Unifying Universal Disciplines Towards a General System Theory

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Abstract

Systems theory, causality, natural language, and logic have traditionally been pursued as separate disciplines. However, underlying each of these domains are fundamental structures that suggest a deeper, unified framework. The way we structure our understanding of these disciplines is not arbitrary. Rather, it is dictated by principles that govern perception and cognition. It may also be dictated by principles that govern reality.

The Unified Universal Disciplines Hypothesis (UUDH) proposed in this paper posits that *Fundamental systems theory, causality, natural language, and logic are different manifestations of the same underlying structure in the way that human beings perceive reality and reason. Each of these domains encodes and processes causal interactions in ways that reflect the level of complexity and perspective employed by the observer.*

This paper presents the argument and describes the methodology for unifying these disciplines into a cohesive model that enables more precise reasoning across them. Symbolic Reasoning, an enhancement of traditional set theory, provides a formal tool to facilitate this unification.

Introduction

Domain specific disciplines apply in some fields of study but not others. Geology, for example, is not directly applicable to psychology. Universal disciplines, on the other hand, apply in all fields of study. They are applicable not only to geology and psychology but also to any other field. Such universal disciplines include fundamental systems theory, causality, natural language, and logic.

The unification of these universal disciplines would provide not only more precise reasoning across them but also a significant advance towards a true General System Theory (GST). Despite decades of effort, GST remains fragmented, largely due to an overemphasis on domain-specific models and human-centred interpretations (Bertalanffy, 1968). To build a true GST, we must shift our focus to fundamental principles that transcend individual disciplines.

A true GST should emerge from the synthesis of universal disciplines, rather than attempting to unify domain-specific ones that do not share common principles. While domain-specific models are valuable, they often cannot be merged due to emergent and vanishing properties. Their utility lies within their respective domains, and attempting to unify them under a meta-theory is a distraction from identifying truly universal principles.

It is important to recognise that GST, like all scientific theories, is ultimately a cognitive model. While it structures our interpretation of reality, it is not necessarily reality itself. So, reflexivity, the critical examination of our personal assumptions and biases, is necessary to ensure that GST remains objective.

One of the key reasons GST has struggled is the overwhelming influence of human needs, motivations, and biases on its direction (Bhaskar, 2008)(Kahneman, 2011). Many previous attempts at GST have been shaped by social sciences, management theories, and human-designed systems, which, while insightful, do not necessarily constitute universal system principles. This has resulted in systems theory being highly domain-specific rather than truly foundational. If we are to develop a universal explanatory framework, we must remove anthropocentric assumptions and focus on the core structures that govern all systems.

Finally, for GST to be meaningful, it must go beyond conceptual clarity and be scientifically testable. A genuine GST should be empirically validated, refined, and expanded through observation, experimentation, and comparison across domains. Importantly, GST must evolve with the expansion of human knowledge, much like a scientific paradigm that evolves with new discoveries.

Definitions

Some of the terminology used in this paper must first be defined to ensure clarity.

Traditionally, a system is regarded as a combination of inputs, system processes, and outputs. To avoid ambiguity, when referring specifically to a system's processes, this is explicitly stated as "system processes," "processes," or "P" rather than just "system."

Inputs and outputs connect system processes. An output from one system process that serves as an input to another is referred to as a "relationship" between them. Since this relationship involves the transfer of some matter, energy, or information, it is also referred to as a "transfer" or "T."

The term "entity" refers to both system processes (P) and transfers (T).

"Transfer Duality" describes the two perspectives we can take on a transfer (T). Firstly, it can be regarded as a relationship between system processes. Secondly, because a transfer involves some form of matter, energy, or information, it can also be regarded as a system process in its own right. This duality is symmetrical. A transfer (T) is both a relationship and a system process, depending on the perspective taken. These perspectives are likely to be epistemic. Ontologically, the relationship and system process are likely to be one thing.

"Causal Duality" refers to the two structures that can be used to describe causes and effects, i.e., PTP and TPT. Causal duality is likely to be epistemic but not ontological.

Finally, the term "Set Duality," describes the two ways that we can perceive a set: as a singular whole or as a plural collection of component parts. The holistic and reductionist perspectives employ this duality. The holistic perspective focuses on the singular whole as a component of a greater whole, emphasising its external relationships and interactions. Conversely, the reductionist perspective focuses on the internal structure of the set and the relationships between its parts. These two perspectives are complementary and interdependent. Each is a reversal of the other, depending on whether complexity is expanded outward or analysed inward.

Overview of the Universal Disciplines

Understanding reality involves recognising patterns, relationships, and transformations. Traditionally, the universal disciplines of systems theory, causality, natural language and logic have been studied independently, but recent advances suggest that they share common underlying principles that can be brought together into a unified framework.

Each discipline offers a different perspective on the structure and function of reality:

- **Systems Theory** models entities and their interactions.
- **Causality** explains how these entities and their interactions influence one another over time.
- **Natural Language** encodes these entities and their interactions through grammar and semantics.
- **Logic** provides a formal structure for reasoning and consistency (Frege, 1879)(Tarski, 1941). For the purposes of this paper logic is deemed to include mathematics.

Despite their differences, these domains exhibit deep connections.

Causal relationships define how changes propagate through systems. Every system process transforms inputs into outputs, which in turn become causal factors affecting other system processes. Viewing causality as an intrinsic property of systems offers a way to integrate these two perspectives into a coherent framework.

Natural language serves as a bridge between formal reasoning and our understanding of causality and systems (Chomsky, 1957)(Pinker, 2007). Logical structures underlie grammatical rules, and linguistic expressions often follow principles of implication, contradiction, and inference. By recognising that natural language encodes causal and logical relationships between systems, we can better formalise how meaning is constructed and processed (Lakoff & Johnson, 1980).

Systems analysis often relies on qualitative descriptions of causality, but formalising these descriptions using logical principles can yield more rigorous insights (Pearl, 2000). For example, understanding "if-then" and “necessary/sufficient” structures in both natural language and logic provides a way to represent complex system dynamics explicitly.

In summary, systems operate through causal processes, which can be described linguistically and analysed logically. A truly comprehensive framework should not treat these as separate silos but as interdependent components of a single explanatory model.

The Unified Universal Disciplines Hypothesis (UUDH)

The Unified Universal Disciplines Hypothesis (UUDH) proposed in this paper posits that *fundamental systems theory, causality, natural language, and logic are different manifestations of the same underlying principles that govern the way that human beings perceive reality and reason*.

The hypothesis suggests that all formal reasoning, whether systemic, causal, linguistic or logical, ultimately emerge from the same fundamental set of principles. It also suggests that our understanding of reality is fundamentally shaped by the concept of systems. Everything we perceive is filtered through this framework, and our ability to describe, explain, and reason about the world is ultimately a function of how well the four components align.

Although these fundamental principles are cognitive, our cognitive skills have evolved to enable us to successfully interact with reality, grasp its opportunities, and avoid its threats. So, it is likely that these principles also reflect those of reality.

One potential tool for achieving unification is Symbolic Reasoning. This is an enhancement of set theory that allows us to represent knowledge in domains that were previously treated independently. Symbolic Reasoning can, of course, emulate traditional set theory and so it underpins mathematics. It also unifies the many branches of logic, including Boolean algebra, propositional logic, predicate logic, alethic or probabilistic logic, deontic logic (obligation, permission, etc.), epistemic logic, temporal logic, causality, etc. So, it is capable of formally expressing and manipulating any type of natural language proposition. It is also capable of expressing the dualities and other terms described in the Definitions section. Finally, Symbolic Reasoning has been axiomatised. That is, fundamental rules have been identified from which its theorems are all derived using those same rules and no other. This suggests that Symbolic Reasoning is foundational.

Some limited symbolism is used in this paper and is explained in Appendix B, but a full description of Symbolic Reasoning can be downloaded via reference (Challoner, 2022).

The four universal disciplines will now be explored in more detail.

Fundamental Systems Theory

Much of systems theory is domain specific. However, there are also fundamental principles that have universal applicability. Some of these are explained below. Many are described in more detail in Ludwig von Bertalanffy's book, "General System Theory" (Bertalanffy, 1968).

- A system at its simplest comprises three main components, its inputs, its process, and its outputs. Everything that is not a part of the system's process is a part of its environment. In the same way as the domains described in critical realism (Bhaskar, 2008), the system itself is also a part of its environment.

Figure 1. A system at its simplest.

- Systems interact with one another via their inputs and outputs. That is, the outputs from one system are always inputs to others. With notable exceptions discussed later, all systems comprise lesser component systems that are also related to one another via their inputs and outputs. Conversely, all systems are components of greater systems. Thus, systems form a nested hierarchy (Meadows, 2008). An example of a nested hierarchy is the way that molecules form cells, cells form organisms, and organisms form ecosystems.

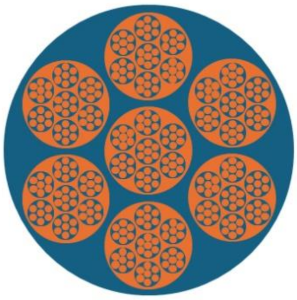

Figure 2. A nested hierarchy.

- The level of organisation or complexity of a system in this hierarchy can be defined by the number of fundamental physical particles that make up its process. As an aside, it is notable that the maximum level of organisation has increased over time since the big bang and probably continues to do so.

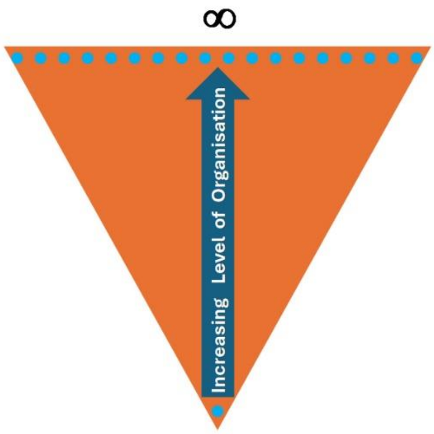

Figure 3. Levels of organisation or complexity.
The blue dots represent fundamental physical particles. Each row represents an entity comprising those particles.

- Outputs from and inputs to systems are themselves systems that, except for information, were once a part of the source system. They comprise matter, energy, or information. However, information is organised energy or matter, and matter is organised energy. So, what is transferred is organised or raw energy. Information differs from matter and energy in that it is organisation within them that can be replicated, and so, may remain in the source even if it is a part of the latter's output.
- The source system causes an existential change to its output. That is, the output is caused to exist.
- An output from a source system or an input to a destination system causes a change of state for both, unless there is a balanced flow of inputs and outputs that maintain those states.
- If the source system and destination system are both components of the same parent system, then the relationship between the two is a part of the parent system's process. If the source system or the destination system are a part of the environment rather than the parent system, then this is not so.
- If an input to a system is retained as an intact component, then the following are possible:

a) The input can be combined with other components and then output. An example is the manufacture of cars from component parts. Assembly theory may apply if an output was organised partially or entirely by its source system.

b) The input may be retained and serve a function within the main system such as the generation of outputs or self-maintenance.

- If the destination system does not retain the transferred system intact, but breaks it down into lesser components, then the transferred system experiences an existential change, i.e., it ceases to exist. However, its components can be treated as systems and employed in the manner described above.

The following example illustrates these concepts, and the terminology used. When one of an organism's cells divides, self-maintenance of the organism occurs, and it undergoes a change of state. The original cell undergoes an existential change by ceasing to exist. The two new cells are its outputs and undergo an existential change by beginning to exist. The matter and energy that comprise these new cells were once a part of the original cell, but the information content of the original cell, i.e., its genome, was replicated into the two new cells.

Causality

1. Introduction

The important features of causality are described below.

- Causality describes laws in which changes in the state or existence of an entity of one type lead to changes in the state or existence of entities of another type.
- As the Scottish philosopher, David Hume (1711 – 1776), observed, a cause and an effect are always contiguous in space and a cause always precedes its effect (Hume, 1748). So, any causal relationship comprises two entities, the cause, one of its effects, and a common feature that binds them together in space-time. He also argued that causality is not necessarily observed directly but inferred from patterns.

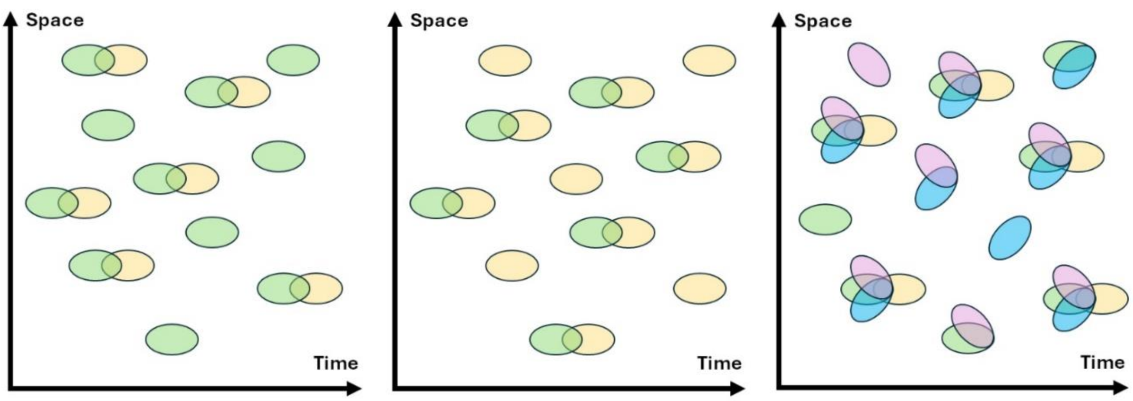

Figure 4. Causes and effects.

The green ellipses represent causes and the yellow ellipses effects. In the left hand diagram the cause is necessary for the effect, i.e., the effect cannot occur in the absence of the cause. In the central diagram the cause is sufficient for the effect, i.e. the effect always occurs in the presence of the cause. In the right-hand diagram several causes are necessary but only together sufficient for the effect.

- Causality forms chains of cause and effect. In any causal chain, causes result in effects, those effects in turn become causes that create other effects. In practice, however, more than one cause may be necessary for an effect, but only together may they be sufficient. In the absence of inhibitors, a root-like structure forms, expanding backwards in time. Also in practice, a cause may have more than one effect. Again, in the absence of inhibitors, a branch-like structure forms, expanding forwards in time. However, to simplify the explanations given in this paper a simple causal chain will be considered.
- As described in the previous section, a causal relationship can have an existential effect or result in a change of state.
- A feature of causality often overlooked is that a cause can either enable or inhibit an effect. Thus, causes can be described as enablers or inhibitors. Both proliferate in nature. An inhibitor will always prevent an effect, irrespective of the sufficiency of any enablers. In the presence of inhibitors, the root and branch-like structures mentioned above can be disrupted. Roots and branches can be pruned to just a few or even just one.
- When causal relationships between entities of one type and entities of another type are the same, and when what they hold in common is also the same, then the relationship becomes a causal law or theory. Providing there are no inhibitors, this law or theory can then be applied to predict the behaviour of the entities whenever that situation is encountered.
- Finally, a causal explanation is cause and effect traced backwards in time.

2. Systems Causality

Systems and causality are related concepts and can be combined into a single theory, referred to here as systems causality. Some of its important features are described below.

- Systems interact such that some matter, energy or information is transferred from one system's process to the next, e.g., ...Process – Transfer – Process – Transfer – Process... or, more simply, ...PTPTP... .
- Causal relationships comprise causes and their effects. Any effect can, in turn, become a cause with its own effects. So, the structure of a cause must be the same as the structure of an effect.
- Interactions between systems can be regarded as causal. Thus, some part of ...PTPTP... must comprise a cause or an effect. There are two ways in which this is possible (see Fig. 5):
    - PTP causality, in which an adjacent process, transfer, and process together form a cause or effect. In this option a cause and its effect have a system's process in common.
    - TPT causality in which an adjacent transfer, process, and transfer together form a cause or effect. In this option a cause and its effect have a transfer between systems in common.
- This is the basis for causal duality, i.e., the potential to frame causes and effects either as PTP or TPT . Depending on the perspective, a causal event may be framed as either PTP (Process, Transfer, Process), where a process alters another, or TPT (Transfer, Process, Transfer), where a system's state change is correlated with another. These perspectives allow different levels of causal reasoning: TPT for pattern recognition and PTP for process verification.

- The shared component is the basis for the requirement that a cause and its effect must share a region of space-time. This shared region is occupied by a common system process, P or by a transfer between systems, T.
- A system's process comprises component systems that are also related by PTP and TPT causality.
- Transfers between systems are also systems. This is because some matter, energy or information is transferred which comprises component systems related as described above. Some, but not necessarily all the organisation in what is transferred will have been brought about by the cause's process. If the same system is transferred from cause to effect in a chain of causality, and is steadily increasing in its level of organisation, then assembly is taking place. Thus, assembly theory applies.
- The transfer of information can also be regarded as the transfer of a system. This is because what is transferred is some energy or matter structured in a way that conveys information. The transfer still involves a physical system. For example, speech is structured energy transmitted via sound waves; writing is ink on paper or pixels on a screen, digital communication is electrical signals or photons that encode and transmit structured data.
- The function of a system's process is to produce its outputs. Failing systems tend to be the exception rather than the rule. So, in the case of TPT causality, by default and unless otherwise stated, we assume that the system is functioning as it should and is producing its outputs.
- Necessity and sufficiency are features of a system's inputs or what is transferred to it. An input may be necessary for the system's process to function and produce its outputs. Without that input the system does not function. An input may also be sufficient for a system's process to function and produce its outputs. With that input the system always functions. Normally, however, several inputs may be individually necessary but only together sufficient for a system's process to function and produce its outputs. With all of those inputs the system will always function. For example, the necessary inputs for photosynthesis are light, carbon dioxide and water. Only together are they sufficient.
- If a system is functioning and producing its outputs, then it must be receiving sufficient necessary inputs. So, in the case of TPT causality, it is also assumed by default that the system is receiving those inputs. The focus of attention in TPT causality is therefore functioning processes.
- However, different functioning processes can produce the same output. Thus, as explained by the epidemiologist, Ken Rothman, in his "Sufficient Component Cause" model, different combinations of system process can produce the same set of outputs required for an effect (Rothman, 1976). Rothman's perspective is therefore one of TPT causality in which processes are assumed to be functioning as they should. As a consequence, knowledge of what is transferred between the systems becomes unnecessary or can be overlooked.

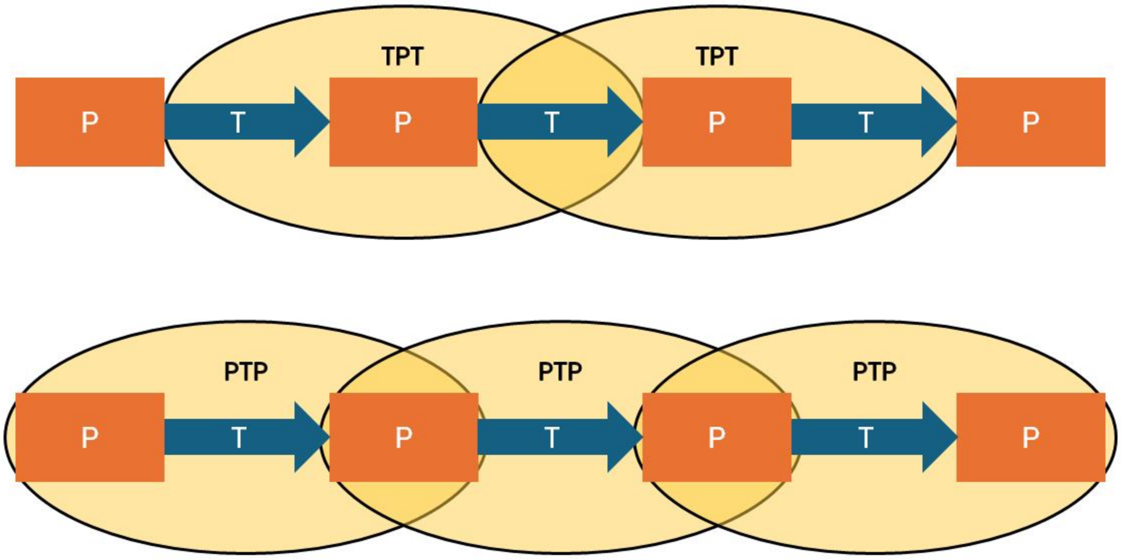

Figure 5. Systems in a causal chain.
P is a system's process. T is a system's output or input. The orange ellipses are both causes and effects. In each linked pair, the left-hand ellipse is the cause and the right-hand ellipse the effect.

In summary, both system processes and what is transferred between systems are organised entities or systems in their own right. What is taking place is the breaking of old structures and the creation of new ones. At all levels of organisation, new entities are constantly formed, whilst existing ones change their state or expire. Thus, reality comprises ever-changing forms of organisation at all levels (Holland, 1998). The unification of causality and systems theory into systems causality describes this ongoing process.

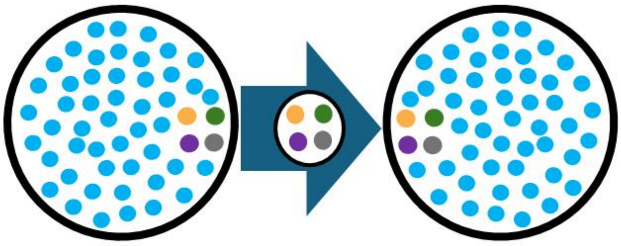

Figure 6. Systems causality as the breaking of old structures and the making of new ones.
Note that every circle in this diagram represents a system.

3. Transfer Duality

Relationships between systems are not just static links between them, but rather dynamic transfers, where the matter or energy being transferred is itself a system. A relationship doesn't just connect systems. It transforms them by transferring something physical from one to the other. This suggests a duality within the transfer whereby it can be regarded as a system or a relationship. Furthermore, every relationship, when treated as a system, inherently contains component systems within it, leading to a nested or fractal-like structure.

Note however, that transfer duality does not explain causal duality. Causal duality is asymmetrical. In any causal relationship, a transferred system process is necessarily less complex than, or as complex as, the originating system process. It cannot be more complex. A reversal of PTP to TPT or vice versa would contravene this requirement.

At the quantum level, wave-particle duality arises as a manifestation of transfer duality. Measurement collapses wave functions into definite states just as inspection collapses relationships into systems (Zeh, 1970). As system complexity increases, the relationship aspect of transfer duality becomes less dominant, and classical determinism emerges in the form of the system aspect.

4. Universality of Causality

The idea that causality is universal, i.e., applicable at all scales of reality, is often challenged by interpretations of quantum mechanics. Some argue that causality itself is emergent, meaning that it only arises at macroscopic scales and does not fundamentally exist at the quantum level.

The justification for universal causality is given in Appendix A and can be summarised as follows. Time is fundamental to causality in that a cause must always occur before its effect. At the macroscopic level, time progresses in one direction only. This is known as the arrow of time. Consequently, causality also progresses in just one direction. However, there is much evidence that, at the quantum level, time can progress in either direction, as one would normally expect in a physical dimension (Aharonov et al., 1964).

Thus, at the quantum level, causality can also occur in either direction. So, rather than causality being emergent, it is the arrow of time that emerges at higher complexity levels. As system complexity increases, entropy, which is reliant on complexity, comes into play. The macroscopic arrow of time emerges, constraining causality to a uni-directional form.

Linguistics

1. Causality as the Foundation

Causality is the engine that drives changes within systems. If causality can be observed from two perspectives, then it makes sense that natural language would evolve to reflect these perspectives. In the English language at least, this is the case:

- PTP (Process-Transfer-Process) causality describes a dynamic process. A cause or an effect comprises one system process transferring something to another. This can be described as an event, i.e., “something doing something to something”. In turn, an event is described in natural language by a non-copular proposition, e.g., “I write this text”. When PTP causes and effects are concatenated, this can be described as one event causing another.

- TPT (Transfer-Process-Transfer) causality describes structural, state-based systems, i.e., “something being (or becoming) something”. These are described linguistically by copular propositions, e.g., “this text exists (or comes into existence)”. When TPT causes and effects are concatenated this can be described as the state (or change of state) of one entity causing the same in another.

2. Natural Language as the Encoding System

Language is not just a tool for communication. It is a way of representing systems and causality symbolically. Since language must capture both events and states, it seems to have evolved multiple causal perspectives, which mirror what we are trying to describe. Thus, different sentence structures highlight different causal patterns:

- Copular propositions ("X is Y") highlight static states and classifications.
- Non-copular propositions ("X does Y") highlight dynamic processes and events.
- Modality ("X might have done Y") encodes uncertainty in causal structures.
- Counterfactuals ("If X had happened, Y would have happened") encode alternative causal models.

However, natural language is an informal language and incorporates many linguistic shortcuts. So, when translating it into the more formal language of logic, we need to be aware of these.

3. Linguistic Shortcuts and Ambiguity in Natural Language

Natural language is efficient, allowing speakers to communicate complex ideas with minimal effort. However, this efficiency comes at the cost of ambiguity, as languages often rely on shortcuts, contextual inference, and implicit meaning rather than fully explicit structures. These shortcuts, while useful in everyday communication, can create interpretational challenges, especially in fields such as formal logic, artificial intelligence, legal discourse, and cross-cultural communication. Below, we explore key types of linguistic shortcuts that contribute to ambiguity.

One of the most common sources of ambiguity is ellipsis, where words are omitted because they are assumed to be understood from context. While this makes speech and writing more concise, it also forces the listener or reader to infer the missing elements. For example, in the sentence "If you want to go, I will take you," the destination is left unspecified, requiring additional context to resolve the meaning. Similarly, zero anaphora, a more extreme form of ellipsis, omits not just words but entire subjects or objects, as in "Gave it to her." Without further context, the sentence leaves the agent, object, and recipient ambiguous.

Pronoun reference (anaphora) is another significant source of ambiguity. Because pronouns such as he, she, it, they replace nouns in discourse, their referents must be inferred. In the sentence "John told Mark he should study more," it is unclear whether he refers to John or Mark. Similarly, deictic expressions, such as this, that, here, there, now, then, depend on the speaker's perspective and can be ambiguous without additional context. The phrase "Let's meet there at 5," for instance, leaves both the location and time zone unspecified.

Words with multiple meanings further complicate interpretation. Polysemy occurs when a single word has multiple related meanings, such as 'bank,' which can refer to a financial institution or the side of a river, both involving a sense of storage or accumulation. More problematic is homonymy, where identical words have completely unrelated meanings, such as 'watch,' which can refer to a timepiece or the act of observing, two meanings with no semantic connection. In both cases, context is required to disambiguate the intended meaning, but even with context, ambiguities may persist, leading to misinterpretations.

The structure of a sentence itself can introduce ambiguity through syntactic, i.e., grammatical, ambiguity. A sentence such as "Flying planes can be dangerous" could mean either that the act of flying planes is dangerous or that planes that fly are dangerous. Likewise, "She saw the man with binoculars" could mean either that she used binoculars to see the man or that the man she saw was holding binoculars. Such ambiguities arise because natural language lacks formal markers to explicitly indicate which syntactic structure should be preferred.

Another type of shortcut that leads to ambiguity is metonymy, where a term is used to refer to something closely related rather than explicitly stated. For example, "10 Downing Street issued a statement" does not mean that the physical building made a statement, but rather that a representative of the U.K. government did. While such expressions are intuitive to native speakers, they can create confusion in machine translation and formal reasoning systems. Similarly, idiomatic expressions introduce non-literal meanings that require cultural knowledge to interpret correctly. The phrase "kick the bucket," for instance, means to die, yet nothing in the literal meanings of kick or bucket suggests this interpretation.

Conversational speech often relies on implicature, where meaning is suggested rather than explicitly stated. For example, if Speaker A asks, "Are you coming to the party?" and Speaker B responds, "I have to work early tomorrow," the intended meaning is likely that B will not attend the party, even though this is not explicitly stated. Such unstated assumptions rely on shared cultural norms and background knowledge, making them highly efficient but potentially ambiguous when cultural expectations differ. Similarly, vague expressions, such as "That's a big problem," require further specification. Big in what sense? Financially? Logistically? Morally?

Finally, even punctuation can contribute to ambiguity. Scope ambiguity arises when the placement of punctuation affects meaning, as in "Let's eat, Grandma!" versus "Let's eat Grandma!" Similarly, the sentence "I love cooking my family and my pets." could be misinterpreted as advocating cannibalism if commas are omitted. Such ambiguities are especially problematic in legal texts, contracts, and computational linguistics, where precision is paramount.

In summary, while natural language is a powerful and flexible communication tool, its reliance on shortcuts, implicit meanings, and structural ambiguities makes it inherently prone to misinterpretation. Understanding these mechanisms is crucial for linguistic analysis, artificial intelligence, legal interpretation, and cross-cultural communication, as it enables the development of strategies to mitigate misunderstandings and enhance clarity.

4. Combining Causal Relationships in Natural Language

Natural language provides multiple ways to express and combine causal relationships, allowing speakers to convey complex cause-effect structures with efficiency. Unlike formal logic, where causal relationships follow well-defined syntactic rules, natural language is highly flexible, permitting a variety of structures to link causes and effects. This flexibility enhances communication but also introduces ambiguity in how causal relations are understood and interpreted. The key methods by which causal propositions are combined in natural language include causal chaining, nesting, conjunction, disjunction, and counterfactual reasoning.

One of the most common ways to structure causality in natural language is through causal chaining, where multiple events are linked in a sequential cause-effect relationship. This allows for stepwise explanations, where each event leads to the next in a logically connected sequence. For example, in the sentence "The heavy rain caused flooding, which in turn led to road closures, resulting in delays," the causal chain progresses from rain to flooding to road closures to delays. While this structure provides a clear narrative of events, it can also introduce ambiguity regarding whether all intermediate events were necessary or whether some were merely coincidental. This issue is particularly relevant in scientific, legal, and forensic contexts, where distinguishing between direct and indirect causation is crucial.

In addition to causal chaining, nesting of causal relationships is another way that natural language structures causality. Nested causality occurs when one causal statement is embedded within another, forming a hierarchical structure. For instance, in the sentence "Because the city failed to upgrade drainage systems, the heavy rain caused flooding", two levels of causality are present: (1) the primary cause, i.e., failure to upgrade drainage systems, and (2) the secondary cause, i.e., rain leading to flooding. This nesting allows for multi-layered explanations, but it also makes it difficult to assign causal responsibility, particularly in policy discussions and legal reasoning, where determining ultimate causation is often contentious.

Another way that causal propositions are combined in natural language is through conjunction, where multiple causes are presented as jointly responsible for an effect. In the sentence "The accident happened because the driver was speeding and the road was icy," the causes, speeding and road conditions, are treated as co-contributors to the outcome. However, natural language does not always specify whether each cause was independently sufficient or whether they only contributed in combination. In formal logic, such a relationship might be expressed as (Cause A ∧ Cause B) → Effect C, but in natural discourse, these distinctions are often left implicit. This can create interpretational challenges in fields such as legal liability and forensic analysis, where responsibility must be assigned based on precise causal attribution.

Conversely, causal relationships can also be combined using disjunction, where multiple alternative causes are suggested, but not all are necessarily responsible for the outcome. For example, in the sentence "The power outage was caused either by a technical failure or by human error", the disjunctive structure implies that only one of these factors is the true cause, but without further information, it is unclear which one. This form of causal reasoning is frequently used in diagnostic settings, such as medicine and engineering, where multiple hypotheses must be evaluated before determining the actual cause of a problem. The lack of explicit probabilistic weighting in natural language makes it difficult to quantify the likelihood of each alternative cause, a limitation that formal causal models attempt to address.

Beyond direct causal assertions, natural language also allows for counterfactual causality, in which an event is described in terms of what could have happened under different conditions. Counterfactual reasoning is often framed using conditional constructions such as "If the driver had braked sooner, the accident could have been avoided." Unlike direct causal statements, counterfactuals deal with hypothetical scenarios rather than observed realities, making them particularly useful in legal argument, risk assessment, and moral reasoning. However, because counterfactuals are based on inferred alternative outcomes, they introduce a degree of speculation, which can complicate causal attribution in empirical sciences and legal cases.

While natural language provides great flexibility in expressing causal relationships, this very flexibility introduces significant ambiguity. Some of the main sources of causal ambiguity include implicit vs. explicit causality, where some cause-effect relationships must be inferred rather than directly stated; proximity of causes and effects, where long causal chains make it unclear which factor is the primary cause; and multiple possible interpretations, where the same causal statement can be understood differently depending on context. For example, in the sentence "The fire spread because the firefighters arrived late," the lateness of the firefighters could be interpreted as the direct cause of the fire spreading, or merely as an aggravating factor in an already unfolding event. Such distinctions are critical in legal, ethical, and scientific discourse, where different interpretations can lead to vastly different conclusions regarding responsibility and causation.

In summary, natural language allows for a variety of ways to combine causal relationships, including causal chaining, nesting, conjunction, disjunction, and counterfactual reasoning. While these structures enhance expressiveness and efficiency, they also introduce interpretational challenges, particularly in fields requiring precise causal analysis, such as law, artificial intelligence, and scientific modelling. Understanding the mechanisms behind causal ambiguity in natural language is essential for improving computational models of causality, knowledge representation, and automated reasoning systems. By incorporating formalised methods of disambiguation, future research can bridge the gap between natural language understanding and formal causal reasoning, enabling more accurate interpretations of causality in human discourse.

Logic

1. Introduction

Logic is essentially a refined and rule-based form of language designed to make reasoning explicit and error-free. It provides:

- Rules of inference (how we derive valid conclusions from premises).
- Formal structures for causality (e.g., modal logic, temporal logic, probabilistic logic).
- A way to model different causal perspectives (e.g., Bayesian logic models uncertainty, while classical logic assumes determinism).

Since logic is derived from language, and language encodes causality, logic can be seen as a structured refinement of our causal understanding of systems. However, translation from natural language to formal logic involves translating both what is said and also what is not said but rather implied.

2. The Practical Difficulties of Traditional Logic

Traditional logic, while providing a rigorous foundation for formal reasoning, faces significant practical challenges when applied to real-world problems. One of its primary limitations is rigidity. Classical logic operates within a strict binary framework where statements are either true or false, leaving little room for the uncertainty, context-dependence, and likelihoods of truth that characterise human reasoning and complex systems. This binary structure makes it difficult to model probabilistic reasoning, temporal dependencies, and causal interactions, which are essential for scientific inquiry, artificial intelligence, and decision-making in dynamic environments.

Furthermore, while various extensions of classical logic, such as modal logic, fuzzy logic, temporal logic, and probabilistic logic, have been introduced to address these limitations, they do not integrate well with one another. Each extension introduces its own specialised symbolism and inference rules, leading to a fragmented landscape where different logical systems cannot be easily combined into a single framework. For example, a system that needs to reason about uncertainty (probabilistic logic), causality (causal logic), and time (temporal logic) would require complex hybrid models that lack internal coherence, making them computationally inefficient, difficult to interpret, and impractical for large-scale applications.

Symbolic Reasoning – The Tool for Unification

1. Introduction

The challenges of traditional symbolic logic underscore the need for a more unified and expressive reasoning system. Symbolic Reasoning was developed to overcome these issues, providing a single, coherent framework capable of handling structured systems, dynamic relationships, uncertainty, and causal dependencies in an integrated manner. By redefining how logical structures interact and allowing for more fluid, context-sensitive interpretations, Symbolic Reasoning offers a practical alternative to the fragmented nature of traditional formal logic.

Symbolic Reasoning is the ideal tool to unify the universal disciplines because, as an enhancement or generalisation of set theory, it:

- Bridges logic, language, and systems.
- Allows for structural and dynamic representations, which aligns with how causality and systems operate.
- Works for both mathematical and natural language propositions, meaning it can serve as a universal reasoning system.

2. A Summary of Symbolism used in Symbolic Reasoning

Some of the very basic symbolism used in Symbolic Reasoning and how it relates to systems theory, causality and natural language, is described below. This is, however, merely a taster to demonstrate its potential. More detail is provided in Appendix B.

2.1. Modified Set Theory: The Dual Nature of Sets

Traditional set theory treats sets as singular entities. Symbolic Reasoning introduces a modification in which a set can be perceived in two ways:

- A set as a singular entity, symbolised $\mathbf{a}^1$, retains its conventional meaning.
- A set as a plural collection of entities, symbolised **a**, allows natural language alignment, e.g., "Apes" or **a** vs. "The apes" or $\mathbf{a}^1$.

This duality permits logical expressions that more accurately represent linguistic structures and systemic relationships. It also reflects the holist / reductionist duality of systems theory.

2.2. The Duality of Objects and Relationships

The symbolism used for sets reflects transfer duality, i.e., the same symbolism can be used both for sets of systems and for sets of relationships. Thus, for example:

- A set of relationships as a singular entity, e.g., instances of “something climbing something”, can be symbolised $\mathbf{a}^1$.
- A set of systems as a singular entity, e.g. “the climbers”, can also be symbolised $\mathbf{a}^1$.

The same is true when these sets are treated as plural collections of entities. Thus, a plural collection of relationships and a plural collection of systems can both be symbolised **a**.

2.3. Structural Relationships or Sub-relationships

A number of special relationships are used to connect other relationships and objects to form structure. Notable among these are **V**, **S** and **Q**.

All relationships have a direction. **V** operates on a relationship to reverse that direction. Thus, if $\mathbf{c}^1$ is a relationship in one direction, $\mathbf{Vc}^1$ is the relationship in the other. Among other benefits, this allows the active and passive tenses of natural language to be symbolised.

All relationships are between two entities. Because relationships have a direction, this can be used to define those entities as the subject or object of a relationship, just as in a natural language sentoid. These entities can be defined from a relationship in the following ways.

- $\mathbf{Sc}^1$ is the subject of the relationship $\mathbf{c}^1$. **Sc** are the subjects of the relationships **c**.
- $\mathbf{Qc}^1$ is the object of the relationship $\mathbf{c}^1$. **Qc** are the objects of the relationships **c**.

S and **Q** can be operated on by **V** to reverse their direction and define a collection of relationships from a subject or object. Thus:

- $\mathbf{(VS)a}^1$ **or** $^{V}\mathbf{Sa}^1$ is the plural collection of relationships with $\mathbf{a}^1$ as their subject.
- $\mathbf{(VQ)b}^1$ **or** $^{V}\mathbf{Qb}^1$ is the plural collection of relationship with $\mathbf{b}^1$ as their object.

$\mathbf{a}^1$ and $\mathbf{b}^1$ can of course be replaced by **a** and **b**.

Note that, because it reverses relationships, **V** also reverses the subject and objects of the relationship. The subjects become objects and vice versa.

2.4. Conjunctions and Disjunctions

Conjunction and disjunction are logical terms. Their equivalents in set theory are intersection and union. The union of two sets comprises the members of either. The intersection of two sets comprises the members of both. This allows statements in natural language that use “and” and “or” to be symbolised.

In Symbolic Reasoning only sets as plural collections, e.g., **a** or **b**, are normally conjoined and:

- the conjunction or intersection of two sets **a** and **b** is symbolised **a.b** or **ab**.

Sets as singular entities can only be conjoined if they are the same, i.e., $\mathbf{a}^1\mathbf{.a}^1 = \mathbf{a}^1$. Otherwise, the result is the null set, Ø.

In Symbolic Reasoning, only sets as plural collections can be disjoined and:

- the disjunction or union of two sets **a** and **b** is symbolised **a + b**.

Sets as singular entities can be disjoined but the result is a set as a plural collection of entities, e.g., $\mathbf{a}^1 + \mathbf{b}^1 = \mathbf{c}$.

2.5. Propositions

Natural language propositions can be expressed using the symbolism described above. For example:

- $^{V}\mathbf{Sa}^1$ represents all relationships where "The apes" are the subject.
- $^{V}\mathbf{Qb}^1$ represents all relationships where "The bananas" are the object.

- $^{V}Sa^{1}.c.^{V}Qb^{1}$ represents all relationships in which "The apes consume the bananas," where **c** denotes the verb or action.

Note that $^{V}Sa^{1}.c.^{V}Qb^{1}$ is a collection of relationships but can also be understood as a collection of systems. No function is needed to convert a relationship to a system and vice versa. Rather, an expression like $^{V}Sa^{1}.c.^{V}Qb^{1}$ adequately describes the system transferred from a^{1} to b^{1}.

Because $^{V}Sa^{1}.c.^{V}Qb^{1}$ is a plural collection of relationships or systems its symbolism can be simplified to, for example, **p**. Note that **p** is a plural collection because the same relationship between a^{1} and b^{1} can occur at different times.

2.6. Truth and Falsity

The truth or falsity of a proposition can be expressed by equating it to the null set, ∅, as follows:

- $^{V}Sa^{1}.c.^{V}Qb^{1} = \emptyset$ represents "It is false that the apes consume the bananas"
- $\sim(^{V}Sa^{1}.c.^{V}Qb^{1} = \emptyset)$ represents "It is true that the apes consume the bananas"

2.7. Operators and Implication

The subset operator (⊆) serves a dual role:

- Between entities: "Apes are mammals" or $a \subseteq m$
- Between propositions: "If it rains, the ground is wet" or $p \subseteq q$

This unification of categorisation and implication strengthens logical expressiveness while maintaining consistency.

2.8 Alternative forms of Expression

Propositions can be described using different forms of symbolism. Symbolic Reasoning includes rules for converting between them. For example, "It is true that the apes consume the bananas" can be expressed either as $\sim(^{V}Sa^{1}.c.^{V}Qb^{1} = \emptyset)$ or as $a^{1} \subseteq c * b^{1}$.

The latter form allows propositions to be easily quantified, e.g., "some apes consume (some) bananas" or $\sim(a \subseteq \sim(c * b))$, "not all apes consume (some) bananas" or $\sim(a \subseteq c * b)$, and so on.

2.9. Integration of Probability

Symbolic Reasoning incorporates probabilistic logic by allowing truth values to be expressed in terms of certainty, uncertainty, possibility and impossibility. For example:

- $(a \subseteq c * b) = E$ represents "It is certain that apes eat bananas."
- $\sim((a \subseteq c * b) = \emptyset)$ represents "It is possible that apes eat bananas."

where **E** is the universal set as a collection of entities and ∅ is the null set. This extends traditional logic into probabilistic reasoning, making it suitable for real-world uncertainty modelling. It is also possible to symbolise numerical probability using symbolism not described here.

2.10. The Combination and Manipulation of Propositions

Symbolic Reasoning has many axiom-based rules for combining propositions and deducing conclusions from them. For example:

- Aristotle's classical syllogism; "All Greeks are men and all men are mortal, therefore all Greeks are mortal" can be symbolised **(a ⊆ c).(c ⊆ b) ⊆ (a ⊆ b)**,
- where **(a ⊆ c)** means "All Greeks are men" (Premise)
- and **(c ⊆ b)** means "All men are mortal" (Premise)
- and **(a ⊆ b)** means "All Greeks are mortal" (Conclusion)

Note that axioms, theorems and laws in Symbolic Reasoning use the same symbolism as any other statement. This implies that the discipline is foundational.

2.11. Causal Representation

Finally, further symbolism, that for the sake of brevity is not described here, allows causal laws to be described. For example:

- **(@a)E^{1} ⊆ {⊇}Bb** represents "An event **a** is sufficient to cause an event **b**."
- **Ba ⊆ {⊆}(@b)E^{1}** represents "An event **a** is necessary to cause an event **b**."

Where **a** and **b** can be replaced by more specific symbolism such as **^{V}Sa^{1}.c.^{V}Qb^{1}**.

This makes Symbolic Reasoning particularly suited for scientific modelling, AI decision-making, and systems theory.

Discussion - Implications and Applications

The Unified Universal Disciplines Hypothesis doesn't just offer a scientific hypothesis. It also has deep practical, philosophical, and explanatory implications.

1. Artificial Intelligence and Cognitive Science

If the UUDH framework is correct, then human intelligence is essentially a "systems processor" that integrates causal reasoning, language, and logic. AI models that truly "understand" might need to integrate all four components rather than just language processing. True artificial intelligence should not just be a statistical language processor. It must incorporate causal reasoning and logical structures (McCarthy & Hayes, 1969).

While causal AI models such as Pearlian Causal Networks have made strides in integrating causality into AI (Pearl, 2018), they still lack a fully unified framework that connects logic, language, and systemic causality. UUDH provides a broader foundation for integrating these elements into AI architectures, ensuring that AI reasoning mirrors human-like thinking.

2. A More Precise Linguistic Theory

If natural language evolved to reflect causal perspectives, then studying linguistic structures could reveal deeper truths about causality. This could lead to a new approach to natural language understanding. In particular, the analysis of historical texts may shine some light on the evolution of human reasoning abilities.

3. Bridging the Sciences and Humanities

Physics, biology, economics, and the social sciences all study systems at different levels of complexity, yet they often operate in isolation from one another. At the same time, logic, linguistics, and causality provide the structural tools through which we describe and reason about these systems. The Unified Universal Disciplines Hypothesis (UUDH) offers a framework that integrates these perspectives, creating a conceptual bridge between the humanities and the sciences.

One of the key areas where this integration is evident is in human systems, which are composed of individuals and groups of people working together with a common function. These systems, like any others, require inputs that sustain and regulate their processes. These inputs can be understood as causal enablers or inhibitors, meaning that they either facilitate or hinder system function. In human interactions, these enablers and inhibitors can be framed as satisfiers and contra-satisfiers, i.e., external elements that either meet or obstruct a system's needs.

Crucially, human relationships can also be analysed through the lens of causal transfers, much like any other system. A relationship between individuals or groups can be represented as "something giving something to something", where the given entity is a satisfier or contra-satisfier. This aligns naturally with PTP causality. Using the Symbolic Reasoning framework, it can be expressed, for example, as $\mathbf{a}^1\subseteq (\mathbf{g}*\mathbf{c}^1)*\mathbf{b}^1$, where $\mathbf{a}^1$ is the giver, $\mathbf{c}^1$ is what is given, i.e., a satisfier or contra-satisfier, and $\mathbf{b}^1$ is the recipient.

However, unlike non-human systems, humans possess agency, allowing them to take satisfiers rather than just receiving them passively. This introduces a second form of causal transfer, one in which an individual actively takes something from another. In symbolic terms, taking is the reverse of giving (**g**). It can therefore be symbolised **Vg** or $^{V}\mathbf{g}$. Thus, "something taking something from something" can, for example, be symbolised by $\mathbf{a}^1\subseteq (^{V}\mathbf{g}*\mathbf{c}^1)*\mathbf{b}^1$ and the passive equivalent, "something having something taken from it by something", by $\mathbf{b}^1\subseteq {}^{V}(^{V}\mathbf{g}*\mathbf{c}^1)*\mathbf{a}^1$.

This framing demonstrates how human interactions, often considered too complex or qualitative for formal modelling, can be rigorously structured using the same principles that govern other systems. By recognising agency and intentionality as structured causal processes, UUDH provides a mathematically grounded approach to analysing both human and non-human systems.

Through this framework, the traditional divide between the sciences and humanities begins to dissolve, revealing a shared structural foundation that governs both natural and human-driven systems.

4. A New Perspective on Reality

If our perception of reality is shaped by how we organise it into systems, then understanding alternative causal perspectives could lead to new ways of thinking. This could challenge long-held beliefs about determinism, free will, and the nature of knowledge.

On the one hand, if all formal reasoning systems emerge from the same underlying structure, then reality itself may be fundamentally systemic and causal in nature. On the other hand, if our cognition is structured by UUDH principles, then all knowledge must be systemic, causal, and logically structured at some level. This may mean that human perception of reality is constrained by the formal structures that underlie UUDH.

5. Potential to Explain Particle Wave Duality

A fundamental challenge in quantum mechanics is explaining wave-particle duality, where quantum entities, such as electrons and photons, exhibit both particle-like and wave-like behaviour depending on how they are measured. Traditional interpretations often treat this duality as an inherent paradox, leading to multiple explanatory frameworks such as the Copenhagen interpretation and pilot-wave theory. However, an alternative perspective emerges when applying causality's transfer duality, i.e., its system/relationship duality, which suggests that wave-particle duality may not be an intrinsic property of quantum entities but rather a reflection of how causality manifests differently depending on the mode of observation.

Under the UUDH framework, a particle can be viewed as a system, meaning it is understood as a localised, structured entity with definite properties, e.g., position or momentum. In contrast, a wave represents a relationship, meaning it describes the distributed, non-local interactions that a quantum system has with its environment. The wave function, then, is not an inherent feature of the particle itself but a relational structure that governs its potential interactions with other systems. Measurement acts as a selection mechanism, collapsing the relational wave-like behaviour into a structured system-like state. This is much like transfer duality, in which the observation of a causal relationship transforms it into a system.

This perspective aligns with experimental observations. For example, in the double-slit experiment, when no measurement is performed on which path the wave-particle takes, the wave-particle is understood relationally, leading to an interference pattern generated by wave-like behaviour. However, when a measurement is introduced, causality is effectively "collapsed" into a structured, system-like state, forcing the wave-particle to behave as a discrete entity. From this point of view, wave-particle duality is not an inherent contradiction but a consequence of transfer duality in causality. This interpretation offers a more unified way of understanding quantum behaviour by embedding it within a broader causal framework, linking quantum mechanics with systems theory and complex causality.

6. Potential to Explain Emergent and Vanishing Properties

One of the central challenges in understanding complex systems is explaining why certain properties emerge at higher levels of organisation while others vanish as complexity increases. Traditional reductionist approaches struggle with this because they assume that all properties of a system can be derived directly from the behaviour of its individual components. However, by applying transfer duality, we can interpret emergent and vanishing properties as consequences of a shifting dominance between transfers as systems and transfers as relationships.

In systems with few interacting components, causality is primarily system-based. That is, properties are determined by discrete entities and what is physically transferred between them. We have the cognitive capacity to view causality in this way. In such cases, the behaviour of the system is relatively straightforward to predict, as the causal structure is relatively simple and rule-governed. However, as the number of interacting components increases, relationships between them become more complex. At this stage, our cognitive capacity is exceeded, and relationship-based causality begins to dominate, giving rise to emergent properties, i.e., characteristics that do not exist at the level of individual components but arise from the structure of interactions among them.

Conversely, as systems continue to increase in complexity, certain lower-level properties that were once fundamental begin to vanish. This occurs because, at higher levels of organisation, system-based causal transfers are increasingly abstracted away, and new relationship-based transfers supersede them. A clear example of this can be seen in fluid dynamics. At the molecular level, the motion of individual water molecules is governed by Newtonian mechanics, but as complexity increases and our cognitive capacity becomes overwhelmed, individual molecular trajectories cannot be considered. Instead, what emerges is a higher-order, collective behaviour, describable through statistical mechanics and continuum equations, e.g., Navier-Stokes equations. The individual deterministic movement of molecules vanishes, giving way to a system governed by emergent fluid properties such as turbulence, viscosity, and wave dynamics.

This perspective suggests that emergent and vanishing properties are two sides of the same causal transition. As complexity increases, systems-based transfer causality gives way to relationship-based transfer causality which in turn gives rise to new, higher-level properties, while simultaneously causing previous, lower-level ones to lose their explanatory power. In this way, transfer duality provides a coherent framework for understanding why emergent and vanishing properties occur simultaneously in complex systems, offering a more structured explanation for one of the most fundamental puzzles in science.

7. Clarifying the Roles of TPT, PTP, and Guided Causality

Causal reasoning operates at different levels depending on whether we are identifying patterns, verifying causal mechanisms, or actively guiding outcomes. The Unified Universal Disciplines Hypothesis (UUDH) distinguishes between three key causal approaches:

1. **TPT Causality** is used for pattern recognition, correlating system states and forms the basis for hypothesis generation.
2. **PTP Causality** is used for causal verification, ensuring that observed connections are causal and not just correlations.
3. **Guided Causality** is used for agent-driven interventions, in which they actively shape causal structures to achieve specific goals.

By understanding how these causal forms interact, we can better model complex systems across both the natural and human sciences.

7.1. TPT Causality: Recognising Patterns and Correlations

TPT (Transfer, Process, Transfer) causality is best suited for detecting correlations between system states. It allows us to identify patterns that suggest a relationship between observed conditions. However, TPT alone does not confirm causality. The underlying transfers (T) may be unknown or inferred rather than directly observed. This aligns with Rothman's model, where causal inference is often made through correlations between observed states (P) without necessarily understanding the exact transfers (T) involved (Rothman, 1976). It also aligns with Hume's observation that causality is often inferred from patterns rather than directly observed (Hume, 1748).

For example, in a medical diagnosis, the doctor observes that patients with a particular genetic marker (P) frequently develop a specific disease state (P). The biological transfer mechanisms (T) may be unknown, but the pattern suggests a potential causal link. TPT reasoning detects this pattern, forming a hypothesis about causality.

Thus, TPT helps us recognise system-wide patterns, even when specific causal mechanisms remain unclear.

7.2. PTP Causality: Verifying Causal Mechanisms and Process Evolution

PTP (Process, Transfer, Process) causality is necessary for confirming that an observed correlation represents a true causal relationship. Unlike TPT, PTP tracks interactions between entities over time, ensuring that a process (P) actively alters another process (P) through a transfer (T).

For causal verification, either: the transfer (T) must be directly observed, or strong empirical evidence must confirm that similar processes (P) consistently produce the same transfer (T) and effect (P).

For example, in a laboratory experiment on drug effectiveness, researchers may introduce a chemical compound (P) to a cell culture (P) and observe a change in cell behaviour. To confirm causality, they must determine what was transferred (T), i.e., whether it was a biochemical reaction, molecular binding, or another mechanism. Even if the specific details of T remain unknown, empirical consistency indicates causality.

Thus, PTP is required to verify that a process actively changes another process, providing a reliable mechanism for causal inference.

7.3. Guided Causality: Agent-Based System Intervention

Beyond analysing causality, intelligent systems and human decision-makers actively intervene to manipulate events toward desired outcomes. This introduces the third category of Guided Causality, which extends beyond merely observing relationships and involves controlling causal structures.

For example, in medical treatment and policy planning, a doctor does not just diagnose a disease (TPT) or understand its mechanism (PTP). They intervene by prescribing medication to alter the causal trajectory toward recovery. Similarly, policymakers use economic models to predict future trends (PTP) but also design policies (Guided Causality) to optimise social outcomes.

This distinguishes observational causality (TPT/PTP) from causality as an active tool for system control.

7.4. Conclusion

By integrating TPT (pattern recognition), PTP (causal verification), and Guided Causality (intervention and control), UUDH provides a comprehensive framework for causal analysis across multiple disciplines.

8. Potential to Explain Creative Thinking and Mystical Reasoning

When problem solving, TPT (Transfer, Process, Transfer) causality allows us to make connections. Frequently, those connections appear as inspirations or Eureka moments, and TPT analysis seems therefore to be a largely unconscious process. However, the inspirations it provides are often incorrect. PTP (Process, Transfer, Process) causal analysis, on the other hand, is a far more deliberate process and is therefore largely conscious. Using this PTP we can verify or refute the inspirations provided by TPT. This would suggest that TPT reasoning evolved in humans before PTP. However, both TPT and PTP reasoning are essential components of human creativity.

The distinction between TPT and PTP causality also provides insight into the historical prevalence of mystical reasoning. In early human thought, causality was often inferred from observed state transitions rather than from an understanding of underlying transfer mechanisms. This aligns with TPT reasoning, where a state or change of state in one system process leads to a state or change of state in another without requiring knowledge of what is physically transferred between them. Such reasoning is evident in sympathetic magic, where superficial similarities between cause and effect were assumed to imply causal connections, for instance, the belief that consuming rhino horn enhances male potency due to its shape, hardness and strength. Similarly, the Doctrine of Signatures in early medicine held that the shape or colour of a plant determined its healing properties, such as the idea that walnuts improve brain function due to their resemblance to the human brain. These causal assumptions, though empirically unfounded, were based on pattern recognition rather than mechanistic explanation. As scientific thought evolved, PTP reasoning became dominant, allowing for the development of predictive, mechanistic models that required an understanding of what is transferred between systems processes. However, remnants of TPT-style reasoning persist in modern superstitions, pseudoscience, and alternative medicine, highlighting how both forms of causal modelling continue to shape human understanding.

9. Potential to Explain the Evolution of Scientific Thought

Throughout history, shifts in scientific thought have coincided with transformations in causal modelling. Early scientific paradigms, such as Aristotelian physics, relied on TPT (Transfer, Process, Transfer) reasoning, focusing on causes and effects as observed states and state changes rather than modelling dynamic processes. The Scientific Revolution marked a fundamental shift toward PTP (Process, Transfer, Process) reasoning, as Newtonian mechanics introduced deterministic causal laws that allowed for precise prediction rather than mere post hoc explanation. The 19th-century development of thermodynamics and statistical mechanics blended TPT and PTP, incorporating both equilibrium-based state transitions and process-driven system evolution. In the 20th century, quantum mechanics and relativity challenged classical causal assumptions, requiring a hybrid model where quantum measurement aligns with TPT (discrete state changes), while wavefunction evolution follows PTP (continuous process evolution). This historical pattern suggests that causal modelling is not static but adapts to the needs of scientific inquiry, demonstrating how TPT and PTP represent distinct yet complementary approaches to understanding change.

10. Potential for the Derivation of Deeper Rules

While this paper presents a framework for understanding Transfer Duality, Causal Duality, Set Duality, and Wave-Particle Duality, it is likely that these dualities are governed by a deeper set of fundamental rules. Given that Symbolic Reasoning has already demonstrated the ability to unify logic, language, and causality, it may provide a pathway toward formally deriving these rules in a future study.

Testing the Hypothesis

While UUDH provides a compelling framework, it is important to consider possible counterarguments. Some may argue that the connections between systems, causality, language, and logic are mere cognitive artifacts rather than reflections of universal structures in reality. Additionally, empirical tests might reveal exceptions where these domains do not align perfectly.

To validate UUDH, we need empirical tests and theoretical exploration that transcend specialist disciplines. Some aspects have already been explored through Symbolic Reasoning, but further interdisciplinary testing is necessary to fully establish the hypothesis.

The following provide a multi-disciplinary approach to testing UUDH. While Symbolic Reasoning has already provided logical validation, further empirical work, across linguistics, cognitive science, and AI, could fully establish UUDH as a unifying model for causality, language, and systems theory or suggest improvements.

1. Linguistic Prediction

If UUDH is correct, then causal relationships in natural language should structurally mirror formal logical and systems models.

Symbolic Reasoning has already demonstrated that causal expressions can be logically represented in a formal system. However, a broader linguistic analysis could test whether:

- Causal expressions in multiple unrelated languages conform to universal formal structures derived from systems theory.
- Historical language evolution reflects a shift in causal perspective, supporting the transition from TPT to PTP and a merger of both.

Potential Empirical Test: A key question for future research is whether certain languages, particularly in indigenous and historical oral traditions, encode causality in ways that do not fit the TPT/PTP model. Addressing these concerns through cross-linguistic analysis and computational modelling will be crucial for further refining the hypothesis and either determining or confirming universal causal structures.

2. Logical Prediction

If UUDH holds, then formal logic should seamlessly integrate with causal models and systems dynamics. Symbolic Reasoning has already demonstrated how logical inference can be adapted to describe systems interactions. However, additional validation could come from:

- Comparing logical proof systems (e.g., modal, temporal, probabilistic logic) with causal inference frameworks (e.g., Bayesian networks, structural causal models).
- Testing whether complex systems (e.g., nonlinear dynamics) can be fully expressed using logical structures without additional assumptions.

Potential Empirical Test: Mathematical analysis of whether UUDH provides a unifying formalism that bridges traditional logic and dynamic systems modelling.

3. Cognitive Prediction

If UUDH is correct, the human brain should process causality, logical reasoning, and systems relationships using overlapping neural structures. Some existing studies suggest overlap in neural activation when processing logic, causality, and complex systems. However, additional research could:

- Use fMRI and EEG studies to analyse whether brain regions involved in logical reasoning (prefrontal cortex), causal inference (temporal-parietal junction), and systemic thinking (default mode network) show shared activation patterns.
- Compare neurological activity when engaging in formal logical deduction vs. systems/causal reasoning to determine if a common UUDH processing network exists.

Potential Empirical Test: fMRI study on neural overlap when subjects engage in logical proofs, causal reasoning, and systems problem-solving.

4. AI & Computational Prediction

If UUDH accurately describes reality, then AI systems trained using it should outperform purely statistical models in both:

- Logical reasoning tasks (e.g., theorem proving, argument validation).
- Language comprehension (e.g., causal inference in natural language).

Symbolic Reasoning already suggests a more structured approach to integrating systems, logic and causality, but experimental AI models could test whether:

- AI trained with causal, systems and logical models outperforms purely statistical natural language processing models in tasks requiring deep reasoning.
- AI systems that incorporate UUDH principles demonstrate superior generalisation, adaptive problem-solving, and error correction.

Potential Empirical Test: Developing AI models based on UUDH principles and benchmarking them against existing AI frameworks in causal inference and logical reasoning tasks.

Conclusion

As can be seen from the discussion UUDH has considerable and diverse explanatory power. The unification of systems, causality, natural language, and logic represents a promising approach to developing a more comprehensive understanding of human cognition and external reality. By integrating these traditionally separate fields, we can enhance our ability to reason about complex systems in a coherent and structured manner. Symbolic Reasoning offers a powerful tool for this integration. However, the approach is hypothetical, and empirical testing is needed to verify it.

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Appendix A: Universal Causality and the Emergent Arrow of Time

Causality and time are fundamentally linked. In classical physics, causes always precede effects, and physical laws enforce a fixed temporal order. However, at the quantum level, time is bi-directional rather than strictly forward-moving. This is supported by the fact that many fundamental quantum equations, such as Schrödinger's equation, are time-reversible, meaning they do not inherently distinguish between past and future (Aharonov et al., 1964).

Quantum processes, such as superposition, entanglement, and indefinite causal order, suggest that events can occur without a well-defined sequence or in time-symmetric interactions.

- Superposition allows a system to exist in multiple states simultaneously, meaning that before measurement, it is not clear whether an event has already "happened" in a conventional time sense (Zurek, 2003).
- Entanglement links particles across space instantaneously, meaning that a measurement on one particle determines the state of the other regardless of spatial and temporal separation, challenging traditional cause-effect ordering (Aspect, Dalibard & Roger, 1982).
- Indefinite causal order has been demonstrated in quantum experiments where two events appear to occur in a superposition of sequences, meaning there is no clear "before" or "after" (Oreshkov et al., 2012).

Despite this, at macroscopic scales, time acquires a fixed direction, and causality becomes unidirectional (Aharonov et al., 1964). This transition is driven by entropy, which increases as system complexity grows, a principle dictated by the Second Law of Thermodynamics (Boltzmann, 1896; Carroll, 2010).

- As systems become larger and more complex, quantum superpositions decohere into classical states, leading to time-irreversible processes (Zeh, 1970; Joos & Zeh, 1985).
- Thermodynamic entropy accumulates information loss, making it increasingly impossible to reverse large-scale processes, reinforcing the one-way arrow of time (Penrose, 1989).

Thus, causality remains universal, but the direction of time emerges due to entropy growth, which is complexity-dependent. At the quantum scale, causality remains flexible and reversible, but at macroscopic levels, entropy forces an irreversible time structure, fixing cause-effect sequences.

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Appendix B – Symbolic Reasoning in a Nutshell

Symbolism	Notes	Natural Language Examples
	Simple Propositions	
a^1	A set as a singular entity but comprising multiple elements. Same concept used in conventional set theory.	**a^1** is the noun phrase “The apes.”
a	A set as a plural entity. This is a modification of conventional set theory.	**a** is the noun “Apes”.
$^VSa^1$	All relationships whose subject is **a^1**. This is a simplified way of expressing the more complete **$^VS{*}a^1$** (see below).	
$^VQb^1$	All relationships whose object is **b^1**.	**b^1** is the noun phrase “The bananas”
. (dot)	Logical “and”. Same as $\bigwedge$ in conventional logic. Also, same as $\bigcap$ in conventional set theory.	
$^VSa^1.^VQb^1$	The relationship between a subject **a^1** and an object **b^1**. This is the same as an ordered pair in conventional set theory.	
$^VSa.^VQb$	The plural collection of relationships between any **a** and any **b**.	
$^VSa^1.c.^VQb^1$	The relationship between a subject **a^1** and an object **b^1** modified by conjunction with the collection, **c**, which is a collection of relationships of a particular type. There may be many such relationships at different times.	**c** is the verb “consume” **$^VSa^1.c.^VQb^1$** is a relationship in which “the apes consume the bananas”.
$^VSa.c.^VQb$	The plural collection of relationships between any **a** and any **b** modified by conjunction with the collection, **c**.	**$^VSa^1.c.^VQb^1$** is the plural collection of relationships in which “any ape consumes any banana”.
$\varnothing$	The null set.	“Nothing” or “In no circumstances”
$^VSa^1.c.^VQb^1 \neq \varnothing$	The above collection of relationships converted into a proposition by equating it to the null set, i.e., relationships of type **c** exist between **a^1** and **b^1**.	**$^VSa^1.c.^VQb^1 \neq \varnothing$** is the proposition “The apes consume the bananas”.
$\subseteq$	The binary operator “is a subset of or equal to”. This is the same as $\subseteq$ in conventional set theory. It is also the same as in $\rightarrow$ conventional logic.	$\subseteq$ means “is” or “are” between two nouns, or “if… then…” between two propositions.
$c{*}b^1$	The collection of relationships **c** operating on the object **b^1** to define a collection of subjects.	“Things that consume the bananas.”

a¹⊆c∗b¹	The proposition **ᐯSa¹.c.ᐯQb¹** ≠ ∅ in relationship form transformed into standard form.	**a¹⊆c∗b¹** is also the proposition "The apes consume the bananas" or more fully "The apes are something that consumes the bananas".
a⊆c∗b		**a⊆c∗b** is the proposition "(All) apes consume (some) bananas". N.B. words in brackets are normally omitted in plain English.
⊄	The binary operator "is not a subset of and not equal to". This is same as ⊄ in conventional set theory.	
a ⊄ c∗b		**a ⊄ c∗b** is the proposition "Not all apes consume (some) bananas".
c∗b	N.B. ∗ is underscored. The complement of (or everything but) the collection of relationships **c** operating on the objects **b** to define a collection of subjects.	"Things that consume (some) bananas"
a ⊄ c∗b		**a ⊄ c∗b** is the proposition "Some apes consume (some) bananas".
a ⊆ c∗b	N.B. ∗ is underscored.	**a ⊄ c∗b** is the proposition "No apes consume (some or any) bananas".
Truth and Probability		
E	The universal set.	"Everything" or "Every circumstance"
(a⊆c∗b) = E	A probabilistic proposition. N.B. **a⊆c∗b** is the same as **(a⊆c∗b) = E** by default.	"It is true (or certain) that all apes consume bananas."
(a⊆c∗b) ≠ E	A probabilistic proposition.	"It is uncertain that all apes consume bananas."
(a⊆c∗b) ≠ ∅	A probabilistic proposition.	"It is possible that all apes consume bananas."
(a⊆c∗b) = ∅	A probabilistic proposition.	"It is false (or impossible) that all apes consume bananas."
Adjectives and Adverbs		
*g*¹	A characteristic as opposed to a physical entity.	*g*¹ is the characteristic "grey".
{⊆}∗ᐯ𝒜∗*g*¹ or **g**	The collection of physical things with that characteristic. Rather curiously, a characteristic and the conventional set of physical things with characteristic are reciprocals in space-time. **ᐯ𝒜∗** maps the former onto the latter. **{⊆}∗** specifies the elements of that conventional set of physical things and in Symbolic Reasoning they comprise a plural collection. The whole expression can also be simplified to **g**.	**{⊆}∗ᐯ𝒜∗*g*¹** or **g** is the collection of "grey things".
a.{⊆}∗ᐯ𝒜∗*g*¹⊆c∗b or **a.g⊆c∗b**	A subject modified by an adjective.	"All grey apes consume bananas"
a⊆(c.{⊆}∗ᐯ𝒜∗*h*¹)∗b	A verb modified by an adverb.	"All apes hungrily consume bananas".

or $\mathbf{a} \subseteq (\mathbf{c.h}) * \mathbf{b}$		
Compound Propositions		
$(\mathbf{a} \subseteq \mathbf{c} * \mathbf{b}).(\mathbf{d} \subseteq \mathbf{e} * \mathbf{f})$	Conjoined propositions.	"(All) apes consume (some) bananas and (all) dragons exhale (some) fire".
$\mathbf{+}$	Logical "or". Same as $\bigvee$ in conventional logic and $\bigcup$ in conventional set theory. N.B. Natural English is inconsistent and sometimes is referred to as "and". For example, apples and bananas are fruits or $\mathbf{a} + \mathbf{b} \subseteq \mathbf{f}$.	
$(\mathbf{a} \subseteq \mathbf{c} * \mathbf{b}) + (\mathbf{d} \subseteq \mathbf{e} * \mathbf{f})$	Disjoined propositions.	"Apes consume bananas or dragons exhale fire".
$(\mathbf{a} \subseteq \mathbf{c} * \mathbf{b}) \not\subseteq (\mathbf{d} \subseteq \mathbf{e} * \mathbf{f})$	A second order proposition.	"If apes consume bananas, then this does not imply that dragons exhale fire".
$((\mathbf{a} \subseteq \mathbf{c} * \mathbf{b}) = \mathbf{E}) \subseteq ((\mathbf{d} \subseteq \mathbf{e} * \mathbf{f}) \neq \varnothing)$	A second order probabilistic proposition.	"If it is certain that apes eat bananas, then it is possible that dragons exhale fire"
$(\mathbf{a} \subseteq \mathbf{c} * \mathbf{b}) + (\mathbf{d} \subseteq \mathbf{e} * \mathbf{f}) \subseteq (\mathbf{i}^{1} \subseteq \mathbf{j} * \mathbf{k}^{1})$		"If apes consume bananas or dragons exhale fire, then I join the conscripts".
$\mathbf{f}.{}^{V}\mathbf{Qe} \subseteq \{\subseteq\} * {}^{V}\mathcal{A} * \mathcal{d}^{1}$ or $\mathbf{f}.{}^{V}\mathbf{Qe} \subseteq \mathbf{d}$		"Finding examples is difficult".
Tense		
$\{<\}_{\mathcal{T}} * \mathbf{e}$	Circumstances before any event **e**.	
$\{>\}_{\mathcal{T}} * \mathbf{e}$	Circumstances after any event **e**.	
${}^{V}\mathbf{Sa}^{1}.\mathbf{c}.{}^{V}\mathbf{Qb}^{1} \neq \varnothing$	Tenseless Proposition.	Andrew climbs Mont Blanc.
$\{\supset\}_{\mathcal{T}}({}^{V}\mathbf{Sa}^{1}.\mathbf{c}.{}^{V}\mathbf{Qb}^{1}) \neq \varnothing$	Continuous Tense Proposition.	Andrew is climbing Mont Blanc.
$\{>\}_{\mathcal{T}}({}^{V}\mathbf{Sa}^{1}.\mathbf{c}.{}^{V}\mathbf{Qb}^{1}) \neq \varnothing$	Imperfect Tense Proposition.	Andrew climbed Mont Blanc.
$\{>\}_{\mathcal{T}}\{\supset\}_{\mathcal{T}}({}^{V}\mathbf{Sa}^{1}.\mathbf{c}.{}^{V}\mathbf{Qb}^{1}) \neq \varnothing$	Imperfect Continuous Tense Proposition.	Andrew was climbing Mont Blanc.
$\{>\}_{\mathcal{T}}\mathcal{C}_{\mathcal{T}}({}^{V}\mathbf{Sa}^{1}.\mathbf{c}.{}^{V}\mathbf{Qb}^{1}) \neq \varnothing$	Perfect Tense Proposition.	Andrew has climbed Mont Blanc.
$\{>\}_{\mathcal{T}}\mathcal{C}_{\mathcal{T}}\{\supset\}_{\mathcal{T}}({}^{V}\mathbf{Sa}^{1}.\mathbf{c}.{}^{V}\mathbf{Qb}^{1}) \neq \varnothing$	Perfect Continuous Tense Proposition	Andrew has been climbing Mont Blanc.
$\{<\}_{\mathcal{T}}({}^{V}\mathbf{Sa}^{1}.\mathbf{c}.{}^{V}\mathbf{Qb}^{1}) \neq \varnothing$	Future Tense Proposition.	Andrew will climb Mont Blanc.
$\{<\}_{\mathcal{T}}\{\supset\}_{\mathcal{T}}({}^{V}\mathbf{Sa}^{1}.\mathbf{c}.{}^{V}\mathbf{Qb}^{1}) \neq \varnothing$	Future Continuous Tense Proposition.	Andrew will be climbing Mont Blanc.
Causality		
	A collection of events is the same as a collection of relationships and simplified symbolism can be used. Thus, for example the collection ${}^{V}\mathbf{Sa}^{1}.\mathbf{c}.{}^{V}\mathbf{Qb}^{1}$ can be simplified to **a**. This is because both are entities which occupy a region of space-time.	
$(@\mathbf{a})\mathbf{b}$	The regions of space-time occupied by both an event **a** and an event **b**.	
$\mathbf{E}^{1}$	The universe, i.e., all of space-time, as a singular entity.	

(@a)E¹	The regions of space-time occupied by an event **a**.	
B∗c	The collection of beginnings in time of **c**s.	
{⊇}∗c	The collection of regions of space-time that include the region of space-time occupied by an event **c**, and which may be more extensive than the latter.	
(@a)E¹ ⊆ {⊇}∗B∗c	A causal proposition.	An event **a** is sufficient to cause an event **c** (to begin).
(@a)(@b)E¹ ⊆ {⊇}∗B∗c	A causal proposition.	An event **a** and an event **b** are together sufficient to cause an event **c** (to begin).
{⊆}∗a	The collection of regions of space time that are contained by a region of space-time occupied by an event **a**, and which may be less extensive than the latter.	
B∗c ⊆ {⊆}(@a)E¹	A causal proposition.	An event **a** is necessary to cause an event **c** (to begin).