GST 82 — The Physical Basis of Causality

Formal Description

Causal interaction requires a physical connection between the processes involved. Where one process influences another spatially separate process, that influence is physically instantiated through a transfer of matter, energy or physically embodied information. A causal transfer therefore connects an originating process with a receiving process and provides continuity between them.

Information requires particular care because it can easily appear to constitute a separate, non-physical form of causation. Within the framework adopted in these course modules, information is always physically embodied in matter or energy. A pattern of electrical activity, a chemical signal or the arrangement of marks on a surface can carry information because its physical structure can affect a receiving process capable of responding differently to different structures.

Causal interaction therefore depends not only upon the existence of a transfer but also upon the capabilities of the processes involved. The originating process must be capable of producing the relevant transfer, the transfer must be capable of reaching the recipient, and the recipient process must be capable of responding to it. The same transfer may consequently produce different effects upon different recipients, or no significant effect at all.

A receiving process may transform or integrate incoming transfers rather than simply passing them onwards unchanged. Several transfers may converge upon the same process, and the resulting behaviour may depend upon their combination. Causal networks can therefore become complex even though their physical foundation remains processes connected by transfers.

This gives the basic causal relationship:

Originating Process → Transfer → Receiving Process

This relationship will later be described as **Process–Transfer–Process (PTP)**. For the present module, however, the important principle is simply that causal influence between separate processes requires a physical pathway connecting them.

Plain English Explanation

Suppose you press a doorbell button and hear the bell sound. In everyday language we might simply say: **Pressing the button caused the bell to sound.**

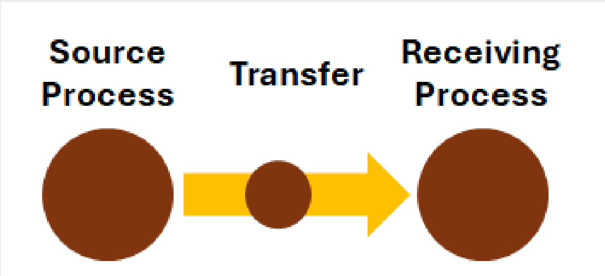
This tells us *what caused what*, but it does not tell us how the causal influence got from the button to the bell.

When the relationship is examined more closely, physical processes and transfers can be identified. Pressing the button changes the configuration of an electrical circuit. This allows electrical energy to be transferred through the circuit. Processes within the doorbell then use that incoming transfer to produce sound. The apparently simple relationship between pressing the button and hearing the sound therefore contains an intervening physical causal pathway.

The same principle applies when matter is transferred. Water falling as rain can subsequently move across or through the ground and enter a river. The water itself is being transferred between processes and can contribute causally to what happens next.

Information may initially seem different. Imagine that a sensor sends a signal telling a control system that a water level is too high. The significance of the signal lies in its pattern or structure, but that pattern must still have a physical embodiment. It might be represented by changing electrical voltages, pulses of light or some other physical arrangement. The receiving system responds differently because it is capable of distinguishing between those physical patterns.

This leads to an important distinction. A transfer does not cause an effect merely because it arrives somewhere. The recipient must be capable of responding to it. Sunlight falling upon a solar panel can contribute to the production of electricity because of the physical properties and organisation of the panel. The same sunlight falling upon an adjacent wall does not produce the same effect.
Causality therefore involves relationships between processes and transfers, not merely sequences of events. Identifying those processes and transfers begins to decompress statements such as “A caused B” into an explanation of how A could physically influence B.



Examples
A simple example involving **matter** is water flowing from one reservoir through a pipe into another. Processes associated with the source produce a transfer of water; the transferred matter reaches the receiving reservoir and changes its state. The causal connection is not an abstract relationship between the two reservoirs: matter physically passes between them.
An **energy** example is sunlight heating a surface. Electromagnetic radiation transfers energy from the Sun to the surface. Processes occurring when that radiation interacts with the material can increase its temperature.
An **information** example is a digital temperature sensor communicating with a controller. The sensor produces a physically structured electrical signal representing the measured temperature. The controller is organised so that different signal structures produce different responses. The causal significance of the information therefore depends both upon its physical embodiment and upon the receiving process being capable of interpreting, or responding differentially to, its structure.
Biological causation frequently combines all three descriptions. A chemical signalling molecule may be transferred between cells. It consists of matter, possesses physical energy and has a molecular structure to which particular receptor mechanisms respond. Describing it as carrying information does not make the causal interaction non-physical; the information is embodied in the physical organisation of the transferred material.
These examples illustrate why matter, energy and information should not necessarily be regarded as three mutually exclusive kinds of physical object. They are useful ways of describing what is causally significant about a transfer.

Provenance and Links
The requirement for a physical account of causal mechanisms is consistent with the broader mechanistic tradition in philosophy of science, in which mechanisms are explained through organised entities, activities and interactions rather than merely through observed regularities. Work

by Machamer, Darden and Craver has been particularly influential in developing contemporary mechanistic accounts of scientific explanation.

The treatment of information as physically embodied is consistent with the work of Rolf Landauer, whose analysis of information processing emphasised that information has a physical basis. Information can therefore have causal consequences without requiring a separate non-physical causal substance. The course adopts this physicalist interpretation when treating information alongside matter and energy as something transmitted through causal relationships.

The more specific proposition developed in these course modules is that causal influence between separate processes must be physically instantiated through a connecting transfer. Matter, energy or physically embodied information may be transferred, but an unexplained relationship between two spatially separate processes should not itself be treated as a complete causal mechanism.

This principle provides the foundation for later modules on causal networks, PTP and TPT representation, persistent causal organisation and causal mechanisms.

Practical Exercise

Continue your investigation of the town experiencing local flooding after heavy rainfall introduced in the previous module. Previously you considered the deliberately compressed causal sequence:

Heavy rainfall → surface runoff → increased river flow → rising water level → flooding → property damage

Your task in this module is to begin physically decompressing this sequence.

Start with the relationship:

Heavy rainfall → surface runoff

Identify what is physically transferred and where the transfer originates and terminates. Consider whether saying simply that “rainfall causes runoff” conceals intermediate processes that might be important.

Now examine:

Surface runoff → increased river flow

Identify the matter, energy or physically embodied information that must pass between the relevant processes for the first phenomenon to influence the second. Ask yourself what physical pathway connects them.

Continue with:

Increased river flow → rising water level

Consider carefully whether the two expressions describe completely separate processes connected by a transfer or different aspects of a more complicated hydrological process. Do not assume that every arrow in the simplified sequence necessarily corresponds to a single physical transfer. If the representation seems too compressed to decide, identify what additional information you would need.

Next consider:

Flooding → property damage

Choose one particular form of property damage, such as water entering a building. Identify the physical transfer through which the flooding produces that effect and the receiving process or entity whose state is changed.

Finally, return to the complete sequence and identify at least one point where the simple arrows conceal a more complicated physical causal pathway. Expand that part of the sequence by inserting any additional processes and transfers you think are required.

Do not worry if your representation is incomplete. The purpose of the exercise is not to construct a complete hydrological model. It is to practice asking a more fundamental causal question whenever you encounter:

A → B

namely:

What physically passes between A and B, through what pathway, and how is B capable of responding to it?

In the next module, you will return to the same flooding example and examine why some causal contributions are necessary, sufficient, enabling or inhibiting.

