Floridi, 2010).

By extending informational status beyond humans to non-human organisms, technical artifacts, and institutions, Floridi sketches an informational ecology. Servers, sensors, software agents, financial algorithms, and legal codes all function as sources, processors, and sinks of information. The environment becomes a dynamic web of informational interactions, feedback loops, and emergent patterns. The move from 'environment' to 'infosphere' is meant to register this complexity and to signal that, in the digital age, what matters for an agent is less a stable physical geography than the constantly shifting structure of accessible information.

Yet Floridi's framework inherits tensions from the information-centric worldview it refines. One concerns the ontological status of information. Floridi denies that information is an immaterial substance and criticizes both crude physicalism and talk of 'pure information' as metaphysically naive (Floridi, 2010). Nonetheless, his focus on semantic content, truth, and LoAs foregrounds the epistemic and logical dimensions of information, while its material instantiation tends to appear as a secondary, implementation-level issue. The infosphere can thus seem like a quasi-abstract relational space that could, in principle, be realized in different substrates without altering its essential structure.

For the purposes of this article, the key point is that Floridi offers a powerful way to conceptualize digital environments as informational environments, but in a way that leaves the rooting of information in matter underdeveloped. His language of *inforgs* and *onlife* captures how our surroundings have become informationally saturated and technologically mediated, yet it risks reinscribing a subtle gap between an informational 'level' where environments truly matter and a material 'base' that is conceptually secondary. To make sense of 'environment as information', I will build on Floridi's insights while placing the materiality of information at the centre rather than at the margins.

1.2 *The dematerialization of information: Hayles' genealogy*

If Floridi offers a normative and conceptual vocabulary for informational environments, Hayles provides a critical genealogy of the very idea that

information could be detached from material embodiment. In *How We Became Posthuman*, Hayles provides the detailed genealogy of the dematerialization tendency I noted in the Introduction. Her reconstruction traces how a methodological abstraction – Shannon's bracketing of semantics – gradually hardened into an ontological thesis (Hayles, 1999).

Hayles locates a key shift in early cybernetics. In Claude Shannon's theory, information is defined as reduction of uncertainty – a purely statistical measure deliberately bracketed from meaning (Shannon & Weaver, 1949). This methodological abstraction enabled engineers to design communication systems without addressing semantics, but when extended beyond that technical context it supported broader claims: information came to be seen as a pattern or form ontologically independent of any specific physical realization. Wiener's statement, cited above, becomes in Hayles' reading the hinge of this dematerialization (Wiener, 1948; Hayles, 1999). What began as a methodological separation gradually hardened into an ontological thesis: information is neither reducible to matter nor fully constrained by it.

Hayles' genealogy is invaluable, but it should be situated. As a scholar of literature and science, her focus falls on the cultural and narrative dimensions of cybernetic discourse – on how the 'information/materiality dyad' shaped posthumanist imaginaries of uploaded minds and disembodied consciousness. This is an important part of the story, but it is not the whole. Within physics and the philosophy of physics, as I will note below, there are sophisticated accounts of information that resist both crude physicalism and immaterialism (see Section 2.2). My use of Hayles is therefore strategic: she offers the clearest diagnosis of how immaterialist assumptions migrated from technical contexts into broader cultural and philosophical discourse. The critique I develop is directed at these extrapolations, not at information theory in its technical or physical-scientific uses.

For Hayles, this is not just a theoretical mistake but a cultural transformation. The post-war era witnesses the rise of an 'information/materiality dyad', in which information and embodiment are conceptually separated and hierarchically ordered. Information is linked to pattern, mind, control, and replicability; matter to noise, finitude, decay, and the constraints of embodiment. Within this dyad, value and identity attach to informational pattern: what matters about a person is the informational structure of their mind, not the particular body that bears it (Hayles, 1999). Hence the imagined possibility of 'uploading' a mind is not a neutral technological scenario but the expression of a prior commitment to the primacy of information. If the self is fundamentally an informational pattern, it can in principle be copied, backed up, transmitted, and re-instantiated across substrates. Bodies become interchangeable platforms, relevant only as supports; they do not participate in what is essential. Hayles' critique is not primarily that such scenarios are technically infeasible, but that they rely on an ontology that marginalizes embodiment in constituting subjectivity.

This dematerialized view of information, she argues, has also shaped how we talk about environments. Descriptions of digital platforms as 'virtual worlds', 'cyberspace', or 'the cloud' often treat them as spaces of pure information detached from physical geography. Data appear to 'flow' across networks in ways that render invisible the infrastructures – server farms, undersea cables, energy grids – that make such flows possible. Users' environments are framed as patterns of interfaces and content, while the environmental costs of maintaining and cooling servers, mining rare earths, and disposing of electronic waste remain out of sight. Hayles' genealogy shows that this is not an accidental oversight but the outcome of a long history in which information has been abstracted from its material conditions of existence. To the extent that digital environments are imagined as spaces of pure information, they inherit an ontology that treats materiality as secondary or accidental. The political and ecological consequences are significant: it becomes easier to overlook the extractive and polluting practices sustaining digital infrastructures, and to reconceive environmental problems as issues of information management rather than material justice.

Yet Hayles does not urge us to abandon the language of information. Instead, she argues that information must always be understood as embodied: «There is no information without a material medium» (Hayles, 1999, p. 49). Information is not an ethereal substance floating free of its carriers, but a pattern always realized in, and constrained by, specific material configurations. Recognizing this allows us to resist the information/materiality dyad and to think in terms of complex feedbacks between patterns and substrates, codes and bodies, virtual sequences and physical processes.

Taken together, Floridi and Hayles sharpen the central tension motivating my project. On the one hand, our experience and understanding of environments today are undeniably informational: we navigate worlds structured by data, algorithms, and interfaces; we are 'onlife' in an infosphere that shapes identities and actions (Floridi, 2014). On the other hand, the conceptual apparatus used to describe this situation is inherited from a tradition that has dematerialized information and treated material environments – biological, social, planetary – as mere supports or backgrounds. If we are to claim that environments are information, we must do so in a way that avoids both the immaterialism critiqued by Hayles (1999) and the semantic-epistemic focus that sometimes sidelines materiality in Floridi's account (Floridi, 2010).

In the next section, I therefore turn to the conceptual history of 'environment' itself, drawing on Georges Canguilhem's analyses of milieu to show that this notion has always been theoretically unstable and contested (Canguilhem, 2008). This instability, I argue, becomes particularly problematic when it intersects with the dematerialized view of information just described. Clarifying these historical and epistemological obstacles is a necessary step towards a materialist account of environment as information.

2. *Epistemological obstacles: environment and information*

The convergence between 'environment' and 'information' sketched so far is not conceptually innocent. Both terms carry heavy historical baggage, much of which resists the materialist, non-dualist framework I aim to develop. Before arguing that environments are best understood as ensembles of information, we need to identify the main epistemological obstacles (*sensu* Bachelard, 1938) that have shaped thinking about both notions, often in divergent ways.

On the side of environment, the obstacle is an instability that is at once historical and conceptual. 'Environment' oscillates between a neutral, external container and a relational field co-constituted by organisms and their surroundings. These two senses coexist in contemporary discourse, frequently without clear differentiation. On the side of information, the obstacle is a persistent dualism: information is either reduced to purely physical magnitudes (energy, entropy, probability) or elevated to an immaterial realm of meanings and patterns, detached from material substrates. When these two histories intersect – an unstable notion of environment and a dualist notion of information – we obtain a picture in which environments appear either as brute physical backgrounds or as purely informational constructs, with no coherent account of how material structures can be informational *for* organisms.

In what follows, I address two questions. First, how has the concept of environment (or *milieu*) been constructed in modern science, and what tensions does this construction entail? Second, how have dominant understandings of information – especially after Shannon and Wiener – encouraged forms of dualism that make it difficult to think of information as materially instantiated? Clarifying these obstacles will prepare the ground for an account in which environment and information can be brought together without collapsing into either naïve realism or disembodied idealism.

2.1 *The unstable history of 'environment'*

Georges Canguilhem's analyses of *milieu* offer a sharp lens on the conceptual instability of 'environment' in modern biology and medicine (Canguilhem, 2008). His key claim is that milieu has always been a 'mixed' concept – at once physical, biological, and normative – and that any attempt to treat it as a purely objective, external reality smuggles in assumptions about the organisms it surrounds. There is no single, unproblematic concept of environment; only shifting attempts to stabilize a relation between living beings and their surroundings.

In classical mechanics, environment is pictured as a homogeneous medium: an isotropic space in which forces act and bodies move. This Newtonian image underwrites early physiological and experimental setups, where the environment is a controlled set of external variables acting on an organism conceived as a mechanism. Environment is a manipulable background,

conceptually distinct from the organism: it exerts pressure, delivers stimuli, provides resources, but does not itself depend on the organism's structure.

Evolutionary thinking transforms this image without fully abandoning it. In Lamarck and Darwin, environment appears as the 'circumstances' or 'conditions of existence' that shape development and select traits (Canguilhem, 2008). Organisms now adapt, struggle, and sometimes modify their surroundings, yet the environment remains a pre-given system of conditions – climate, terrain, predators, food – to which organisms must respond. The environment is 'out there', the organism 'in here', and science traces causal arrows from one to the other.

Around the turn of the twentieth century, several lines of research problematize this opposition. Physiology and developmental biology show that the same 'objective' environment can have very different effects depending on organisms' internal organization, and that organisms actively regulate their own conditions of existence. In psychology, especially *Gestalt* theory, Kurt Koffka distinguishes between the 'geographical environment' (as described by physics) and the 'behavioral environment' – the environment as structured by the subject's perceptual field, intentions, and past experience (Koffka, 1935). Jakob von Uexküll's *Umwelt* similarly insists that each species lives in its own experiential world, carved from the same physical surroundings but composed of different 'marks' and 'carriers of significance' (von Uexküll, 2010).

Canguilhem reads these developments as evidence that environment cannot be defined independently of the organism. There is no environment 'in general'; there are only organism-environment systems, where what counts as a relevant milieu is determined by the organism's structure, needs, and normativity (Canguilhem, 2008). A human and a tick may share the same forest as geographical space, but not the same environment, because the informational structures that matter (visual contrasts, heat gradients, chemical cues) differ. Environment is not a neutral container; it is a relational configuration.

This relational turn introduces a tension that never fully resolves. On one side, the natural sciences require stable, shared descriptions of environments to generalize, compare, and intervene. On the other, biology and psychology show that environments are always partly internal to organisms in the sense that they exist *as* environments only by virtue of organisms' capacities and projects. 'Environment' thus oscillates: sometimes naming an objective external system, sometimes an organism-relative field of significance – most often sliding between these senses without explicit clarification.

This oscillation is evident in contemporary talk of 'environments', including 'digital environments'. When we speak of 'the digital environment', we may refer to:

1. the global technical infrastructure of servers, cables, protocols, and standards (an objective system);
2. the interfaces and content a user actually encounters (a behavioral or experiential environment);

3. the algorithmically curated field of affordances, nudges, and constraints that shape behavior (a normative, relational environment).

All three dimensions are real but not identical. Without a clear account of how they relate, 'environment' remains conceptually fuzzy, and it becomes difficult to specify in what sense environments could be said to be informational.

2.2 *Dualisms in the concept of information*

A parallel, and partly complementary, obstacle comes from the history of the concept of information. Shannon's mathematical theory deliberately brackets semantics, defining information as uncertainty reduction in selecting messages from a set of possibilities (Shannon and Weaver, 1949). This abstraction is methodologically powerful, but when read ontologically it invites two opposite – and equally problematic – tendencies.

On the one hand, information is reduced to purely physical magnitudes. In statistical mechanics and thermodynamics, it is often identified with negative entropy: the more ordered a system, the more information it 'contains'. Information becomes a way of talking about physical states and their probabilities, 'nothing but' a quantitative description of matter-energy distributions. This underlies some forms of physicalism that treat information as a fundamental physical quantity on a par with mass or charge. While such views rightly resist immaterialism, they tend to dissolve information into microphysical descriptions, leaving little conceptual space for the functional and relational aspects that matter for organisms and cognition. On the other hand, as I discussed in Section 1.2 through Hayles' genealogy, information is elevated into a quasi-ideal realm of meanings and patterns – a structure that can be 'realized' in different substrates without being identical to any of them. This route leads to the 'pattern identity' theory in which selfhood becomes a transferable informational structure.

These two tendencies – reductive physicalism and disembodied idealism – seem opposed but share a crucial feature: they separate information from the specific material organization of systems. In the first case, information collapses into microscopic physics and loses its functional character; in the second, it detaches from its material carriers and becomes an abstract pattern. Both make it difficult to think of information as a way in which matter is organized so as to play particular roles in the behavior of organisms and systems.

Recent debates on the 'immateriality of information' crystallize this difficulty. Some explicitly argue that information is non-physical, citing its apparent independence from particular media and the normative nature of semantic content (Wang, 2022). Others defend 'informational realism', claiming that informational structures are the basic constituents of reality, with matter and energy derivative (Floridi, 2005; Caticha, 2014). Despite their differences, such views often preserve the idea that information is something

over and above physical structures, or at least not adequately captured in physical terms.

It should be acknowledged, however, that the two poles sketched above (i.e. reductive physicalism and disembodied idealism) do not exhaust the positions available within physics and the philosophy of physics. A more nuanced debate has unfolded, particularly in the context of quantum information theory. Chris Timpson, for instance, has argued that quantum information is best understood neither as a new physical substance nor as a substrate-independent abstraction, but as a way of characterizing what physical systems can do – their correlational and representational capacities (Timpson, 2013). On this reading, to speak of 'information' in physics is not to posit an immaterial entity but to describe physical systems at a particular level of analysis, one that foregrounds structure, correlation, and functional role. Similarly, John Archibald Wheeler's celebrated slogan 'it from bit' – often cited as evidence for the primacy of information over matter – admits of a more careful interpretation. Wheeler's original proposal was not that information floats free of physics, but that the fundamental physical facts might themselves be constituted through yes-or-no observational acts, such that physical reality and informational structure are co-constitutive rather than hierarchically ordered (Wheeler, 1990). This is closer to the structural materialism I will develop via Somenzi than to the disembodied patternism critiqued by Hayles.

My target, therefore, is not physics as such, nor even information-theoretic approaches within physics. It is rather a set of philosophical extrapolations – visible in popular discourse, certain strands of cognitive science, and some versions of informational ontology – that detach information from material constraints and treat it as a quasi-ideal realm. This tendency, which Hayles traces through cybernetics and posthumanist thought, is what I call 'immaterialism' about information. Recognizing that physics itself offers resources for a non-dualist, structurally grounded account of information strengthens rather than undermines the materialist position I will defend.

From the standpoint of this article, the issue is not that these debates are simply mistaken, but that they remain trapped in a dualistic framework. Either information is 'really' physical (and its distinctive functional and relational properties become hard to articulate), or it is 'really' non-physical (and its connection to material structures becomes opaque). What is missing is an account of information as a mode of material organization: a way in which physical systems are structured so that certain differences become functionally salient for some organism or process.

When this dualistic conception of information meets the unstable concept of environment described above, the result is especially unhelpful. The environment is treated either as a brute physical background (described in purely energetic or material terms) or as a 'representation' or 'model' in the head of an organism (described in informational terms). Information appears either 'in' the environment or 'in' the organism, but rarely as a property of the organism-environment system itself. Digital environments exacerbate this split:

the 'real' environment is identified with physical infrastructure, while the 'virtual' environment is cast as an informational construct, with little conceptual clarity about how the two are related.

2.3 *A compounded obstacle*

We can now see why defining environments as ensembles of information encounters a double resistance. 'Environment' is conceptually split between an external, objective medium and a relational, organism-dependent milieu; 'information' is split between reductive physicalism and disembodied idealism. Each term pulls in two directions, and their combinations are unstable:

- A realist environment + immaterial information yields images of 'virtual worlds' or 'infospheric layers' hovering over physical reality with unclear ontological status.
- A relational environment + reductive information yields images in which organism-specific environments are nothing more than different partitions of the same physical data, without explaining how these partitions become functionally relevant.

In both cases, the organism-environment relation is recast as a relation between a physical body and an informational representation, whether internal (mental models, neural codes) or external (digital content, media representations). The environment itself is not treated as informational in a robust sense; information becomes either an external description of the environment or a representation of it within an organism.

The core hypothesis of this article – that environments can be defined as systemic ensembles of information available to an organism at a given moment – is intended to help navigate these dichotomies. I do not claim that this formulation is entirely novel; similar intuitions animate ecological psychology, enactivism, and aspects of Floridi's informational ontology. What I offer is an explicit ontological grounding, drawing on Somenzi's materialism, that makes these intuitions more precise and defensible.

In the next section, I turn to Somenzi's work and to related distinctions between internal structural information and external descriptive information. These distinctions, I argue, help dissolve the dualism that has plagued the concept of information and support a view in which environment and information are not two ontological domains but two aspects of the same material reality.

3. *A materialist turn: environment as information*

The epistemological obstacles just reconstructed point in a clear direction. To hold 'environment' and 'information' together without lapsing into naïve realism or disembodied idealism, we need a notion of information that is both material and functional, and a notion of environment that is both relational and objective. In other words, we must be able to speak of information as a

structural feature of material reality, and of environments as configurations of such structures that matter for organisms.

This is precisely what Vittorio Somenzi's materialist theory of information attempts. At the intersection of physics, biology, and philosophy, Somenzi treats information as neither immaterial substance nor a synonym for energy or entropy, but as a specific way in which matter is organized so as to realize functions (Somenzi, 1972). Information is a structural property of material systems that underlies their capacity to act, regulate, and represent; it is because matter is informationally structured that organisms can have environments at all. In what follows, I sketch this materialist turn in three steps: first, outlining Somenzi's conception of information as functional structure; second, introducing a distinction between internal structural information and external descriptive information; and third, showing how these ideas together allow us to define environments as systemic ensembles of information available to an organism at a given moment.

3.1 *Information as functional structure of matter*

Somenzi's starting point is deceptively simple: material systems are not mere heaps of particles but organized in ways that make some processes possible and others impossible. A crystal lattice, a DNA molecule, a neuron, a printed page, and a microchip are all made of matter, but not in the same way. They differ in structure – the arrangement and constraints of their components – and this structure enables specific functions: diffraction, genetic replication, synaptic transmission, reading, computation. 'Information' names precisely this functional organization of matter.

> [The] key concept of information, […] stripped of any mentalistic character, emphasizes its nature as a specific form taken by a particular material structure – one that, by virtue of this form, manages to transmit all the characteristics of an organism to its descendants (Somenzi, 1967, p. 34)[1].

This definition is broader than semantic or Shannon-style notions. It does not require that information be meaningful for a subject or quantifiable as uncertainty reduction. It focuses instead on the capacity of a material structure to participate in processes in a configuration-sensitive way. A DNA sequence 'contains' information insofar as its nucleotide order affects protein synthesis; a set of synaptic weights 'contains' information insofar as it modulates how inputs are transformed into outputs. In both cases, information is not something hovering above the system; it is the way the system is materially organized.

[1] «[Il] concetto-chiave di informazione, […] privato però di ogni carattere mentalistico sottolineandone l'aspetto di forma particolare assunta da una certa struttura materiale la quale, proprio in virtù di tale forma, riesce a trasmettere tutte le caratteristiche di un organismo ai suoi discendenti».

On this basis, Somenzi reinterprets the Wienerian slogan discussed in the Introduction. Rather than an ontological split, it is read as a reminder that information is not reducible to the *quantity* of matter or energy. Two systems can share mass and energy yet differ informationally because their components are arranged differently. This does not make information non-material; it shows that materiality has structural dimensions that scalar quantities cannot capture (Somenzi, 1972). Information is a property of how matter and energy are arranged and constrained in space and time. The advantage is that it preserves the intuition – central to biology and cognitive science – that information concerns form, organization, and pattern, while firmly anchoring it in physical reality. There is no need for a separate informational 'substance', nor to reduce information to thermodynamic variables. Information designates the functionally relevant structure of physical systems. Somenzi's theory is thus materialist without being reductionist: everything informational is materially instantiated, but not every material property is informationally relevant.

3.2 *Structural versus descriptive information*

A second key move in this materialist framework is to distinguish two often-conflated senses of 'information': *structural* and *descriptive* information. Structural information is the information *in* a system: the organization of its material components that enables certain functional roles. This is information as defined above: the pattern of connections in a neural network, the layout of a city street, the configuration of a chemical gradient. It exists whether or not anyone describes or notices it. Descriptive information is the information *about* a system: representations, models, data structures, or symbolic codes that an agent or device uses to describe, predict, or control that system. A city map, a DNA sequence in a database, a digital twin of a factory, a textbook diagram are all descriptive information. They are themselves materially instantiated (paper, memory, screen) but stand in a representational relation to other structures.

The distinction is not between 'real' and 'unreal' information. Both are physically realized and causally efficacious. Structural information makes a system the kind of system it is; descriptive information allows some other system to treat it as an object of knowledge or control. A DNA molecule's structural information is operative in cellular metabolism; a geneticist's digital record of that sequence is descriptive information operative in scientific practice. This distinction is crucial for avoiding the dualisms discussed earlier. If we take information *only* as descriptive – models, messages, representations – we tend to locate it 'in the head' or 'in the cloud' and see it as detachable from material reality. If we take information *only* as structural – microphysical states – we risk collapsing it into low-level physics and losing its functional, organism-relative aspects. Keeping both senses in play lets us say that:

- a *forest* has structural information in spatial arrangements, ecological networks, chemical gradients;

- a *satellite image of that forest* is descriptive information used by humans and algorithms to monitor deforestation;
- a *bird* flying through the forest uses some of the forest's structural information (tree density, airflow, sounds) *as information for it* in guiding flight.

The bird does not need a descriptive model of the forest to be informed by it; it suffices that forest-structure and bird-body/nervous-system are coupled so that a certain «difference makes a difference» (Bateson, 1972, p. 453). This coupling is the basis of *Umwelt*, affordances, and behavioral environments, to which I will return. For now, the important point is that environments can be treated as reservoirs and configurations of structural information, while organisms (and their cognitive extensions) generate and manipulate descriptive information about them. The two are related but not identical. Confusing them yields familiar errors: treating 'the environment' as only what appears in an organism's internal model, or treating digital representations of an environment as a separate, more real informational space.

3.3 *Defining environment as systemic ensemble of information*

When I propose that environments can be defined as 'the systemic ensemble of information available to an organism at a given moment', I am not claiming that environments are made of words, symbols, or mental constructs. Environments are configurations of structural information that can function as information for some organism, given its own structural organization.

Consider an organism O at time *t*. It occupies a region of physical space, has a particular bodily structure (sensory organs, effectors, internal states), and is embedded in a broader material world *W*. At any moment, only a subset of the structural information in *W* is functionally available to O. Some gradients can be sensed, some surfaces touched, some signals processed; others lie outside its sensory range, metabolic capacities, or current context. The environment of O at time *t* can then be defined as:

the set of structurally informational features of W that are, in principle or in practice, accessible to O in virtue of its organization, and that can modulate its behavior, development, or survival.

This definition has several consequences.

First, it is explicitly organism-relative without being purely subjective. The environments of a tick, a human, and a bacterium in the same 'geographical' space will differ because different structural features of the world can function as information for each (von Uexküll, 2010). These differences are not arbitrary: they are grounded in objectively existing structural information – heat gradients, chemical signals, visual contrasts – that is physically there whether or not any organism currently exploits it. Environment is neither a mental construct nor a purely external object, but a relational configuration of structural information.

Second, the definition integrates the insights of Floridi and Hayles while avoiding the pitfalls they diagnose. It acknowledges that environments are informational through and through: what matters for organisms is not matter in the abstract but matter structured in ways that can be sensed, processed, and acted upon. At the same time, it insists that information is always materially instantiated and functionally constrained: there is no environment 'made of' disembodied information, and no information without a material medium (Hayles, 1999).

Third, this framework scales naturally from 'traditional' physical environments to digital ones. A social-media feed is an environment in this sense because it is a specific configuration of structural information – interface layouts, ranking algorithms, content items – accessible to users and shaping their possible actions. Its informational structures are materially realized in servers, code, and network infrastructures; they are not less material than a forest's undergrowth or a city's street network, even if their dynamics and scales differ. To inhabit a digital environment is to be embedded in a particular ensemble of structural information, some of which is available as information for perception, decision-making, and social relations.

Finally, this definition suggests to introduce in the psychological and philosophical vocabulary the word *concealment* as well as affordance. If an environment is an ensemble of available information, it is also an ensemble of *unavailable* information – that is, structural features present but not accessible or salient for a given organism. The limits of an environment are the limits of informational availability: what cannot, even in principle, be detected or exploited by an organism does not belong to its environment, though it may belong to another's. This will be crucial when we consider how digital environments are designed to make some informational structures visible and others invisible, thereby shaping not only what can be done but what can even be encountered.

In sum, Somenzi's materialist theory of information and the structural/descriptive distinction make it possible to assert, without contradiction, that:

- information is a structural property of material systems;
- environments are configurations of such structural information;
- organisms are themselves informational structures embedded in informational environments.

The organism-environment relation is thus not a relation between a physical body and an abstract informational layer, nor between raw matter and internal representations. It is a relation between structurally informative systems at different scales, coupled so that certain differences become salient and actionable. In the next section, I turn more directly to Somenzi's confrontation with Wiener and to subsequent elaborations of structural information, in order to ground this reconceptualization of environment and prepare the transition to classic ecological notions such as *Umwelt*, affordances, and behavioral environments.

4. *Somenzi and the materiality of information*

The materialist turn outlined above is not an abstract philosophical gesture but the result of a concrete attempt to rethink information at the intersection of physics, biology, and epistemology. Vittorio Somenzi's work is exemplary in this regard. Writing in dialogue with cybernetics and early information theory, Somenzi confronts the ambiguous Wienerian slogan I have traced through the preceding sections and turns it into the basis for a theory of information as a structural property of matter (Somenzi, 1972).

In what follows, I develop three aspects of Somenzi's contribution that are central to this article: (1) his re-interpretation of Wiener and his critique of both immaterialist and reductive views of information; (2) his account of structural information in biological and cognitive systems, including self-representation; and (3) his dissolution of the subject/object split that underlies many theories of environment, which opens the way to reconceiving environments as informational systems.

4.1 *Rereading Wiener: against dualism, beyond reduction*

As Hayles shows, Wiener's aphorism has often been taken to license treating information as a third ontological kind – neither physical nor mental but somehow more fundamental (Wiener, 1948; Hayles, 1999). For Somenzi, this is a misreading. The slogan correctly signals that information cannot be identified with scalar physical quantities such as mass or energy; but it does not imply that information is non-physical. Instead, it means that physical reality has *structural* dimensions irreducible to traditional physical magnitudes.

In his 1972 paper, Somenzi offers a systematic articulation of the positions I sketched in Section 2.2. He distinguishes three options:

1. Reductive physicalism: information is 'nothing but' energy, entropy, or other physical magnitudes – essentially shorthand for statistical mechanics.
2. Ontological dualism: information is a distinct substance or realm with causal efficacy, neither matter nor energy.
3. Structural materialism: information is a property of how matter-energy is organized – a functional, structural feature entirely dependent on material substrate yet irreducible to scalar quantities.

The first two correspond to the poles I identified as epistemological obstacles; the third is Somenzi's alternative.

Somenzi's alternative is to treat information as *form* in a robust, Aristotelian-physical sense: not a ghostly essence but the organization of material components enabling specific operations (Somenzi, 1972). A neural configuration, a gene-regulatory network, or a digital circuit possesses information because its structure constrains how it can evolve and interact. The same matter-energy, differently structured, would be informationally different. This reread preserves the cybernetic insight that information

concerns control, regulation, and feedback, while avoiding disembodied patternism. Information is neither ethereal code nor mere microphysical description: it is the organization that allows differences to make a difference (Bateson, 1972).

Environmentally, this means that an environment's 'informational' character does not lie in an extra symbolic layer added to a physical base, but in how that base is structurally organized – how gradients, surfaces, rhythms, and distributions afford or inhibit perception, action, and coupling.

4.2 *Structural information and self-representation*

A second key move in Somenzi's framework is to apply the structural/descriptive distinction introduced in Section 3.2 to cognitive and representational capacities. Rather than treating these as signs of a separate mental substance, Somenzi sees them as special cases of structural information.

Applying the structural/descriptive distinction within the nervous system, Somenzi argues:

- Neural circuits have structural information – patterns of connections, weights, dynamics – that enable specific transformations.
- When these transformations track or control aspects of the world or the body, the resulting states carry descriptive information about those aspects.
- Descriptive information is itself structurally realized: a representation is a physical configuration whose functional role is to stand in for, or model, another configuration.

This avoids treating representations as mysterious inner entities: to say a neural pattern 'represents' something is simply to note a stable mapping that guides behavior. The representation is not a picture in the head but organized matter in a control loop.

It also resists a strict divide between 'mere' physical structure and 'genuine' informational structure. A configuration becomes informational when its differences make systematic differences to a system's behavior relative to some task or norm.

This has direct implications for environment-as-information. If organisms are informational structures that build descriptive information, then environments are not external domains waiting to be internally mirrored; they are the relational counterpart of these capacities. Organismic and environmental structural information jointly determine what can be perceived, acted upon, and learned. *Umwelt* and behavioral environments are thus specific couplings, not subjective overlays.

Self-representation follows the same logic. No immaterial self is needed to 'read' the brain's information: neural structures can track and modulate other neural structures, generating loops of descriptive information about their own states. Consciousness, on this account, is not an extra informational ingredient but a regime of self-modeling and global integration supported by structural

information. Whether or not one accepts this view of consciousness, the principle is crucial: informational organization is recursively applicable within and across systems – and environments themselves often contain structures that carry information about their own states (e.g., regulatory mechanisms, feedback loops, digital analytics).

4.3 *Beyond subject and object: environments as informational systems*

Once information is understood as structural and representation as a special case of structural coupling, the traditional subject/object divide becomes easier to question – not because it vanishes entirely, but because it can be reframed as a difference of organization within a shared informational reality rather than a metaphysical chasm.

Instead of a linear sequence – environment → senses → internal model – we have a bidirectional coupling between two informational structures:

- The environment carries structural information (spatial, temporal, chemical, social patterns).
- The organism carries structural information (sensorimotor and neural organization).
- Through interaction, some environmental patterns become information *for* the organism because of how the organism is structured.

'Environment' thus names the subset of structural information in the world that is functionally coupled to an organism at a given time.

This aligns neatly with ecological and enactivist views. Gibson's affordances can be recast as informational relations between environmental and organismic structures: a surface affords walking if its properties (friction, rigidity, slope) can function as information for an organism's motor system (Gibson, 1979). Uexküll's *Umwelt* describes how species carve out different informational worlds from the same surroundings (von Uexküll, 2010).

Somenzi's materialism gives these ideas explicit ontological grounding: the same physical world supports multiple *Umwelten* because it contains rich structural information that different organisms couple to differently; and affordances are relational informational properties, grounded in both organism and environment.

This layered picture also situates digital environments without granting them quasi-virtual special status. A social-media platform is an informational system whose structural organization – code, databases, ranking functions – constitutes an environment for users because it shapes the ensemble of information available to them. At the same time, the platform is embedded in further informational environments (electrical, logistical, economic, legal). All of these layers are materially instantiated informational structures.

From a Somenzian perspective, shifting from 'physical' to 'digital' environment is not a move from material to immaterial, but from one kind of structural organization to another. A mountain path and a recommendation algorithm differ in substance and timescale, but both are environments insofar

as they are ensembles of structural information that can function as information for some agent.

To summarise Somenzi's contribution:

- Information is a structural, functional property of material systems, not an immaterial substance.
- Organisms and environments are informational systems, coupled such that some structural features of the world become information for the organism.
- Representations are higher-order informational structures built within these couplings.

With these elements in place, we can now reinterpret classical ecological and psychological notions – *Umwelt*, affordances, behavioral environments – in explicitly informational terms. This will clarify what it means to treat an environment as the systemic ensemble of information available to an organism at a given moment, across both biological and digital domains.

5. *Features and forms of environment as information*

I have referred throughout to three classic notions – von Uexküll's Umwelt, Gibson's affordances, and Koffka's behavioral environment – as anticipations of the 'environment as information' perspective I am developing. It is now time to examine these notions systematically and show how they can be reinterpreted within the materialist framework elaborated in Sections 3 and 4.

Seen through Somenzi's lens, environments are informational fields: ensembles of structural information selectively coupled to organisms with particular bodies, histories, and norms. At the same time, these notions help specify how information can be present in an environment (as structural organization) yet available or unavailable to different organisms, thereby introducing *concealment* alongside *affordance*.

5.1 *Umwelt: species-specific informational worlds*

Von Uexküll's concept of *Umwelt* is a clear attempt to break with the idea of a single, homogeneous environment shared by all organisms. Against an ostensibly objective *Umgebung* (surroundings), he insists that each species inhabits its own *Umwelt*: a 'self-world' composed of meaningful cues and action possibilities specific to its bodily organization (von Uexküll, 2010).

The tick example makes this vivid. Physically, the tick's surroundings are rich in light, color, texture, sound, and molecular complexity. Functionally, its *Umwelt* is reduced to three 'marks': the smell of butyric acid, the warmth of mammalian blood, and the tactile sensation of a hairless spot (von Uexküll, 2010). Everything else in the physical surroundings is, for the tick, 'worldless'.

In the present framework, we can restate this as follows. The wider world contains immense structural information: gradients, surfaces, fields, patterns of matter and energy. The tick's body and nervous system have their own structural information, organized so that certain worldly differences can

modulate its states and actions. The tick's Umwelt is the ensemble of structural features of the world that are *available as information for it*, given its structural organization.

This does not reduce Umwelt to a merely 'subjective' construct. Butyric acid, heat gradients, and skin textures are objectively existing structures. What is species-specific is which of these features are coupled to the tick's informational organization and thus can play a functional role in its behavior. The same forest also supports the *Umwelten* of deer, bacteria, and humans, each picking out different subsets of available structural information.

Uexküll stresses that *Umwelten* are lawful, biologically anchored constructions. The 'keys' organisms use to unlock their environments are evolved sensorimotor patterns; the 'locks' are objective features of the surroundings (von Uexküll, 2010). From Somenzi's standpoint, *Umwelten* are relational informational systems: they exist in virtue of specific couplings between the structural information of organisms and that of their surroundings.

Two consequences for our hypothesis follow:

1. There is no need to choose between a single 'objective' environment and many 'subjective' ones. There is one materially structured world that supports multiple, overlapping informational environments, depending on which structures are available as information for which organisms.
2. Defining environments as ensembles of information is not a claim about internal representations but about which parts of the world's structural information are functionally coupled to which organisms. *Umwelt* is Uexküll's name for one such coupling.

5.2 *Affordances, behavioral environments, and concealments*

If *Umwelt* foregrounds the species-specificity of informational environments, Gibson's affordances foreground the action-relevance of environmental information. For Gibson, to perceive is to pick up information about what the environment affords – what it makes possible or impossible – for a given organism (Gibson, 1979). Affordances are neither in the head nor in a purely geometrical world; they are relational properties: a surface affords walking for an animal with certain limbs, but not for an ant or a whale.

Gibson's ecological optics already comes close to environment as information. He defines information in terms of structured energy arrays – patterns of light, sound, etc. – that lawfully specify environmental layouts and events (Gibson, 1979). The optic array carries information about surfaces, distance, motion, texture, directly available to an appropriately organized visual system.

In Somenzian terms:

- The environment has structural information in surfaces, textures, and dynamical relations.

- These structures generate informational invariants in ambient energy (e.g. light patterns).
- An organism with the right structural organization can couple to these invariants, so that some environmental structure becomes available as information for it.
- Affordances are relational informational structures connecting environmental features to possible actions, given morphology and skills.

An affordance is thus neither a mere subjective 'interpretation' nor a purely objective property. It is a relational informational property: a way environmental structural information is poised to modulate organismic structure in a behaviorally relevant way.

Koffka's distinction between geographical and behavioral environments fits neatly here (Koffka, 1935). The geographical environment is the world as described by physics and geography; the behavioral environment is the world as it functions in experience and behavior. From the standpoint of environment-as-information, the geographical environment corresponds to the total structural information of a region of the world, while the behavioral environment is the subset actually available and functionally active for a given organism. Gibson's affordances describe how this subset is carved out, by matching environmental structures with organismic ones.

Crucially, this coupling is always partial. For any organism, there is more structural information in the world than can be taken up as information-for-it. Here the notion of *concealment* becomes indispensable. If affordances are the 'positive' face of environment-as-information – what the environment offers to do – concealments are the 'negative' face: what the environment withholds or renders unavailable as information. Concealment can be understood at several levels:

- *Bodily and sensory limits*. A flower's ultraviolet patterns are structural information available to bees but concealed from human vision. The information is there structurally, but not available for us.
- *Developmental and cognitive limits*. A city's street network affords routes for an experienced inhabitant that remain effectively concealed for a tourist. The same structural information is differentially available due to learned organization (schemas, habits, skills).
- *Intentional design*. Built environments often engineer concealments: 'defensive' architecture that hides resting spots; malls that conceal exits and clocks. Here structural information is arranged so that certain possibilities remain hard to detect from typical vantage points.

In each case, concealment is not absence but a relation of non-availability between existing structural information and a particular organismic structure. Where affordances mark intersections between environmental and organismic information – what can be done – concealments mark their disjunction – what is structurally there but cannot, in practice, become information-for that organism.

Umwelt, affordances, behavioral environments, and concealments together provide a concrete vocabulary for thinking of environments as informational fields. They flesh out the earlier definition: an environment is the systemic ensemble of structural information available to an organism at a given moment. Availability is always partial, relational, historically situated, and always accompanied by structural information that remains, for that organism, concealed.

Conclusion

Bringing environment and information together under a single materialist framework reveals that both concepts, long treated as either opposed or ambiguously overlapping, can be understood as mutually specifying aspects of one and the same reality. If organisms and environments are informational systems – each defined by the structural configurations that make differences matter – then the classical divides between subject and object, digital and physical, representation and world lose much of their force. What emerges instead is a layered ontology in which structural information forms the backbone of ecological, cognitive, and technological relations, while descriptive information provides higher-order ways of tracking, modeling, and transforming these structures. Reinterpreting *Umwelt*, affordances, behavioral environments, and concealments through this lens shows that organisms inhabit worlds that are at once materially grounded and informationally articulated, each shaped by specific couplings between bodily organization and environmental structure. In biological and digital contexts alike, environments become the dynamic ensembles of structural information available to an organism at a given moment – partial, situated, and historically contingent. By integrating Somenzi's theory with the insights of Uexküll, Gibson, Koffka, Floridi, and Hayles, we gain a conceptual toolkit for understanding contemporary informational ecologies without sliding into immaterialism or reductive physicalism. The framework developed here does not claim to resolve all tensions between materialist and informational approaches; rather, it offers a synthesis that draws on resources from both traditions. By grounding informational concepts in Somenzi's structural materialism and showing their continuity with ecological and enactivist insights, I hope to have contributed to an ongoing conversation rather than closed it. Future research might investigate more precisely how structural information is distributed, concealed, and made actionable across diverse environments (i.e. biological, social, and digital) and how organisms, including humans, continue to evolve within these informational worlds.

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ABSTRACT
This article argues that contemporary debates in biology, cognitive science, and philosophy of technology cannot clarify the concept of 'environment' without rethinking what we mean by 'information'. Drawing on Vittorio Somenzi's materialism, information is treated as a structural property of matter: modes of organization through which differences become functionally salient and causally efficacious. By distinguishing between structural information (in a system) and descriptive information (about a system), environments are defined as the systemic ensemble of structural information available to an organism at a given moment. A rereading of von Uexküll's Umwelt, Gibson's affordances, and Koffka's behavioral environment leads to the notion of concealment and shows how this framework lets us conceive physical and digital environments within a single informational ontology.

KEYWORDS
Environment; Information; Vittorio Somenzi; Umwelt; Affordances; Digital environments

SOMMARIO
L'ambiente come informazione. L'articolo sostiene che i dibattiti contemporanei in biologia, scienze cognitive e filosofia della tecnologia non possono chiarire il concetto di 'ambiente' senza ripensare quello di 'informazione'. Ispirandosi al materialismo di Vittorio Somenzi, l'informazione è intesa come proprietà strutturale della materia: modi di organizzazione grazie a cui le differenze diventano funzionalmente salienti e causalmente efficaci. Distinguendo tra informazione strutturale (in un sistema) e informazione descrittiva (su un sistema), gli ambienti vengono definiti come l'insieme sistemico dell'informazione strutturale disponibile a un organismo in un dato momento. Una rilettura di 'Umwelt' (von Uexküll), 'affordance' (Gibson) e 'ambiente comportamentale' (Koffka) porta a introdurre il concetto di *concealment* e a mostrare come questo quadro consenta di pensare ambienti fisici e digitali entro un'unica ontologia informazionale.

PAROLE CHIAVE
Ambiente; Informazione; Vittorio Somenzi; Umwelt; Affordance; Ambienti digitali