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From Noise Cometh Signal

Preserved Contrast and the Physical Grounding of RRP

Abstract

Signal is not by itself RRP-indexed information.

A signal is not a metaphysical content, a semantic message, an intrinsic unit of matter, or a free-floating difference waiting to be read. It is physical variation preserved as contrast through a medium under conditions in which discrimination may become possible.

A signal does not establish operational information for a locus merely because it travels, persists, can be described, or can be interpreted after the fact. It becomes informational for that locus only where the contrast it carries becomes available as distinction under specified reference conditions.

The preceding paper established the reference architecture of operational information for a locus. Within that architecture, information for a locus is physical difference made relationally available as operational distinction. This is a scoped definition. It does not deny thermodynamic, statistical, physical, Shannon, or other legitimate informational descriptions beyond the evaluated access relation. A finite locus does not possess reality as total state. It encounters reality only through relations by which difference becomes available, classed, registered, retained, and possibly redeployed. The Relative Reference Point fixes the locus-interface-regime position from which distinction evaluation becomes well-posed. OP supplies available contrast. OA classes that contrast. OR selects one classed alternative into state. RAS retains the registered distinction. RSD redeploys retained distinction into later branch-realisation.

That architecture is necessary. It is not yet the whole physical pathway.

Before a difference can become available as distinction for a locus, physical interaction must first produce variation. Energy is redistributed, dissipated, stored, released, transformed, constrained, or channelled through matter and field relations. These interactions generate uneven physical variation: gradients, residues, pressure differences, charge distributions, molecular conformations, thermal asymmetries, phase shifts, boundary marks, and altered state trajectories.

At this level, operational information for the evaluated locus has not yet been established. The relevant condition is lawful physical state evolution.

The signal paper therefore begins below signal. It asks how physical interaction produces variation, how variation becomes preserved contrast, how contrast is carried through media, how contrast survives or fails through signal paths, how channel-relative discriminability becomes possible, and how such discriminable contrast may enter the RRP Set as available distinction.

RRP defines the relational condition under which difference can count as operational information for a locus. Signal defines the physical condition under which difference can become available to that relation.

This distinction is the governing frame of the paper.

Signal is the physical pathway by which relational access becomes possible. A finite locus does not encounter raw totality. It encounters physically mediated relation. Signal is the preservation of contrast through which such relation can become available. A signal path does not carry the world whole. It carries selected contrast under material, energetic, thermodynamic, channel, noise, threshold, and medium constraints.

The paper locates this pathway within the inherited physical ladder. Trivial Computation names lawful state evolution redescribable under an encoding. Thermodynamic State Space describes stable macrostate variation under boundary conditions. Thermodynamic information anchors the cost, stability, maintenance, manipulation, discrimination, and erasure of distinguishable states. Shannon Information Theory applies more narrowly where channel, alphabet, noise model, coding regime, and receiver or locus discrimination capacity are specified. These remain legitimate informational regimes under their own conditions. RRP-indexed operational information for a locus is established where channel-discriminable or otherwise physically available contrast becomes available as distinction for that locus.

The paper blocks two errors.

First, it rejects signal inflation. Not all physical variation is signal. Variation becomes signal-bearing only where contrast is preserved through a medium under possible discrimination conditions.

Second, it rejects RRP-status inflation. Not all signal establishes operational information for the locus under evaluation. Signal-bearing contrast becomes informational for that locus only where it becomes available as distinction under RRP conditions.

The central sequence is:

Interaction produces physical variation.

Physical variation may become signal-bearing where contrast is preserved through a medium under possible discrimination conditions.

Signal-bearing contrast may become channel-discriminable where channel, alphabet, noise, and receiver or locus conditions are satisfied.

Channel-discriminable contrast may become RRP-indexed information where it is available as distinction for a locus.

Available distinction becomes OP.

OP becomes registerable through OA.

OA-classed OP becomes OR when one alternative is selected into state.

OR becomes RAS when retained over the operational horizon.

RAS becomes recursively powerful through RSD.

RSD becomes NTC where retained or operative distinction alters downstream trajectory selection under comparator discipline.

Life becomes possible only where such NTC supports persistent driven thermodynamic constraint-maintenance.

This paper does not redefine RRP, OP, OA, OR, RAS, RSD, TC, NTC, BD, IPL, or life. It inherits them. Its task is narrower: to ground the physical pathway from dissipative variation to signal, from signal to channel-relative distinction, and from channel-relative distinction to RRP-indexed informational availability.

With the physical pathway into RRP now grounded, the sequence can proceed in two linked directions. One direction makes the realism-facing consequence explicit: finite access is not possession of total reality, but indexed relation under constraint. That is the task of the reference-indexed realism paper. The other direction asks what status available distinction has when it persists as present accessible state.

That is the question of knowledge.

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1. Why RRP requires a Signal layer

1.1. The problem after RRP

Relative Reference Points establishes the reference architecture of operational information for a locus.

A physical difference does not by itself establish information for the evaluated locus. It becomes informational for that locus where it is available as distinction under reference conditions that make availability, classing, registration, retention, and possible redeployment well-posed. This prevents operational informational status from being attributed to every physical state merely because it exists or can be described. It also prevents the status from becoming whatever an external observer chooses to impose.

The distinction should remain precise. A physical variation or signal may already fall under a legitimate thermodynamic, statistical, physical, or Shannon informational description. What has not yet been established is its operational availability as distinction for the locus under evaluation.

That correction is essential.

It leaves a further problem.

If information for a locus is physical difference made relationally available as operational distinction, then the next question is how a physical difference survives, travels, transforms, stabilises, or becomes discriminable enough to become available at all.

A finite locus does not encounter raw totality. It encounters reality through boundary, interface, channel, threshold, scale, discrimination regime, abstraction, registration pathway, retention condition, and possible redeployment. This is not a denial of reality. It is the condition under which finite access becomes possible.

But relational access is not automatic.

A difference may exist and never reach a relevant interface. A contrast may be produced and immediately dissipate. A persistent physical alteration may remain outside the operative scale. A pressure variation may be masked by noise. A molecular difference may not fit the receptor architecture. A voltage fluctuation may fall within tolerance bands and never become a circuit alternative. A mark may persist but remain unreadable to the locus under evaluation.

The signal problem appears at this point.

RRP tells us for what locus, through what interface, at what scale, over what horizon, and under what regime a difference may become operationally informational. Signal explains how physical contrast can reach that condition at all.

RRP gives the reference condition of operational information for a locus.

Signal gives the physical pathway of possible availability.

Without RRP, signal becomes too easy to over-read as operational information for a locus. Every propagating contrast becomes informational for a locus merely because it could be described. Without signal, RRP risks appearing too abstract, as if difference simply becomes available without physical cost, channel, medium, threshold, stability, or noise.

This paper closes that gap.

It does not replace the RRP Set. It grounds the physical entrance into it.

1.2. Signal is not the primitive

The paper does not begin with signal as a given.

Signal is already a selective term. To call something a signal is to say that some physical variation has been preserved as contrast in a way that can matter for discrimination. That is already more than ordinary physical change.

The primitive is interaction.

Physical systems interact. They exchange, absorb, scatter, transform, transmit, constrain, dissipate, redirect, store, release, or redistribute energy and matter. These interactions alter state. A surface warms. A molecule changes conformation. A pressure wave propagates. A photon is absorbed. A charge distribution shifts. A chemical gradient forms. A boundary is marked. A phase relation changes. A residue remains. A path becomes more or less available than another.

None of this yet establishes operational information for the evaluated locus.

It requires lawful physical state evolution.

At the broadest level, such evolution may be computationally redescribed. That is the domain of Trivial Computation. TC preserves the insight that lawful physical trajectories may be encoded, represented, or modelled computationally. But TC does not show that the system itself distinguishes, registers, retains, or applies informational alternatives.

This distinction is decisive.

If every interaction is called signal, every signal is treated as operational information for a locus, and every process described as information-bearing is called computation, then the discriminator collapses. Every collision, relaxation, diffusion, decay, gradient, vibration, current, mark, residue, and lawful transition is redescribed as information processing by vocabulary alone.

The paper therefore separates the levels.

Interaction produces variation.

Variation may become signal-bearing where contrast is preserved.

Signal-bearing contrast may become channel-discriminable.

Channel-discriminable contrast may become available distinction.

Available distinction may become registered.

Registered distinction may become retained.

Retained distinction may become redeployed.

Redeployed distinction may become non-trivially computational.

Only the relevant status should be claimed.

Signal sits between raw physical variation and RRP-indexed operational information for a locus. It is more structured than undifferentiated state change because contrast must be preserved. Signal status alone is weaker than established RRP-indexed information because availability for the evaluated locus has not yet been shown. It is weaker than RAS because no retained registration has yet been demonstrated. It is weaker than NTC because no comparator-stable downstream dependence has yet been established.

Signal is not the primitive.

It is the first disciplined form of preserved contrast.

1.3. The physical burden of availability

Availability is not free.

For a difference to become available as distinction, something must preserve contrast across an interval, boundary, medium, channel, or state transition. A difference must not simply vanish into undifferentiated relaxation. It must remain distinguishable enough, at the relevant scale and over the relevant horizon, to enter a possible discrimination regime.

This physical burden is often hidden by ordinary information-language.

A spoken word appears as meaning. But before meaning, there is breath, airflow, vocal control, air pressure variation, acoustic propagation, auditory coupling, cochlear transduction, neural patterning, memory, language training, and social convention.

A voltage state appears as a bit. But before the bit, there are voltage ranges, tolerances, circuit thresholds, noise margins, write pathways, read pathways, timing conditions, and stabilised code states.

A chemical signal appears as a message. But before the message, there are molecular gradients, receptor affinities, binding probabilities, conformational transitions, pathway thresholds, and downstream regulatory couplings.

A measurement appears as a number. But before the number, there is physical coupling, instrument design, calibration, scale, sensor range, noise tolerance, sampling, readout, inscription, and retention.

The paper therefore treats availability as a physical achievement.

A contrast must be supported. It must be carried. It must be discriminable. It must survive the noise regime. It must be classable. It must be registerable. Where retention is claimed, it must persist. Where redeployment is claimed, it must remain accessible to later transition.

This does not make operational information for a locus subjective. It makes informational attribution physically answerable.

A difference may exist and fail to become available.

A signal may propagate and fail to become operational information for the evaluated locus.

A registration may occur and fail to persist.

A retained state may exist and fail to be redeployed.

A redeployed state may alter transition but fail to do so in a comparator-stable way.

The signal layer makes these failures visible.

1.4. Signal as physical mediation of relation

The new framing of the series can be stated as an access principle:

A finite locus does not possess reality as total state. It encounters reality through relation.

Paper 1 established this principle at the level of informational architecture. Paper 1a grounds it physically.

For a relation to become available to a locus, there must be some physical mediation. A difference must be carried, preserved, transformed, filtered, amplified, attenuated, or stabilised through a medium. The relation must reach the locus as contrast, or persist in a physical state from which a later pathway can carry contrast.

Signal is this physical mediation of possible relation.

A signal is not reality itself. It is not the total source condition. It is not the whole carrier. It is not the entire event. It is preserved contrast in a physical pathway. It allows some relation to survive where total state cannot be carried.

A photograph does not carry the event. It preserves light-mediated contrast through lens, sensor, exposure, surface, and processing. A thermometer does not carry the full thermal state. It preserves a relation between thermal regime and instrument state under calibrated conditions. A receptor does not carry the whole molecular environment. It preserves a binding-relevant distinction through conformational and pathway change. A digital channel does not carry total physical state. It preserves selected alternatives under coding and noise constraints.

The signal path therefore embodies the same principle that later becomes central to observation: the locus does not receive the whole. It receives what the relation can carry.

This aggregate limit can be called the Locus Event Horizon.

The term does not name an edge of reality. It names the ingress-boundary of relation for a finite locus under specified reference conditions. Beyond this horizon, a difference may be

real, consequential elsewhere, or theoretically reachable through another pathway, but it cannot become signal-bearing contrast capable of entering OP for this locus under the present regime.

The Locus Event Horizon is not one simple boundary. It is a multidimensional access profile formed by the combined limits of distance, latency, medium, coupling, channel, threshold, scale, noise, filter, abstraction, and interface. A receptor, instrument, relay, model, institution, or technical channel may extend or reshape the horizon, but only by altering the physical route through which contrast can become available. The horizon is therefore not fixed once for all loci. It is locus-relative, regime-relative, channel-relative, and scale-relative.[1]

This keeps the term disciplined. What lies beyond the horizon is not unreal and need not be non-informational under every other legitimate description. It is unavailable to this locus as incoming relation under the present regime. What crosses the horizon is not yet RRP-indexed information for the locus. It is difference or signal-bearing contrast capable of entering the pathway by which OP may appear.

This use should remain signal-layer specific. The Locus Event Horizon names the ingress-boundary of possible relation before OP is established for the locus. Later observation papers may call the inherited limit the Observer Event Horizon where the evaluated locus is an observer-locus or Observer, but the concept remains the same kind of limit: not an edge of reality, not an epistemic excuse, and not a measure of program performance. It names the boundary at which difference can or cannot enter the access pathway as signal-bearing contrast.

Signal is not a defect because it reduces. It is useful because it reduces. It permits selected contrast to travel across medium, distance, substrate, transformation, delay, and scale without requiring total physical possession.

But this selectivity has a cost.

What is not preserved may later matter. What is compressed may later distort. What is filtered may later become uncertainty. What is treated as noise under one regime may become signal under another. What survives a channel may be too weak, too late, too ambiguous, too degraded, or too mis-scaled to become OP for the locus in question.

Signal therefore prepares both informational availability and informational failure.

1.5. The purpose of this paper

The purpose of this paper is to ground relational access in the physical pathway from interaction to dissipative variation, from variation to signal-bearing contrast, from signal-bearing contrast to channel-relative discriminability, and from discriminability to RRP-indexed information.

The paper has four controlling aims.

First, it locates physical variation below established RRP-indexed informational availability. Lawful interaction and energy dissipation produce uneven states, but unevenness alone does not establish operational information for a locus.

Second, it places signal between physical variation and RRP-indexed distinction. Signal is variation preserved as contrast through a medium under possible discrimination conditions.

Third, it places Shannon Information Theory where it belongs: not as a complete theory of all information, but as the formal discipline of channel-relative uncertainty, coding, noise, symbols, bits, and transmission.

Fourth, it prepares the later concepts of knowledge, intelligence, and observation. Knowledge requires retained distinction. Intelligence requires applied distinction. Observation requires bounded registration. Each presupposes that distinction can first become physically available, discriminable, classable, registerable, and retainable.

The paper therefore does not introduce a new primitive into the series. It supplies the missing pathway between the physical generation of variation and the operational architecture of informational distinction.

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2. Interaction, dissipation, and TC-level variation

2.1. Interaction produces uneven physical variation

Physical interaction is difference-making.

When systems interact, their states are altered. Energy may be exchanged, dissipated, stored, released, redirected, scattered, absorbed, transformed, or constrained. Matter may be rearranged. Boundaries may be modified. Gradients may form. Constraints may be imposed or relaxed. Some trajectories become more available; others become less available.

These changes do not need to be complex to matter for the present argument.

A heated surface, a pressure wave, a charge displacement, a molecular binding event, a concentration gradient, a catalytic residue, a crystallisation front, a phase transition, a deformation mark, or a boundary perturbation is already an uneven physical result of interaction.

The point is not that every such result is operationally informational for a specified locus.

The point is that signal cannot arise without physical variation capable of supporting contrast.

Interaction supplies the pre-signal field. It generates differences in state. Some are transient. Some persist. Some remain local. Some propagate. Some are amplified. Some are dissipated into noise. Some become stabilised by boundary conditions. Some later become available to a locus as contrast.

At this level, the paper is concerned with physical and thermodynamic variation before RRP-indexed informational availability for a locus has been established.

A physical residue is not yet a message.

A gradient is not yet a signal.

A mark is not yet a record.

A transition is not yet computation in the non-trivial sense.

These are physical differences produced by lawful interaction. Some may later become signal-bearing. Some may later become OP. Some may later be registered, retained, and redeployed. But those later statuses must be earned.

2.2. Dissipation does not by itself establish operational information

Dissipation is central to the pathway, but it must not be overinterpreted.

Dissipation spreads, degrades, redistributes, or transforms energy under physical constraints. It may produce thermal gradients, chemical gradients, pressure differences, flow structures, state transitions, residues, local asymmetries, and altered boundary conditions. These may later become signal-bearing. But dissipation does not automatically produce information for a locus.

A hot object cooling in a room produces physical variation. Thermal energy flows. Gradients change. Air currents may form. Surfaces expand or contract. Molecules alter their kinetic distributions. An external physicist can describe these changes. A sufficiently sensitive instrument may register them. A biological organism may respond to them.

But until a locus-interface-regime relation makes some variation available as distinguishable contrast, the dissipative process remains physical state evolution, not RRP-indexed information for the evaluated locus.

The same point applies across chemical, mechanical, electromagnetic, and biological contexts. A molecule may collide with another molecule. A pressure fluctuation may propagate through fluid. A photon may strike a surface. A membrane may deform. A charged particle may alter a local field. A reaction product may accumulate.

Each event changes the physical situation.

Each may be describable.

Each may leave a persistent physical alteration.

But describability is not enough.

Dissipation makes variation.

Variation may support contrast.

Contrast may support signal.

Signal may support RRP-indexed informational availability.

Available distinction may support registration.

Registration may support retention.

Retention may support recursion.

The sequence matters because each stage adds a discriminator.

2.3. TC as lawful state evolution

Trivial Computation is the correct first computational placement for dissipative interaction.

A physical system evolves lawfully. An observer may encode states and transitions. Under such an encoding, the state sequence can be represented computationally. This is legitimate, but weak. It does not establish that the system itself distinguishes, registers, retains, or applies informational alternatives.

TC therefore protects two insights.

The first is permissive: physical evolution can often be redescribed computationally.

The second is restrictive: such redescription does not by itself show physically enacted information processing.

This distinction is necessary because signal-language can easily smuggle non-triviality into ordinary physical evolution. Once a pressure wave, voltage fluctuation, molecular gradient, or surface mark is called a signal, it becomes tempting to treat it as already operationally informational for the target locus. Once that status is assumed, it becomes tempting to treat the system as already computing in the stronger sense.

That move must be blocked.

In TC, a trajectory may carry physical differences without those differences being operative distinctions for the system. A downstream state may differ because lawful dynamics carried it there, not because an internal organisation selected an outcome conditional on a registered distinction. A physical alteration may persist because material conditions preserve it, not because it is retained as an OA-keyed token-state. A gradient may guide a later reaction by ordinary physical constraint, not because it has been abstracted, registered, and redeployed.

The relevant transition is from lawful state evolution to physically enacted discrimination.

That transition is not produced by naming. It is produced only where the organisation of the system makes downstream trajectory classes depend counterfactually on discriminable distinctions under specified reference conditions.

Signal belongs between these positions.

It is more structured than undifferentiated state change, because it requires preserved contrast.

It is weaker than NTC, because preserved contrast need not yet alter downstream trajectory selection through organisation-dependent, comparator-stable discrimination.

2.4. Persistence and propagation are not informational stages

Physical interaction may produce states that are transient or persistent, local or propagating. These are properties of physical evolution, not independent informational statuses. A persistent mark, gradient, sequence, deformation, residue, or altered state may preserve dependence on an earlier interaction. Conversely, physical variation may propagate and disappear without leaving a durable remainder.

Persistence alone does not establish signal. Signal begins where physical variation is preserved as contrast through a medium under possible discrimination conditions. A persistent state may later supply contrast to a signal path, while a transient pressure wave, photon, molecular cue, or voltage pulse may carry signal without leaving a durable physical remainder.

Nor does persistence establish OP, registration, or RAS. OP begins only where contrast becomes available at an interface for a locus under specified reference conditions. Registration requires selection through OR. RAS requires the resulting distinction to be retained over the relevant operational horizon.

The physical properties and the relational statuses must therefore remain separate. Interaction produces variation. Variation may persist locally or propagate. Signal begins where contrast is preserved. RRP-indexed information begins where that contrast becomes available as distinction for a locus.

3. The NMF informational ladder

3.1. Why the NMF ladder is needed here

The signal paper requires the Nested Multiscale Framework because signal sits between physical variation and RRP-indexed informational availability.

If the paper begins directly from Shannon Information Theory, it risks narrowing information too quickly to messages, channels, alphabets, symbols, and bits. That would make signal technically sharp, but it would not fully ground the broader physical emergence of distinction.

If the paper begins directly from RRP, it risks treating availability as if it appeared without the thermodynamic and channel constraints required to support it.

If the paper begins directly from physical difference, it risks inflating every variation into operational information for a locus.

The NMF ladder prevents all three errors.

It allows the paper to move from physical admissibility to thermodynamic macrostate description, from thermodynamic distinction to physically costly state discrimination, from channel-relative discriminability to RRP-indexed information for a locus, and from RRP-indexed information to NTC.

The ladder does not add new ontology. It adds disciplined descriptive regimes. Each layer becomes valid only where its variables, constraints, and distinctions remain stable under the relevant boundary, scale, horizon, and noise conditions.

This is why the paper must not say simply that every physical distinction is already operational information for every locus.

That formulation is too compressed.

A physical distinction becomes operationally informational for a specified locus only through the physical, thermodynamic, signal-theoretic, and relational conditions required by the evaluated access path.

3.2. From KMB and BC to TSS

The Kinematic Microstate Baseline names the underlying physical admissibility of state evolution. It is not the level at which signal, RRP-indexed operational information, or meaning have yet been established. It supplies the lawful background from which all higher descriptions must remain physically admissible.

Boundary Conditions then delimit the system-environment relation. They determine which exchanges, constraints, flows, interactions, and state variables become relevant to a regime. Without boundary conditions, there is no controlled domain in which thermodynamic or informational description can be stabilised.

Thermodynamic State Space appears where macrostate variables become stable and predictive at the reference scale. Temperature, pressure, density, chemical potential, entropy, free energy, volume, and related variables do not capture total microstate. They are

compressed macrodescriptions. They become useful where coarse-grained relations remain stable under boundary conditions.

This matters for signal because signal does not arise from undifferentiated microphysical totality. It arises where some physical variation can be treated as a contrast at a scale and through a medium.

TSS therefore supplies the first disciplined level above raw physical variation.

A gradient can be described. A pressure difference can be tracked. A concentration field can be stabilised. A thermal asymmetry can persist. A chemical potential can drive transition. These are not yet messages or bits. They are thermodynamic differences within a structured regime.

The signal paper treats TSS-level variation as prior to established RRP-indexed availability, but signal-capable.

3.3. Thermodynamic information as anti-floating discipline

Thermodynamic information supplies the next necessary control.

A distinction cannot be maintained, manipulated, erased, stabilised, or made reliably discriminable without physical cost. The physical world does not supply free tokens. Distinguishable states require support. Their stability depends on barriers, energy landscapes, constraints, noise regimes, material organisation, and dissipation.

This matters because abstraction-language can make distinctions sound weightless.

A binary alternative may be written as 0 or 1 on a page, but a physical binary state must be stabilised against noise, drift, thermal fluctuation, degradation, and accidental transition. A molecular distinction must persist in a chemical regime. A memory distinction must maintain sufficient separation between states. A biological distinction must be robust enough to affect downstream pathway selection. A measurement distinction must survive instrument noise, calibration limits, and readout constraints.

Thermodynamic information anchors distinction in physical support.

It does not yet give the full RRP architecture. It does not by itself establish knowledge, intelligence, observation, or life. But it prevents distinction from floating above substrate.

Thermodynamic information is therefore informational within its own physically constrained regime. Its status does not depend on later entry into OP or later availability to a particular locus. What remains unestablished at this stage is the further RRP-indexed claim that some physically supported distinction is operationally available within the access relation under evaluation.

The relevant claim is not that thermodynamics already gives all information.

The claim is that any later informational distinction must be physically supportable. It must be embodied in a regime where state separation, persistence, manipulation, discrimination, maintenance, or erasure are constrained by thermodynamic conditions.

Signal inherits this burden.

A signal that cannot preserve contrast through a medium cannot become available distinction. A token that cannot be stabilised cannot carry a reliable state. A channel that cannot preserve separability cannot support Shannon-style communication. A retained state that cannot persist over the operational horizon cannot become RAS.

Thermodynamic discipline is therefore a lower physical constraint on every later operational informational claim.[2]

3.4. SIT as channel-relative discriminability

Shannon Information Theory enters at a narrower and more technical point.

SIT does not define all information in this framework. It defines a formal discipline for uncertainty, channel transmission, coding, noise, symbols, and discriminability under specified communication conditions.

This is why it is indispensable for signal, but insufficient for the whole architecture.

A Shannon-style analysis requires a source or set of possible alternatives, a coding regime, a channel, a noise model, and a receiver or discrimination capacity. Within that frame, information can be measured in relation to uncertainty reduction over possible messages or symbols. A bit is the unit associated with binary discriminability or uncertainty reduction under such a regime.

Within such a specified communication frame, Shannon information is already well-defined. RRP does not create or revoke that channel-relative informational status. It asks the further question of whether the carried contrast becomes operationally available as distinction for the particular locus and relation under evaluation.

This is a stricter condition than mere physical difference.

A voltage fluctuation is not a bit merely because it differs. A molecular state is not a symbol merely because it can vary. A sound is not a message merely because it propagates. A mark is not a code merely because it persists.

The system must support alternatives that are discriminable under the relevant channel and coding regime.

SIT therefore gives the paper a technical discipline for channel-relative signal and information without taking over the definition of operational information for a locus.[3]

The broader framework requires further questions.

For what locus is the contrast available? Through what interface? At what scale? Over what horizon? Under what abstraction regime? Has the contrast been registered? Has it been retained? Can it be redeployed? Does downstream trajectory selection depend on it under comparator pressure?

SIT sharpens signal, bit, coding, and transmission.

RRP determines operational informational availability for the evaluated locus.

NTC determines physically enacted downstream dependence.

These roles must remain separate.

3.5. From SIT to RRP-indexed information

Channel-relative discriminability is not yet RRP-indexed information.

A signal may be well-defined within a Shannon communication frame and still not be information for the locus under evaluation if the receiving relation is absent, the interface is

wrong, the scale is misfit, the abstraction regime does not class it, or the system cannot register the distinction.

Conversely, RRP-indexed information may occur in systems that are not best described as explicit message-passing systems. A molecular receptor, chemical threshold, developmental constraint, immune pathway, cell membrane, or material feedback loop may make physical differences available as operational distinctions without resembling a human communication system.

The bridge is this:

SIT describes discriminability across a channel.

RRP specifies when discriminable contrast becomes information for a locus.

Where signal-bearing contrast reaches an interface inside the Locus Event Horizon and becomes available as an alternative under reference conditions, OP appears. Where the operative abstraction regime classes that field, OA appears. Where one classed alternative is selected into state, OR appears. Where that selected state persists over the relevant operational horizon, RAS appears. Where it is redeployed into later branch-realisation, RSD appears.

This sequence locates Shannon-style signal discipline inside the broader RRP stack. It also prevents operational informational status from floating free of physical support. The difference must be physically generated, thermodynamically supportable, channel-discriminable where SIT is invoked, inside the relevant ingress horizon, and RRP-indexed before it becomes information for a locus.

3.6. From RRP-indexed information to NTC

RRP-indexed information is not yet NTC.

A difference may become available as distinction without altering downstream trajectory selection in the strong comparator-stable sense. A signal may be available but not registered. A distinction may be registered but not retained. A retained state may persist but remain unused. A retained state may be consulted but fail to make a counterfactual difference. A downstream difference may occur but fail under comparator discipline.

NTC requires more.

It requires physically enacted discrimination: downstream trajectory classes depend counterfactually on discriminable distinctions under specified reference boundary, reference scale, operational horizon, discrimination or noise regime, and comparator conditions.

The signal layer therefore prepares NTC but does not itself establish it.

This distinction is especially important for the life-genesis problem. Prebiotic chemistry may produce gradients, conformational states, catalytic residues, channel-forming structures, and other persistent or transient physical variations. Some may preserve contrast strongly enough to become signal-bearing. Some may become available as OP. Some may be registered into state. Some may persist. But life requires the stricter condition in which distinction-conditioned organisation supports persistent driven thermodynamic constraint-maintenance.

The present paper does not redefine that life condition. It prepares the pathway into it.

Signal is the physical preservation of contrast.

RRP-indexed information is available distinction.

RAS is retained registration.

RSD is redeployed retained distinction.

NTC is comparator-stable downstream dependence on distinction.

Life is driven thermodynamic constraint-maintenance supported by IPL-mediated NTC.

Keeping these steps separate is the paper's primary discipline.

3.7. Compressed inheritance

The working inheritance for the rest of the paper is therefore:

TC provides lawful physical evolution.

TSS provides stable thermodynamic macrostate variation.

Thermodynamic information provides the physical cost and stability discipline of distinguishable states.

SIT provides channel-relative signal, coding, noise, symbol, alphabet, and bit discipline.

RRP provides locus-relative informational availability.

OP provides the available contrast field.

OA provides classing.

OR provides registration.

RAS provides retained token-state.

RSD provides redeployment.

NTC provides physically enacted downstream dependence.

This ladder is not a rigid historical sequence in every case. Mature systems inherit prior structures. Biological, technical, cognitive, social, and institutional systems often stabilise many layers at once. A signal may be generated inside an already functioning code architecture. A retained state may alter later channel conditions. A prior RAS may shape later OP. A deployed distinction may change the very boundary conditions under which future signals arise.

But the dependency discipline remains.

No signal without physical contrast.

No Shannon signal without channel-relative discriminability.

No RRP-indexed information without availability for a locus.

No RAS without registration and retention.

No NTC without comparator-stable downstream dependence.

The next part begins from that controlled position and defines signal directly.

4. Signal and Signal path

4.1. Signal as preserved contrast

Signal is physical variation preserved as contrast through a medium under conditions in which discrimination may become possible.

This definition begins from physical process and stops short of established RRP-indexed information for a locus.

A signal is not yet knowledge, intelligence, observation, meaning, semantic content, or retained record. It is not a message merely because it travels. It does not establish operational information for a locus merely because it differs from background. It is not a bit merely because an external observer can interpret it as one alternative rather than another.

A signal is physically carried contrast.

The contrast may be carried by pressure, light, heat, voltage, molecular concentration, chemical conformation, mechanical deformation, magnetic alignment, acoustic vibration, surface inscription, fluid flow, neural activation, or any other medium capable of preserving differential state over some interval.

The carrier matters because no signal exists without physical support. A signal cannot float above its medium. It must be embodied in a process that preserves some difference rather than allowing all difference to collapse into undifferentiated relaxation.

But the signal is not identical with the total physical carrier.

A pressure wave carries more physical detail than the acoustic signal relevant to a receiver. A photon flux carries more physical variation than the visual contrast registered by an organism or instrument. A molecular gradient contains more physical complexity than the concentration distinction available to a receptor. A voltage waveform contains more microvariation than the code state stabilised by a circuit. A written mark contains more surface detail than the token it can become for a trained reader or machine.

Signal therefore sits between raw variation and RRP-indexed informational availability.

It is more than arbitrary physical change, because some contrast is preserved. It is weaker than established RRP-indexed information for the evaluated locus, because availability for that locus has not yet been established. It is less than RAS, because no retained registration has yet been shown. It is less than NTC, because no comparator-stable downstream dependence on distinction has yet been established.

The first discriminator is preservation of contrast.

Where physical variation occurs but no contrast survives, there is no signal in the relevant sense. Where contrast survives but cannot reach or be discriminated by any relevant locus, there may be signal-bearing structure in a weak physical sense, but no information for that locus. Where contrast reaches a locus-interface-regime and becomes available as distinction, the signal may enter the RRP architecture as OP.

4.2. Medium and carrier

A signal requires a medium.

The medium is the physical support through which contrast is carried, transformed, attenuated, amplified, delayed, distorted, or lost. It may be material, energetic, electromagnetic, chemical, mechanical, biological, symbolic, technical, or institutional, provided that it preserves a difference sufficiently for the relevant discrimination conditions.

A medium is not a neutral container.

It participates in what can survive. It determines which differences pass, which differences degrade, which differences are amplified, which differences are filtered, which differences become ambiguous, and which differences are lost. A medium has its own limits of scale, speed, stability, noise, saturation, bandwidth, resolution, and transformation.

A spoken word passes through several media. It begins in motor control and airflow. It becomes patterned pressure variation. It becomes eardrum motion. It becomes cochlear excitation. It becomes neural activity. It becomes linguistic token. It may become memory. It may later become action.

A chemical cue also passes through several media. It begins as molecular distribution. It becomes receptor binding probability. It becomes conformational change. It becomes pathway activation. It becomes regulatory state. It may alter later sensitivity, expression, movement, repair, or maintenance.

A digital instruction begins as an encoded symbol. It becomes stored voltage or magnetic state. It becomes memory address. It becomes processor transition. It becomes an output state sequence. It may later become further stored state or action.

A scientific measurement begins as physical coupling. It becomes instrument response. It becomes readout. It becomes inscription. It becomes dataset. It becomes model constraint. It may later become experimental design, institutional claim, or technological intervention.

In each case, no single medium contains the whole informational relation.

The relation survives only where the relevant contrast survives transformation.

This is why medium-change is not incidental. Medium-change is one of the central tests of signal identity. A contrast may survive a medium transition, degrade across it, invert through it, become amplified by it, become distorted by it, or fail entirely. A signal path is therefore not a neutral conduit. It is a selective physical process that preserves some differences while destroying, suppressing, or reclassing others.

The carrier is always richer than the signal.

A medium contains more physical variation than the signal-relevant contrast. A pressure wave contains more microphysical detail than the acoustic distinction available to a listener. A photon flux contains more variation than the image relation retained by a sensor. A molecular gradient contains more chemical structure than the concentration distinction available to a receptor. A page contains more surface detail than the written word it can carry. A database contains more physical and architectural structure than the record it exposes to a query.

The signal is not the medium itself.

It is preserved contrast in the medium.

This is the carrier discipline of the paper. A carrier is necessary because no signal floats without physical support. A carrier is insufficient because no carrier is identical to the signal relation it supports. The same carrier may support different signals under different regimes. The same signal relation may also survive across different carriers where the relevant contrast is preserved.

Signal identity therefore depends on preserved contrast, not on carrier totality.

4.3. Signal path

A signal path is the physically sustained route through which contrast propagates, transforms, attenuates, amplifies, or is lost across one or more media.

The path may be short.

A receptor changes conformation when a molecule binds. A switch crosses threshold when voltage enters a range. A surface changes state under contact. A detector records one event. A membrane potential shifts. A local chemical concentration alters a pathway.

The path may be extended.

Light travels from an object to a sensor. Sound passes through air into an ear. A hormone moves through blood. A written sign moves through storage, perception, language, and institutional procedure. A database record moves through memory, software, interface, decision rule, and downstream act.

The path may be recursive.

A retained state may alter later sensitivity, threshold, channel selection, response probability, or future signal generation. A thermostat changes heating dynamics. A cell changes receptor expression. An organism learns salience. A model changes future sampling. An institution changes future classification rules. A scientific instrument is recalibrated by prior measurements. A language shifts after repeated use.

In every case, the path determines what survives.

Some paths preserve amplitude but lose timing. Some preserve timing but lose amplitude. Some preserve category while losing metric precision. Some preserve local contrast but lose global relation. Some preserve binary state but lose history. Some preserve semantic token while losing tone, context, or uncertainty. Some preserve procedure while losing lived relation. Some preserve statistical regularity while losing individual case structure.

A signal path is therefore already an abstraction pathway before it becomes an RRP-indexed information pathway for a locus. It does not carry total reality. It carries selected contrast under physical constraint.

The important question is not whether something travels.

The important question is what relation survives the travel.

A path may also fail.

It may fail before contrast is preserved. It may fail because the medium dissipates the relevant difference. It may fail because the channel saturates. It may fail because background variation masks the signal. It may fail because timing is lost. It may fail because the contrast reaches a locus but not at the scale, threshold, or horizon required for discrimination. It may fail because the receiving regime has no classing structure capable of making the contrast registerable.

These failures are not peripheral. They are part of what signal analysis is for.

Signal path analysis asks where the contrast is generated, how it is carried, what is preserved, what is transformed, what is lost, what arrives, what becomes available, and what fails before availability.

4.4. Transmission and transformation

Transmission is never perfect copying of total state.

A signal does not move by transferring the whole physical condition of its source into a receiver. It moves by preserving some contrast through lawful physical transformation. In many cases, what arrives is not the original physical form, but a downstream state whose current difference depends on an earlier difference.

This dependence can be strong without being total.

A thermometer reading depends on thermal relation, but it does not contain the full microscopic thermal state. A photograph depends on light relations, but it does not contain the event. A receptor state depends on molecular contact, but it does not contain the full chemical environment. A voltage output depends on input state, but it does not contain every fluctuation in the circuit. A written word depends on a prior inscription event, but it does not contain all the conditions of writing.

Transmission therefore has two sides.

It preserves enough relation to permit later discrimination.

It omits, compresses, transforms, or loses the rest.

This is not a defect added to signal after the fact. It is how finite signal paths work. A signal path that preserved total physical state would not be a channel for usable contrast. It would be the whole physical system.

Signals are useful because they reduce.

They allow some differences to travel without requiring all differences to travel. They make relation portable across medium, distance, delay, substrate, and scale. But portability is paid for by selectivity. The signal path carries what the regime can preserve, not the totality of what occurred.

This is the point at which signal begins to prepare abstraction.

A signal path physically reduces variation before any explicit observer interprets it. A medium filters. A channel attenuates. A threshold cuts. A receptor selects. A code discretises. A memory writes only some alternatives. A record preserves only selected classes. A transmission protocol preserves some states and discards others. A measurement compresses a relation into a value.

Signal therefore physically anticipates the later abstraction architecture. It does not yet define OA, but it prepares the conditions under which OA can operate. A signal path that preserves no stable contrast cannot support classing. A path that preserves contrast at the wrong scale may support one abstraction but not another. A path that loses relevant differences may yield misleading registration. A path that preserves irrelevant variation may overload the receiving regime.

Transmission is relation carried through loss.

Transformation is the cost of carrying relation through medium.

The signal question is whether enough of the relevant relation survives.

4.5. Signal, noise, and regime-relative classification

Signal and noise are not intrinsic divisions in matter.

The same physical variation may be signal for one locus, noise for another, and inert variation for a third. A pressure fluctuation may be speech to a listener, noise to a machine, and irrelevant vibration to a stone. A chemical gradient may be signal to a cell and background variation to another system. A voltage variation may be a bit in one circuit and noise in another. A statistical outlier may be noise under one model and signal under another. A bodily sensation may be diagnostic signal under one medical regime and irrelevant discomfort under another.

Signal/noise classification is regime-relative.

This does not make it arbitrary. A signal/noise regime must be physically and operationally constrained. The relevant question is whether the variation preserves a relation that can be discriminated under the channel, threshold, scale, horizon, and abstraction conditions of the locus.

Noise is not simply unwanted variation. Noise is variation that degrades, masks, corrupts, overloads, destabilises, or becomes irrelevant to the distinction being carried under the regime. Noise can come from the medium, the channel, the carrier, the environment, the receiving interface, the measuring apparatus, the abstraction regime, the record pathway, or the redeployment context.

Signal can also become noise by context shift. A contrast useful at one scale may become irrelevant at another. A detail meaningful to one receiver may become interference to another. A high-resolution input may overload a low-bandwidth system. A redundant signal may stabilise one pathway and saturate another. A marker useful in one diagnostic regime may mislead in another.

Noise can also become signal by RRP shift. Background variation may become informative when the locus, scale, or question changes. What was once ignored may become diagnostic. What was once error may become evidence of drift. What was once interference may reveal a hidden channel. What was once residual may become the main contrast under a new abstraction regime.

This is why the signal/noise distinction must remain indexed.

Signal is not privileged matter.

Noise is not meaningless matter.

Both are classifications under a regime of possible discrimination.

The disciplined claim is therefore:

Signal is preserved contrast relevant to possible discrimination under specified conditions.

Noise is variation that degrades, masks, destabilises, or falls outside that discrimination relation.

The world constrains both. The classification is relative to the regime.

4.6. Channel-relative distinction

A channel is a constrained pathway through which contrast can be transmitted, transformed, preserved, degraded, or lost.

A channel is not merely an empty route. It has admissible states, limits, noise characteristics, thresholds, capacity, timing constraints, error modes, and transformations. It determines which alternatives can remain separable and which collapse into the same state.

Channel-relative distinction is distinction preserved under these channel conditions.

A channel may be physical, as in acoustic propagation, optical transmission, molecular diffusion, electrical conduction, thermal flow, mechanical deformation, or fluid movement. It may be biological, as in receptor binding, membrane transport, neural transmission, hormonal circulation, immune recognition, or developmental signalling. It may be technical, as in radio transmission, digital communication, sensor readout, database query, or protocol routing. It may be symbolic or institutional, as in writing, law, measurement standards, classification forms, or procedural records.

In each case, the channel does not simply pass the world through.

It selects, filters, distorts, delays, preserves, compresses, and sometimes creates new contrast relations by transformation.

A channel therefore has an alphabet in the broad sense only where stable classes of alternatives can be supported. The alphabet may be explicit, as in a digital code. It may be physically embodied, as in receptor states. It may be instrumentally calibrated, as in measurement values. It may be institutionally specified, as in procedural categories. It may be socially inherited, as in language.

But a channel alphabet is not arbitrary. It must be supported by physically or operationally stable tokenisation. Alternatives must remain separable enough for the claim being made. If the classes collapse, the channel cannot carry the distinction. If the noise overwhelms the difference, the channel cannot support the signal. If the receiver cannot discriminate the alternatives, the channel relation may exist but fail to become OP for that locus.

Channel-relative distinction therefore bridges signal and RRP.

It shows how contrast can become disciplined before it becomes information for a locus. But it does not remove the need for RRP. A channel can preserve contrast without that contrast being available to the locus under evaluation. A channel can carry alternatives that no relevant receiver can class. A channel can support bits that remain inert outside a code architecture. A channel can preserve a mark that no system can read.[4]

Channel discipline sharpens signal.

RRP discipline determines informational availability.

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5. From Signal to OP

5.1. Preserved contrast is not yet OP

Signal-bearing contrast may exist without becoming OP.

This distinction is central to the paper.

Signal is physical variation preserved as contrast through a medium under possible discrimination conditions. OP is the available contrast field at an interface under specified reference conditions.

Signal says: contrast survives.

OP says: contrast is available to this locus through this interface under this regime.

A radio transmission may propagate through space without being OP for a device that lacks the relevant antenna, tuning, power, decoding architecture, or discrimination regime. A chemical gradient may exist without being OP for a system that lacks the receptor or pathway. A written inscription may preserve contrast without being OP for a reader who cannot distinguish the marks as a relevant alphabet. A voltage pattern may carry signal within one architecture but remain inert variation to another. A sound may be physically present and still unavailable to a deaf organism, to a microphone outside range, or to a system without the relevant classification pathway.

Signal-bearing contrast becomes OP only when it enters the available contrast field of a locus-interface-regime.

The signal may be physically real. It may travel. It may preserve contrast. It may be well-formed under a channel. It may be measurable by some external system. Yet it is not OP for the locus under evaluation unless it becomes available to that locus as a possible distinction.

This is why OP cannot be reduced to signal.

OP is not preserved contrast in general. It is preserved contrast available at an RRP.

The bridge from signal to OP requires at least four conditions.

First, the contrast must reach or otherwise affect the relevant interface.

Second, the interface must support the relevant difference at the reference scale.

Third, the discrimination regime must preserve the alternatives strongly enough for possible classing.

Fourth, the locus must be positioned such that the contrast can become part of its available branch-space.

Where these conditions fail, signal remains below OP for that locus.

5.2. Signal failure before OP

A signal may fail before OP in several ways.

It may fail by dissipation. The contrast is produced but relaxes before it reaches the interface.

It may fail by attenuation. The contrast reaches the region of the locus but below threshold.

It may fail by masking. Background variation overwhelms the distinction.

It may fail by saturation. The channel or interface is overloaded so that alternatives collapse.

It may fail by scale mismatch. The contrast exists at a scale the locus cannot individuate.

It may fail by timing mismatch. The contrast arrives too early, too late, too briefly, or too slowly for the operational horizon.

It may fail by medium incompatibility. The contrast is carried in a medium the locus cannot couple to.

It may fail by classing absence. The contrast reaches the interface but no OA regime can treat it as this rather than that.

It may fail by registration absence. The contrast is available and classable in principle, but no OR event selects it into state.

It may fail by external-only readability. An outside observer can describe or measure the contrast, but the locus under evaluation cannot access it.

These failures are conceptually important because they stop the paper from treating the existence of signal as sufficient for RRP-indexed information for the evaluated locus.

A signal that fails before OP is not nothing. It may be physically real. It may be signal for another locus. It may be retrievable through another instrument. It may become relevant under altered conditions. But under the reference conditions of the claim, it has not become available distinction for the locus.

No OP, no RRP-indexed information.

5.3. Signal entering OP

Signal enters OP when preserved contrast becomes available as a field of possible alternatives at a locus-interface-regime.

The signal does not need to be semantic. It does not need to be conscious. It does not need to be linguistic. It does not need to be intentionally sent. It does not need to be designed. It does not need to be a message.

It must become available contrast.

A molecular gradient enters OP for a cell when the cell’s boundary and receptor architecture make differences in concentration available to regulatory or movement pathways. A voltage range enters OP for a circuit when circuit thresholds make alternatives available as possible state transitions. Light enters OP for a sensor when optical and electronic architecture make contrast available as distinguishable input. A written mark enters OP for a reader when a visual-linguistic regime makes it available as a possible token. A record enters OP for an institution when procedures make it available as admissible difference.

At the OP stage, the signal has not yet been registered. It has entered a field of possible alternatives. Registration requires OR. Retention requires RAS. Redeployment requires RSD. Downstream comparator-stable dependence requires NTC.

OP is therefore the first RRP-indexed status of signal-bearing contrast.

This is the paper’s central bridge:

Signal is preserved contrast.

OP is preserved contrast made available to a locus.

The distinction should remain visible throughout the rest of the series.

5.4. From OP to OA

Once signal-bearing contrast becomes OP, it must still become classable.

OA supplies the operative classing regime by which OP-supported differences become registerable alternatives. It determines which differences count as the same, which count as different, which are relevant, which are irrelevant, which are signal, which are noise, which are within tolerance, and which are outside tolerance at the reference scale.

A contrast field without classing may be available in a loose sense but not yet registerable.

A sensor may be exposed to variation without having a threshold that separates alternatives. A biological system may encounter chemical difference without a receptor regime that classes it. A measuring device may receive input outside its calibration. A human may hear sound without recognising phonemic distinction. An institution may receive material without a category that makes it procedurally admissible.

OA is therefore not interpretation after signal. It is the operational condition that makes signal-bearing contrast registerable.

A signal path may prepare OA by preserving contrast in a form that can be classed. But the signal itself does not determine the abstraction regime. The same signal may be classed differently by different loci. The same physical contrast may be signal/noise, same/different, relevant/irrelevant, within/outside tolerance, depending on the OA regime.

Signal enters OP when it becomes available.

OP enters OA when it becomes classable.

Only then can OR select one classed alternative into state.

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6. Signal, registration, and retention

6.1. Signal is not registration

Signal may prepare registration, but it is not registration.

A signal can propagate without being registered. It can reach an interface without being selected into state. It can become available as OP without OR occurring. It can be discriminable in principle without becoming a token. It can alter a surrounding medium without becoming an internal alternative for the locus.

Ontic Registration occurs only when one OP-supported, OA-classed alternative becomes selected into state.

This distinction matters because signal-language often hides registration status. We say that a cell receives a signal, a machine receives a signal, a person receives a signal, or a system sends a signal. But the technical question is what occurred in the stack.

Did contrast merely propagate?

Did it reach an interface?

Did it become OP?

Was it classed by OA?

Was one alternative selected through OR?

Did the result persist as RAS?

Was it redeployed through RSD?

Did downstream trajectory selection depend on it under comparator discipline?

Only the relevant status should be claimed.

A pressure wave passing by an organism may be signal-bearing in the environment but not registered by that organism. A molecule may diffuse near a cell but fail to bind. A voltage pulse may reach a circuit but fall below threshold. A written instruction may be visible but unread. A measurement may be recorded by an instrument but never consulted by the decision process being evaluated.

Signal is preserved contrast.

Registration is selected state.

The difference is decisive.

6.2. Signal is not retention

Signal is also not retention.

A signal may produce a transient registration without producing a retained token-state. A receptor may change state briefly and return. A voltage may cross threshold and then decay. A sound may be heard and not remembered. A sensor may detect an event but fail to store it. A system may respond to a cue without retaining a record.

RAS requires persistence over the operational horizon.

It is not enough that contrast arrived. It is not enough that classing occurred. It is not enough that OR occurred. The registered state must remain re-identifiable under the relevant scale and horizon conditions.

This prevents another common inflation.

A signal is not a record merely because it once occurred. A transient state is not knowledge merely because it was caused by contrast. Physical persistence does not by itself establish RAS. RAS is retained abstraction: an OA-keyed token-state produced by OR and identifiable under RRP conditions.

Signal can lead to RAS.

Signal is not RAS.

This prepares the knowledge paper. Knowledge begins where registered distinction persists as present accessible state. Signal explains how contrast can reach the registration pathway; it does not itself grant knowledge-status.

6.3. Physical persistence and RAS

Physical systems can preserve dependence on prior states before the evaluated relation satisfies RAS conditions. A polymer sequence, surface mark, material deformation, gradient, or other stabilised state may persist and may later become available through a signal or registration pathway. That persistence is physically real, but it is not an intermediate informational status.

RAS begins only where OP-supported contrast is classed by OA, selected through OR, and retained over the relevant operational horizon at a specified RRP. A persistent state may become RAS for one locus, signal-bearing input for another, or remain outside both relations.

The status belongs to the indexed relation, not to persistence itself.

6.4. Registration pathway and signal path

Signal path and registration pathway are related but not identical.

A signal path is the route by which contrast is carried, transformed, attenuated, amplified, or lost.

A registration pathway is the route by which OP-supported, OA-classed contrast is selected into state.

The signal path may end before registration. The registration pathway may begin only after a signal reaches the locus. In complex systems, the two may overlap, nest, or recur. A receptor binding event may be both the end of one signal path and the beginning of a registration pathway. A sensor readout may be a signal for a downstream system while also being a RAS for the instrument. A written record may be the retained result of one registration and the signal-bearing input to another.

This is how informational chains form.

A signal can produce OR.

OR can produce RAS.

RAS can become signal-bearing for another locus.

The same physical state may therefore occupy different roles in different relations. A mark may be RAS for the writer’s prior act, signal for a later reader, OP for an institution, and RSD input for a procedure. A molecular state may be RAS for a prior cellular process and signal for a later regulatory pathway. A database entry may be RAS for one system and OP for another query.

The framework handles this by indexing status to RRP.

The question is not what the object is in itself.

The question is what role the state plays in the specified relation.

Signal path concerns carried contrast.

Registration pathway concerns selected state.

Retention concerns persistent token.

Redeployment concerns later operative use.

7. Informational recursion

7.1. When signal pathways become recursive

Signal pathways become recursive when retained distinction alters later signal availability, discrimination, registration, or redeployment.

A prior RAS may change later OP. A system that has retained a distinction may become sensitive to contrasts it previously ignored. A cell may express more receptors after prior stimulation. An organism may learn to detect a cue. A machine may update a model and sample differently. An institution may create a new reporting category after prior cases. A scientific field may build an instrument because earlier records revealed a hidden relation.

A prior RAS may change later OA. A retained category may alter what counts as same or different. A calibration record may adjust thresholds. A training history may modify classification boundaries. A legal precedent may alter procedural classing. A learned word may make a previously undifferentiated contrast nameable.

A prior RAS may change later OR. A retained distinction may determine whether a new input is selected into state. A memory may prime attention. A receptor state may modulate activation probability. A stored rule may route a case. A parameter update may alter which input produces a state transition.

A prior RAS may change later signal path. A system may alter channel selection, bandwidth, sampling rate, threshold, amplification, or filtering. A thermostat changes heating dynamics. A camera adjusts exposure. A cell regulates receptor density. An organism turns its head. A scientist changes instrumentation. An institution redesigns a reporting form.

This is informational recursion.

It does not require a new primitive. It requires retained distinction becoming operative in later contrast availability, classing, registration, or redeployment.

Signal recursion begins when past registration changes future signal conditions.

7.2. RSD as the hinge of recursion

RSD is the hinge of recursion.

A retained state may persist without changing future signal relations. It may remain archived, inert, degraded, inaccessible, or unused. Recursion begins only where retained distinction is redeployed into later operation.

RSD can alter what a system can receive. It can alter what it can ignore. It can alter what it treats as signal or noise. It can alter thresholds, channels, sampling, memory, calibration, and action. It can change future OP fields and future OA regimes. It can determine which later OR events occur and which do not.

This is why RSD is stronger than retention.

RAS stores a registered distinction as present accessible state.

RSD makes retained distinction operative again.

Where RSD alters future signal availability or registration, informational architecture becomes historically cumulative. Earlier distinctions reshape later access. The locus no longer simply receives contrast under fixed conditions. Its own retained distinctions modify the conditions under which later contrast becomes available.

This is the bridge from signal to learning, adaptation, calibration, institutional memory, scientific correction, technical development, and intelligent action.

But the paper must not overstate this bridge.

Recursion is not automatically knowledge in the full later sense. It is not automatically intelligence. It is not automatically observation. It is not automatically life. It is a structural possibility opened by RAS and RSD.

The later papers will specify the facet status.

Here, the point is narrower:

Signal pathways become recursively informational when retained distinction changes the later physical pathway by which relation becomes available.

7.3. Recursive signal and branch-space

Recursive signal changes branch-space.

An initial signal may open, close, weight, or stabilise later alternatives. A retained response may make some later signals easier to detect and others harder. A prior registration may narrow possible pathways, expand them, or change which trajectories become available. A redeployed state may alter the system's future field of alternatives.

This is not necessarily conscious choice.

A cell that changes receptor expression after stimulation alters future chemical branch-space. A nervous system that learns a sound alters future auditory branch-space. A machine that updates weights alters future classification branch-space. A scientific discipline that builds a detector alters future observational branch-space. An institution that records precedent alters future procedural branch-space.

The result is that signal does not merely pass through a system. In recursive cases, signal changes the future conditions under which signals can pass.

This matters for the series because it gives the physical entrance to cumulative informational architecture.

Knowledge will take up the retained-state side of this relation.

Intelligence will take up the applied-distinction side.

Observation will take up the bounded-registration and record-provenance side.

The signal paper stops at the physical pathway and its recursive opening.

8. Guardrails and failure modes

8.1. Not all variation is signal

Failure mode: all physical variation is called signal.

Error: because variation exists, persists, propagates, or can be described, it is treated as signal.

Correction: signal requires physical variation preserved as contrast through a medium under possible discrimination conditions. Where no contrast survives, or where the variation cannot support possible discrimination under any relevant regime, signal status is not warranted.

Variation is broader than signal.

8.2. Not all signal is RRP-indexed information

Failure mode: every signal-bearing contrast is treated as RRP-indexed information for a locus.

Error: because contrast is preserved or transmitted, it is assumed to be informational for the locus under evaluation.

Correction: operational information for a locus requires RRP-indexed availability. Signal-bearing contrast becomes informational for the evaluated locus only where it becomes available as distinction through an interface under specified reference conditions.

Signal is preserved contrast.

RRP-indexed information for a locus is available distinction.

8.3. Physical persistence is not RAS

Failure mode: every persistent physical state is treated as a retained abstraction state.

Error: because a mark, gradient, sequence, deformation, memory-like state, or residue persists, it is treated as a record or knowledge-token.

Correction: RAS requires an OA-keyed token-state produced by OR from an OP-supported contrast field at a specified RRP. Persistence and historical dependence are not enough.

No registration, no RAS.

8.4. Not all channel-discriminability is RRP-indexed information

Failure mode: Shannon-style discriminability is treated as the whole theory of information.

Error: because alternatives are discriminable in a channel under alphabet and noise conditions, they are assumed to be informational for the target locus.

Correction: channel-relative discriminability is necessary for many signal cases, but RRP-indexed information additionally requires availability for a locus under interface, scale, horizon, abstraction, and registration conditions.

SIT sharpens channel distinction.

RRP fixes locus-relative informational status.

8.5. Signal/noise is not intrinsic

Failure mode: signal and noise are treated as intrinsic kinds of matter.

Error: a variation is called signal in itself or noise in itself without specifying the locus, channel, scale, horizon, and discrimination regime.

Correction: signal/noise classification is regime-relative. The same variation may be signal for one locus, noise for another, and inert background for a third.

The world constrains the classification.

The classification is indexed to the regime.

8.6. Carrier is not signal

Failure mode: the total carrier is confused with the signal.

Error: the medium, substrate, message-bearer, or physical support is treated as identical with the signal relation.

Correction: the carrier is always richer than the signal. Signal is preserved contrast in the carrier, not carrier totality. The same carrier may support different signals under different RRPs, and the same signal relation may survive across multiple carriers if the relevant contrast is preserved.

No carrier, no signal.

But carrier alone does not define signal.

8.7. Signal is not registration

Failure mode: signal arrival is treated as OR.

Error: because contrast reaches a system, it is assumed to have been selected into state.

Correction: OR requires one OP-supported, OA-classed alternative to become selected into locus-relevant state. A signal may propagate, arrive, or become available without being registered.

Signal prepares possible registration.

It is not registration by itself.

8.8. Signal is not knowledge

Failure mode: signal-bearing contrast is treated as knowledge.

Error: because a signal carries or preserves contrast, it is assumed to count as retained distinction.

Correction: knowledge requires retained distinction. In the minimal physical sense, this means an OA-keyed, OR-produced RAS retained as present accessible state under RRP

conditions. Signal may produce the conditions for knowledge, but signal is not knowledge by itself.

No retention, no knowledge-status.

8.9. Signal is not intelligence

Failure mode: signal responsiveness is treated as intelligence.

Error: because a system responds to signal, or because signal shapes downstream outcomes, intelligence is attributed.

Correction: intelligence requires applied distinction: distinction-conditioned organisation altering downstream trajectory selection for a locus under reference conditions and, in the non-trivial case, comparator discipline. Signal may supply the contrast that intelligence applies, but signal is not intelligence by itself.

No applied distinction, no intelligence-status.

8.10. Signal is not observation

Failure mode: signal reception is treated as observation.

Error: because a system receives or is affected by a signal, it is said to observe.

Correction: observation requires bounded registration. In the minimal observation-facet sense, an OP-supported alternative must be selected through OR into an OA-keyed RAS under specified reference conditions. Mere signal propagation, coupling, or transient perturbation is not observation.

Signal may support observation.

It is not observation by itself.

8.11. RRP-indexed information is not yet NTC

Failure mode: RRP-indexed information is treated as Non-Trivial Computation.

Error: because a distinction becomes available, registered, retained, or redeployed, it is assumed to produce comparator-stable downstream dependence.

Correction: NTC requires organisation-dependent, counterfactually testable downstream outcome dependence on discriminable distinctions under specified reference conditions and comparator discipline. Signal and RRP-indexed information may prepare NTC, but they do not establish it by themselves.[5]

No comparator-stable downstream dependence, no NTC.

8.12. NTC is not yet life

Failure mode: any NTC relation is treated as life.

Error: because distinction-conditioned organisation alters downstream trajectory selection, life-status is attributed.

Correction: life requires the stricter condition of driven thermodynamic constraint-maintenance supported by IPL-mediated NTC. NTC may be necessary for life in this framework, but it is not sufficient by itself.

No driven thermodynamic constraint-maintenance supported by IPL-mediated NTC, no life-status.

8.13. The stack must not collapse

Failure mode: signal, RRP-indexed information, registration, retention, redeployment, NTC, knowledge, intelligence, observation, and life are collapsed into one another.

Error: because the stages are connected, they are treated as equivalent.

Correction: connection is not identity. Each stage adds a discriminator.

Interaction produces variation.

Variation may become signal-bearing where contrast is preserved.

Signal-bearing contrast may become OP.

OP may become classed by OA.

OA-classed OP may become OR.

OR may become RAS.

RAS may become RSD.

RSD may support NTC.

NTC may support life where driven thermodynamic constraint-maintenance is maintained.

The sequence is cumulative, but each threshold remains distinct.

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9. Handoff to Knowledge

9.1. What Paper 1a has installed

This paper has installed the physical pathway into informational availability.

Paper 1 established the reference architecture of operational information for a locus. It showed that physical difference does not by itself establish information for the evaluated locus, and that a difference becomes informational for that locus where it is made relationally available as operational distinction under specified reference conditions. It defined the RRP Set: RRP, OP, OA, OR, RAS, and RSD.

Paper 1a has now grounded the physical entrance into that architecture.

It has shown that signal is not by itself RRP-indexed information. Signal is physical variation preserved as contrast through a medium under possible discrimination conditions. Interaction produces variation; variation may preserve contrast; preserved contrast may become channel-discriminable; and channel-discriminable contrast may become RRP-indexed information where it is available as distinction for a locus.

It has also shown that signal does not erase the need for the RRP Set.

Preserved contrast is not yet OP unless available to a locus.

OP is not yet OA unless classable.

OA-classed OP is not yet OR unless one alternative is selected into state.

OR is not yet RAS unless retained.

RAS is not yet RSD unless redeployed.

RSD is not yet NTC unless downstream trajectory selection depends on distinction under comparator discipline.

NTC is not yet life unless it supports driven thermodynamic constraint-maintenance through an IPL.

The signal paper therefore makes the pathway physically explicit without inflating any downstream status.

9.2. What remains unresolved

The paper has not yet defined knowledge.

It has explained how contrast can become available. It has shown how signal-bearing pathways can support registration and retention. It has distinguished physical persistence from signal, registration, and retention, and has introduced signal path, channel-relative distinction, and the signal-to-OP bridge.

But it has not yet asked what status a retained distinction has once it persists as present accessible state.

That is the next burden.

A signal may leave no retained state. A registration may be transient. A physical state may persist without becoming RAS. A RAS may exist without being consulted. A retained distinction may be deployable in principle but never redeployed. A record may be present but not yet operative in downstream transition.

These are not signal questions alone. They are knowledge-status questions.

The next paper therefore begins where this one stops.

9.3. Handoff formula

The sequence from Paper 1 to Paper 2 can now be stated cleanly.

RRP explains when difference can count as information for a locus.

Signal explains how contrast can become physically available to that locus.

Knowledge asks what status such distinction has when it is retained as present accessible state.

This handoff should remain role-disciplined. A signal path may make contrast available without producing a retained state. A registration pathway may select an alternative without preserving it over the relevant horizon. A retained state may persist without being redeployed. The same physical carrier may function as signal for one locus, RAS for another, and OP for a later relation. The status therefore belongs to the specified relation, not to the carrier in

itself. Signal prepares the conditions under which registration and retention can become possible; it does not assign knowledge-status, intelligence-status, or observation-status by itself.

Knowledge is not belief first. It is not semantic possession first. It is not human cognition first. It is not justified proposition first. Those are stronger or later cases. The first knowledge question is whether a prior difference has been selected, abstracted, registered, and retained as a discriminable token-state under specified reference conditions.

Signal prepares that question by showing how contrast can reach the point of possible registration.

Knowledge answers it by defining retained distinction.

9.4. Final compression

The final position of this paper is:

Physical interaction produces variation.

Variation may preserve contrast.

Preserved contrast is signal.

Signal requires medium, path, and physical support.

Signal/noise classification is regime-relative.

Channel-relative discriminability sharpens signal and may establish Shannon information within a specified channel frame, but it does not exhaust operational informational architecture.

Signal-bearing contrast becomes RRP-indexed information for the evaluated locus only where it becomes available as distinction under RRP conditions.

That available contrast is OP.

OP becomes registerable through OA.

OA-classed OP becomes OR when selected into state.

OR becomes RAS when retained.

RAS becomes recursively powerful through RSD.

RSD becomes NTC only where downstream trajectory selection depends on distinction under comparator discipline.

Life requires the stricter condition of driven thermodynamic constraint-maintenance supported by IPL-mediated NTC.

Signal is therefore the physical pathway of relational access.

It is not the world whole.

It is not by itself RRP-indexed information for the evaluated locus.

It is preserved contrast through which relation can become available.

The next question is what happens when such relation is retained.

That question is knowledge.

Endnotes

[1] Berg and Purcell (1977) show, in chemoreception, that discrimination of environmental concentration is physically limited by receptor geometry, diffusion, statistical fluctuation, and observation time. This is a restricted-domain comparator to finite ingress; it does not supply the general Locus Event Horizon architecture.

[2] Landauer (1961) provides the canonical physical-irreversibility result for logically irreversible information operations; Parrondo, Horowitz, and Sagawa (2015) provide a broader modern thermodynamics-of-information framework. These sources ground the physical cost and constraint claim, not the RRP architecture or the present signal ladder.

[3] Shannon (1948) supplies the channel-relative mathematical framework for entropy, coding, alphabets, noise, and channel capacity used here. The further RRP question of operational availability for a specified locus is additional and is not inherited from Shannon.

[4] MacKay and McCulloch (1952) analyse the limiting information capacity of a neuronal link under coding, relaxation-time, and temporal-resolution constraints. This is an examined historical comparator to channel-relative discriminability; it does not supply the present separation of signal, OP, registration, retention, or downstream consequence.

[5] Bateson (1972) provides a close cybernetic comparator by treating information as consequential difference. The present architecture deliberately places preserved signal and RRP-indexed availability below that burden; comparator-stable downstream consequence is reserved for Non-Trivial Computation.

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