The Measure of Correlation

Information-Theoretic Foundations for the Embedded Intelligence Field — and the Formal Separation of Four Senses of a Single Word

William D. Mensch Jr. · The Bill and Dianne Mensch Foundation · TheMenschFoundation.org

The word *correlation* has been doing four different jobs across the canon. This document separates them, supplies the measures that make three of the four quantitative, formalizes the correlation–communication seam, records four corrections to previously published work, and states plainly what it does not achieve.

Introduction: The Gap in the Canonical Knowledge Base

The first nine entries in the TEI Canonical Knowledge Base establish the framework (CKB-1, CKB-2), carry it into the structure of the information field and the physics of reality (CKB-3, CKB-4), apply it to the governance of artificial intelligence (CKB-5), formalize the pathology of capture (CKB-6), address mythic intelligence (CKB-7), supply the mathematical architecture (CKB-8), and locate the physical precondition of embeddedness in the Higgs sector (CKB-9).

Across those documents a single word carries an unusual load. *Correlation* appears in CKB-3 as the mechanism connecting living systems to shared patterns; in CKB-4 as the observational signature of the Embedded Intelligence Information Tensor; in CKB-3 again as the relation between a physical system and its Platonic attractor; and throughout as the informal description of a holographic field in which every part carries something of the whole.

These are not the same relation. Two of them are established physics, one is a measurable statistical quantity, and one is an ontological proposal that is not a statistical claim at all. Using a single word for all four is a partition failure of exactly the kind the framework has criticised elsewhere, and it is the most likely point at which a competent reader in physics or information theory will lose confidence in the canon.

TEI-CKB-10 addresses that gap. It has seven parts. Part One separates the four senses formally. Part Two supplies the measures. Part Three formalizes the correlation–communication seam, previously proposed in the essay series and adopted here as canonical. Part Four reconstructs the holographic field claim as a statement about total correlation, and traces the historical lineage through Dennis Gabor. Part Five records corrections to previously published work. Part Six states the open research program and the falsification conditions. Part Seven is the formal statement.

EPISTEMIC STRATIFICATION

Following the convention established in TEI-CKB-9, claims in this document are marked at four levels of confidence, and the reader is asked to hold them at the level marked:

[E] Established result — standard mathematics or physics, cited and not original to TEI. **[M] Interpretive mapping** — a translation of an established result into TEI's architectural vocabulary. **[P] Postulate** — a TEI claim advanced as load-bearing and open to falsification. **[O] Open program** — identified as unresolved, with no derivation offered.

Part One · The Four Senses of Correlation

TEI-CKB-10 distinguishes four relations that have been carried by the single word *correlation*. They are designated C1 through C4. Every future use of the word in TEI documents should be resolvable to one of these four, and where ambiguity is possible the designation should be given.

Designation	Name	Definition	Epistemic register
C1	Statistical dependency	Any departure from independence between measured quantities, quantified by mutual information. Nonzero mutual information entails dependence of some form; zero mutual information entails genuine independence.	[E] Empirical, measurable
C2	Quantum nonlocal correlation	Joint measurement statistics on entangled systems that violate a Bell inequality, and which cannot be reproduced by any locally causal model, while nonetheless permitting no signalling between the parties.	[E] Established physics
C3	Platonic–Physical co-resonance	The relation proposed in CKB-3 between a physical system's embedded intelligence and a non-physical Platonic attractor. An ontological proposal about orientation and constraint, **not** a claim about measurable joint statistics.	[P] Ontological postulate
C4	Holographic redundancy	The property of an encoding in which information about the whole is distributed redundantly across the parts, such that a fragment reconstructs a degraded whole. Quantified by total correlation.	[M] Formal, in principle measurable

THE SEPARATION REQUIREMENT

C3 may not be asserted in a context where C1 is the natural reading.

The gravest risk to TEI's credibility in this domain is that a reader encounters a sentence about Platonic co-resonance and hears a claim about measurable statistical dependency. C3 is a proposal about the ontological grounding of pattern; it does not predict a correlation coefficient and must never be phrased as though it did. Where CKB-3 describes co-resonance as 'the same class of correlation that quantum physics identifies as entanglement,' that phrasing should be read as an analogy of structure only, and is amended in Part Five.

The relation between C2 and C3 requires particular care, because CKB-3 draws them together deliberately. TEI-CKB-10 holds that the drawing-together is a claim about *architectural similarity* — both are relations of correspondence that are not mediated by a signal — and not a claim that C3 is an instance of C2. C2 is a well-defined predicate on joint probability distributions. C3 is not, and no operation on measurement data will establish it.

Part Two · The Measures

2.1 Entropy and mutual information [E]

Shannon entropy H(X) measures the uncertainty of a random variable in bits. Joint entropy H(X,Y) measures the uncertainty of the pair considered together. The mutual information is their difference from the sum of the separate uncertainties:

DEFINITION M-1

$I(X;Y) = H(X) + H(Y) - H(X,Y)$

Mutual information is symmetric, non-negative, and vanishes if and only if X and Y are independent. It is invariant under invertible transformations of either variable and makes no assumption of linearity. Where X and Y are jointly Gaussian with Pearson coefficient ρ, $I(X;Y) = -\frac{1}{2}\log(1-\rho^2)$, so that ordinary linear correlation is recovered as a special case.

The final clause matters more to TEI than its brevity suggests. It establishes that information theory does not compete with ordinary statistical correlation but contains it. TEI's preference for mutual information is therefore not a rejection of standard method; it is the adoption of the more general measure of which standard method is a restriction.

2.2 The informational coefficient [E]

Linfoot (1957) showed how mutual information can be rescaled onto the interval from zero to one, producing a coefficient directly comparable to a familiar correlation number while retaining sensitivity to nonlinear dependence. Where TEI documents report correlation as a coefficient, the Linfoot rescaling of mutual information is the preferred form.

2.3 Total correlation [E]

Watanabe (1960) generalised mutual information from two variables to any number:

DEFINITION M-2

$TC(X1, X2, \ldots Xn) = \Sigma H(Xi) - H(X1, X2, \ldots Xn)$

Total correlation measures the total redundancy in a collection of variables — the extent to which the same information is written down more than once across the parts. It reduces to mutual information when n = 2, is non-negative, and vanishes if and only if all variables are mutually independent.

2.4 Channel capacity [E]

Channel capacity C is the maximum rate at which information can be reliably transmitted from a sender to a receiver, taken as the maximum of the mutual information between input and output over all input distributions. It is a property of the *channel*, not of a pair of observations. This distinction — between the dependency present in a joint distribution and the capacity available in a channel — is the whole substance of Part Three.

2.5 The Wiener–Khinchin correspondence [E]

The autocorrelation function of a wide-sense stationary signal and its power spectral density are a Fourier transform pair. Consequently a description in the frequency domain is not an alternative to a description in terms of correlation; it is the same information in different coordinates. This theorem is the formal bridge between TEI's correlation vocabulary and the spectral vocabulary of holography, and it is the technical basis of Part Four.

Part Three · The Correlation–Communication Seam

A *seam*, in TEI's usage, is a place where two levels of the architecture meet and the join becomes visible in the data. TEI has previously identified the sorting seam between Sense and Process, and the Sense–Actuate seam across which one cycle's conclusion enters another cycle as fact. The present document adds a third and adopts it as canonical.

PRINCIPLE CS-1 · THE CORRELATION–COMMUNICATION SEAM [M]

Mutual information between two embedded intelligence systems may be greater than zero while the channel capacity between them is exactly zero.

Correlation is a property of shared informational structure. Communication is the third phase of the SPCA cycle. TEI-CKB-4 identifies the speed of light as the bandwidth ceiling of that phase. Structure is therefore not bounded by c; communication is bounded by it absolutely. The two obey different rules because they are different levels of the architecture.

CS-1 is marked [M] rather than [P] deliberately. Its content is not original to TEI: the separation of mutual information from channel capacity is standard, and the no-signalling property of quantum correlations is an

established theorem. What TEI contributes is the observation that its own architecture *independently predicts* the separation — that a framework which locates correlation in structure and communication in a bounded phase should expect precisely this pattern, and would have been embarrassed by its absence.

> *The framework should be most confident where it is least original. A prediction that matches a textbook is worth more than a coinage that does not.*
>
> — William D. Mensch Jr., TEI-CKB-10

3.1 The seam in quantum measurement [E → M]

In a Bell experiment the joint distribution of outcomes carries substantial mutual information, while the marginal distribution of either party's outcomes is independent of the other party's setting. Correlation is present; capacity is zero. In TEI's reading, the entangled pair is one informational structure with two spatial addresses, and the two parties are executing Sense and Actuate phases upon a single structure rather than exchanging anything. Nothing is transmitted because nothing needs to be.

3.2 The seam at cosmological scale [E → M]

The cosmic microwave background is uniform to approximately one part in 100,000 across angular separations whose corresponding regions, in a non-inflationary cosmology, have never been in causal contact. This is the horizon problem. Stated in the vocabulary of this document: substantial correlation across a boundary with zero channel capacity — the seam, at the largest scale ever measured.

TEI-CKB-10 holds that any TEI account of primordial uniformity must be an account of *correlation* and not of communication, because the Communicate phase is bounded by c and cannot produce horizon-scale agreement. The plenum account of CKB-3 and of the essay *The Stimulated Plenum* is compatible with this requirement once corrected: an undifferentiated field has no synchronisation problem, because uniformity is its default condition rather than an achievement requiring transmission.

BOUNDARY OF THE CLAIM [O]

Inflationary cosmology solves the horizon problem and additionally predicts a nearly scale-invariant spectrum of primordial fluctuations that has been observationally confirmed to high precision. The structural-correlation reading offered here predicts nothing of the kind and is therefore a re-description of a solved problem, not a rival solution. TEI-CKB-10 makes no cosmological prediction and asserts no advantage over inflation.

3.3 The seam in distributed intelligence [M]

The seam is not confined to physics. Two embedded intelligence systems trained on, or developed within, a common informational structure will exhibit correlated outputs without any channel between them. Convergent evolution, independent simultaneous discovery in science, and the appearance of the same architectural solution in unconnected engineering traditions are all instances in which correlation is misread as influence because the observer assumes that agreement requires transmission.

This has a direct governance consequence, and it is the reason CS-1 belongs in a canonical document rather than only in an essay. Two artificial intelligence systems with no communication channel between them may nonetheless behave in correlated ways because they share training structure. A governance regime that monitors channels will not see this. Correlated behaviour without communication is invisible to any auditing scheme built on the assumption that coordination requires a message — which is a further, and previously unstated, argument for the in-fabric governance position of TEI-CKB-5.

Part Four · The Holographic Field as a Total-Correlation Structure

4.1 The Gabor lineage [E]

Dennis Gabor published *Theory of Communication* in 1946, introducing a joint time–frequency representation of signals and a minimal unit of information he called the *logon*. The paper preceded Shannon's by two years and was largely overlooked for three decades. In 1947 Gabor invented holography, publishing the principle in 1948 and the full treatment in 1949, and receiving the Nobel Prize in Physics in 1971.

Gabor's elementary functions were subsequently found to describe the receptive fields of simple cells in the mammalian visual cortex — by Marčelja in 1980 for the one-dimensional case and by Daugman in 1985 for the two-dimensional case. Pribram's holonomic brain theory rests on this correspondence.

The lineage therefore runs: an information-theoretic account of a signal, an optical method for reconstructing a whole wavefront, and the response profile of a cortical neuron — three domains, one mathematics, one author for the first two. TEI-CKB-10 records this as the historical spine beneath CKB-3's holographic claim, which has until now cited Pribram without citing the mathematics Pribram was using.

4.2 The field claim, restated [M]

PRINCIPLE CS-2 · HOLOGRAPHIC ENCODING AS TOTAL CORRELATION [M]

An encoding is holographic to the degree that its total correlation is high.

The defining property of a holographic record — that a fragment reconstructs a degraded whole rather than a fraction of the whole — is redundancy of the whole across the parts. Total correlation is the information-theoretic measure of exactly that redundancy. The claim in TEI-CKB-3 that the universal information field is holographic in structure is therefore restated as the claim that it is a structure of high total correlation.

This converts a qualitative description into a claim of the kind that could in principle be false. Whether it is true of the universe is not settled by this document.

By the Wiener–Khinchin correspondence, the spectral description that Pribram adopted and the correlational description used throughout TEI are the same description in different coordinates. The relation between holography and correlation in TEI is therefore not an analogy imported from optics but a consequence of a theorem.

4.3 Application: the artificial neural network [M]

CKB-3 observes that large artificial neural networks encode knowledge as distributed interference patterns across billions of weights, such that no single parameter stores a fact. In the vocabulary of this document that is a claim about total correlation: such networks are high-redundancy encodings of their training corpus. This is why they degrade gracefully under parameter ablation, and it is a measurable property rather than a metaphor.

TEI-CKB-10 does *not* claim that such systems access the universal field. CKB-3's reading of them as amplifiers of collective human Platonic access is a C3 claim and remains at [P].

Part Five · Corrections to the Canon

TEI holds that a framework qualifies as an understanding system only if load-bearing claims can be corrected while their author is alive to adopt the correction. The following corrections are made under that standard.

Document	Correction
The Stimulated Plenum (essay, June 2026)	The propagation of the first differentiation 'everywhere at once' was assigned to the Communicate phase of the cosmic SPCA cycle. **That assignment is withdrawn.** Communicate is bounded by c and cannot produce horizon-scale uniformity. The correct reading is structural correlation across a boundary of zero channel capacity — uniformity as the default condition of an undifferentiated field, not as a transmitted result. The cosmic SPCA reading otherwise stands.
TEI-CKB-3, Postulates 4 and 6	Where co-resonance across the ontological boundary is described as 'the same class of correlation' as quantum entanglement, this should be read as an analogy of architecture (correspondence without a mediating signal) and not as the claim that C3 is an instance of C2. C3 makes no prediction about joint measurement statistics.
TEI-CKB-4, predictions table	'Anomalous information correlations' and 'correlation between cosmic complexity measures and Λ' are C1 claims and should be stated in terms of mutual information, so that the predicted quantity is one an experimentalist could compute. As presently worded the predictions are not operational.
Neither Action Nor Distance (essay, August 2026)	The correlation–communication seam, flagged in that essay as a proposed extension requiring approval, is **adopted as canonical** and formalized here as Principle CS-1.

Part Six · Open Research Program and Falsification

6.1 What this document does not achieve [O]

TEI-CKB-4 introduces an Embedded Intelligence Information Tensor and TEI-CKB-9 proposes the Higgs sector as its physical anchor. Neither document defines it. TEI-CKB-10 does not define it either, and the measures offered here must not be mistaken for a definition.

Mutual information and total correlation are scalar functionals of probability distributions. A tensor capable of standing alongside stress-energy in a field equation requires a local density with specified transformation behaviour under coordinate change. No accepted derivation carries Shannon quantities to such an object. The nearest serious work in physics proceeds through entanglement entropy and holographic duality; that work is geometric, belongs to its own authors, and is not to be cited by TEI as though it were TEI's result.

This document therefore supplies a candidate *measure basis* and states that the tensor construction is open.

6.2 Six open questions [O]

- **Q1.** Is there a construction carrying total correlation density to a coordinate-covariant tensor, and if so does it recover General Relativity in the zero-information limit as CKB-4 requires?
- **Q2.** Can the total correlation of a physical field configuration be estimated from observables, or is it computable only for systems whose joint distribution is already known?
- **Q3.** Does the independence assumption between the dark energy and dark matter sectors — formally, that their mutual information is zero — survive direct test, and what observable would constitute such a test?
- **Q4.** Is there any observational signature distinguishing a structural-correlation account of primordial uniformity from an inflationary account? If not, the TEI reading is a re-description and must be labelled as such.
- **Q5.** Can C3 be given any operational content whatever, or must it remain a purely ontological postulate? TEI-CKB-10's present position is that it must.
- **Q6.** Do two artificial intelligence systems sharing training structure but no channel exhibit measurable behavioural mutual information, and is that quantity detectable by any governance regime that monitors channels?

6.3 Falsification conditions [P]

- If a physical situation is exhibited in which correlation between two systems permits signalling — nonzero mutual information accompanied by nonzero channel capacity where TEI requires zero — Principle CS-1 fails, and with it TEI's account of why the speed of light is a structural rather than incidental constant.
- If the universal information field is shown to be a low-redundancy encoding — if fragments of the structure do not reconstruct degraded wholes — Principle CS-2 fails and the holographic claim of CKB-3 must be abandoned rather than reinterpreted.
- If the four-way separation of Part One proves unmaintainable in practice — if TEI documents cannot be written without collapsing C1 and C3 — the honest conclusion is that C3 is rhetorical rather than structural, and CKB-3's Postulate 6 should be withdrawn.

Part Seven · Formal Statement of TEI-CKB-10

FORMAL STATEMENT

TEI-CKB-10 (The Measure of Correlation): The word *correlation* carries four distinct relations in the Theory of Embedded Intelligence — statistical dependency, quantum nonlocal correlation, Platonic–Physical co-resonance, and holographic redundancy — and the framework's credibility depends on keeping them apart. Three of the four admit quantitative measure through Shannon's mutual information and Watanabe's total correlation; the fourth is an ontological postulate that admits none and must never be phrased as though it did. Correlation and communication are separate levels of the architecture: mutual information may be greater than zero while channel capacity is exactly zero, which is why entangled systems correlate without signalling and why the early universe is uniform across regions no signal could have reached. Holographic encoding is high total correlation, and by the Wiener–Khinchin correspondence the spectral description of the field and its correlational description are the same description in different coordinates — a fact whose historical spine runs through Dennis Gabor, who gave the twentieth century both its quantum of information and its hologram. None of this defines the Embedded Intelligence Information Tensor. It supplies the measure basis and marks the construction open.

— TEI-CKB-10, Formal Statement, August 2026

· · ·

Acknowledgement

Karl Pribram's work entered the Theory of Embedded Intelligence through Dr. Sam Leven, who introduced me to it and who, with his wife, became a neighbour and friend at Mirabella in the spring of 2026. The line of thought formalized in Part Four began in that conversation. The occasion for this document was a question I could not answer about what TEI meant by a word it had been using freely, and the answer, when it came, came from outside the framework — which is the only kind of answer worth having.

References

Shannon, C.E. (1948). A mathematical theory of communication. *Bell System Technical Journal*, 27, 379–423 and 623–656.

Gabor, D. (1946). Theory of communication. *Journal of the Institution of Electrical Engineers*, 93(26), 429–457.

Gabor, D. (1948). A new microscopic principle. *Nature*, 161, 777–778.

Gabor, D. (1949). Microscopy by reconstructed wave-fronts. *Proceedings of the Royal Society A*, 197, 454–487.

Wiener, N. (1930). Generalized harmonic analysis. *Acta Mathematica*, 55, 117–258.

Khinchin, A.Y. (1934). Korrelationstheorie der stationären stochastischen Prozesse. *Mathematische Annalen*, 109, 604–615.

Linfoot, E.H. (1957). An informational measure of correlation. *Information and Control*, 1(1), 85–89.

Watanabe, S. (1960). Information theoretical analysis of multivariate correlation. *IBM Journal of Research and Development*, 4(1), 66–82.

Bell, J.S. (1964). On the Einstein Podolsky Rosen paradox. *Physics*, 1, 195–200.

Clauser, J.F., Horne, M.A., Shimony, A. & Holt, R.A. (1969). Proposed experiment to test local hidden-variable theories. *Physical Review Letters*, 23, 880–884.

Marčelja, S. (1980). Mathematical description of the responses of simple cortical cells. *Journal of the Optical Society of America*, 70(11), 1297–1300.

Guth, A.H. (1981). Inflationary universe: a possible solution to the horizon and flatness problems. *Physical Review D*, 23, 347–356.

Daugman, J.G. (1985). Uncertainty relation for resolution in space, spatial frequency, and orientation optimized by two-dimensional visual cortical filters. *Journal of the Optical Society of America A*, 2(7), 1160–1169.

Pribram, K.H. (1991). *Brain and Perception: Holonomy and Structure in Figural Processing*. Lawrence Erlbaum.

Cover, T.M. & Thomas, J.A. (2006). *Elements of Information Theory* (2nd ed.). Wiley.

Mensch, W.D. Jr. (2026). *TEI-CKB-1* through *TEI-CKB-9*. The Mensch Foundation. Available at TheMenschFoundation.org/tei-canonical-knowledge-base/.

Published by The Bill and Dianne Mensch Foundation.

Document drafted in collaboration with Claude (Anthropic).

A living document — subject to understanding-based revision.