GST 91 — Causal Interaction Between Epistemic Representations

Formal Description

Hypotheses, explanations and theories are epistemic representations of causal reality. However, once such representations are physically instantiated in brains, language, diagrams, documents or other media, they also become parts of causal reality and can participate in further causal processes.

An epistemic representation can therefore have two distinct causal relationships. First, it may represent some portion of causal reality. Second, through its physical instantiation, it may causally influence agents and other epistemic processes.

This distinction allows hypotheses, explanations and theories to interact. A theory may contribute to the generation of hypotheses; hypotheses may direct observation and investigation; resulting evidence may support, modify or contradict an explanation or theory. Different explanations or theories may also be compared with one another, revealing agreements, contradictions or complementary representations of different portions of the same causal organisation.

Interaction between representations need not result in the wholesale acceptance of one and rejection of another. A hypothesis, explanation or theory may contain some relationships that correspond well with causal reality and others that do not. Testing can therefore support some components while challenging others. Supported components from different representations may sometimes be productively coordinated to form a more comprehensive representation.

The development of knowledge can consequently itself be understood as a causal process. Existing representations contribute causally to the production of new representations, which may subsequently be tested against causal reality and revised.

A simplified representation is:

Existing representations → comparison and reasoning → hypothesis → investigation → evidence → revised representation

The resulting representation can itself participate in subsequent epistemic processes. Causal knowledge therefore develops through a potentially continuing and branching causal network of epistemic activity.

It is important to distinguish this from the causal network being represented. A represented causal network is the portion of causal reality described by a hypothesis, explanation or theory. A causal network of representations consists of the actual causal processes through which physically instantiated observations, hypotheses, explanations and theories influence one another and the agents who construct, communicate and revise them.

Thus, representations of causal networks can themselves become components of causal networks.

Plain English Explanation

Suppose two investigators are trying to explain why the town in our continuing example flooded.

The first proposes:

"The river flooded the town because unusually high runoff caused it to overtop its banks."

The second proposes:

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“The town flooded because high river levels prevented the drainage system from discharging effectively.”

We could treat these as competing explanations and ask which is correct.

But that may be the wrong question.

Investigation might reveal that both contain part of the explanation. High runoff may indeed have increased river levels. Those high river levels may then have reduced the ability of drains to discharge. Surface water may consequently have accumulated within the town.

The two explanations have interacted through comparison and investigation to produce a better explanation than either provided independently.

Something important has happened here. The explanations are representations of causal reality, but they have also participated in a causal process.

One investigator communicates an explanation. Another investigator encounters it. That information changes what the second investigator considers, perhaps leading to a new hypothesis.

Measurements are taken. The resulting information changes the investigators' understanding. A revised explanation is produced and communicated to others.

We therefore have causality operating at two levels.

At one level is the flooding itself:

rainfall → runoff → river and drainage processes → flooding

At another level is our developing knowledge of it:

observation → hypothesis → comparison → investigation → evidence → revised explanation

The second network is just as physically real as the first. Thoughts involve physical processes in brains; conversations involve physical transfers of sound; written explanations are physically embodied; digital information is stored and transmitted through physical media.

An epistemic representation does not cease to be epistemic because it is physically instantiated.

What makes it epistemic is that it represents something. What makes it causally efficacious is that its physical embodiment can affect other processes.

This also explains why disagreement can be productive. Two incompatible theories do not necessarily require us immediately to choose one and discard the other. We can decompress them and ask where exactly they disagree.

Some propositions may conflict. Others may be compatible. Still others may concern different parts or levels of the causal network.

By testing these components separately, we may discover that parts of both representations should be retained and coordinated.

Knowledge can therefore develop not merely through accumulating observations but through causal interaction between representations.

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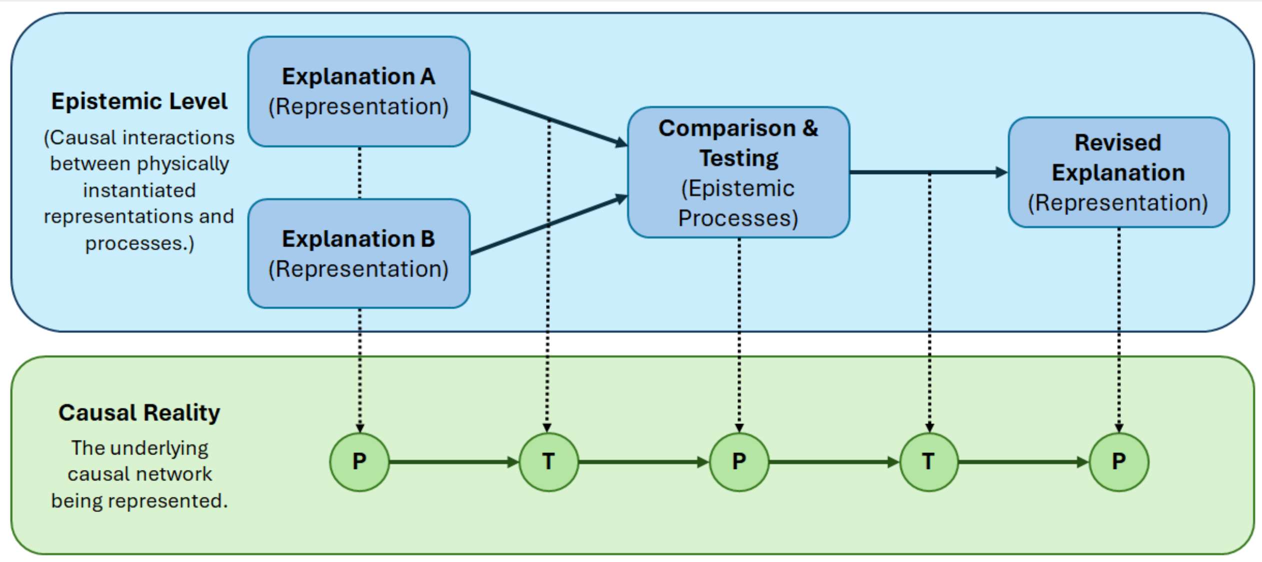

Causal Interaction Between Epistemic Representations

Hypotheses, explanations and theories represent portions of causal reality, but as they are physically instantiated they can also participate in causal processes. Comparison and testing of different representations may therefore generate revised or more comprehensive representations of the same underlying causal reality.

Examples

Scientific theories provide clear examples. A theory may generate predictions from which hypotheses are derived. Experimental results can subsequently affect confidence in the theory or reveal parts requiring modification. The relationship between theory and hypothesis is therefore not merely classificatory: physically instantiated theoretical knowledge contributes causally to subsequent reasoning and investigation.

Different explanations may also prove complementary. One explanation of a biological phenomenon might concentrate upon molecular processes while another concentrates upon interactions between cells. If the two concern different levels of the same causal organisation, they need not be competitors. Coordinating them may provide a more complete causal explanation.

Engineering investigations frequently work similarly. Different specialists may initially propose mechanical, electrical, operational or human explanations for a failure. Investigation may reveal that the eventual failure resulted from interactions among several of these. The final explanation can therefore emerge through productive coordination of initially separate causal representations.

The history of science also contains cases in which apparently competing theories captured different valid relationships. Investigation can reveal which components should be retained, which rejected and how surviving components might be incorporated into a better representation.

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Provenance and Links

The idea that scientific knowledge develops through interaction between hypotheses, criticism and evidence has important antecedents in the philosophy of science. Karl Popper emphasised critical testing and attempted falsification, while later philosophers of science examined more extensively how theories change in response to empirical and conceptual difficulties.

Thomas Kuhn drew attention to the historically situated development of scientific knowledge and the role of existing conceptual frameworks in shaping scientific investigation. Although his account differs substantially from Popper's, both traditions recognise that existing knowledge influences the subsequent production and evaluation of knowledge.

The concept of abduction, particularly associated with Charles Sanders Peirce, is also relevant because observations can stimulate the generation of possible explanations, which can subsequently be investigated and revised.

The treatment in these course modules adds an explicitly causal interpretation. Because epistemic representations must be physically instantiated to be communicated, remembered or processed, they can themselves participate in causal networks. The resulting epistemic processes can therefore be analysed using the same foundational causal principles applied elsewhere in the course.

The further possibility of productive coordination arises where different representations contain compatible or complementary components. Rather than treating competing representations as necessarily indivisible alternatives, their constituent propositions and causal relationships may be examined separately and, where justified by evidence, recombined.

A detailed methodology for hypothesis testing and the representation and productive coordination of knowledge lies beyond the scope of this module. The purpose here is to establish their causal foundation.

Practical Exercise

Return to the town experiencing local flooding after heavy rainfall. You will now examine not only the causal network producing the flood but also the interaction between different representations of that network.

Imagine that two investigations have produced the following explanations:

Explanation A:

The town flooded because prolonged rainfall saturated the surrounding ground. Subsequent rainfall therefore produced unusually high surface runoff, increasing river flow until the river overtopped its banks.

Explanation B:

The town flooded because high river levels restricted discharge from the town's drainage system. Rainwater entering the drainage network could therefore no longer be removed sufficiently rapidly and accumulated within the town.

Begin by representing each explanation as a simple causal network. Do not initially decide which explanation is correct.

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Compare the two networks and identify where they agree, differ or describe different causal pathways. Ask whether any statements in one explanation necessarily contradict statements in the other.

Now identify observations that could test important components of each explanation. For Explanation A, consider what you would expect to observe concerning soil saturation, runoff, river levels and overtopping. For Explanation B, consider what you would expect to observe concerning drainage flows, river levels and surface-water accumulation.

Suppose investigation finds that the ground was saturated and runoff was unusually high, but the river did not overtop its banks. At the same time, measurements show that high river levels substantially reduced drainage discharge.

Identify which components of Explanation A remain supported and which should be rejected or revised. Do the same for Explanation B.

Now attempt productive coordination. Retain those components of each explanation that remain consistent with the evidence and combine them into a revised causal explanation of the flooding.

Compare your revised explanation with the two originals. Explain what new understanding emerged specifically because the representations were compared and tested rather than treated as indivisible alternatives.

Next draw a second causal network representing the epistemic investigation itself:

Initial observations → Explanations A and B → comparison → testing → evidence → revised explanation

Distinguish this from the causal network representing the flood. Explain why the first is a causal network of epistemic activity, whereas the second is the causal network being represented.

Finally, consider your own work throughout the previous modules on causality. Your representation of the flooding example has repeatedly changed as new concepts have been introduced. Explain how your original:

Heavy rainfall → flooding → property damage

has causally contributed, through learning, comparison, decompression and revision, to the much richer causal representation you now possess.

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