Origins

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Scientific origins are information sources that transmit encoded information signals to receivers. Originary sciences identify information preserving receivers and decode the signals to infer their origins. Paradigmatic cases of scientific origination such as the Big Bang, the origins of species, horizontal gene transfer, the origin of the Polynesian potato, and ideational origins in the history of ideas are analyzed to discover what is common to them ontologically and epistemically. Some causes are not origins. Origination supervenes on causation, but has different properties. The unique properties of origins that causes do not share shield theories of origination from the kind of counterexamples and counterintuitive results that challenge comparable theories of causation. The epistemology of origination may serve as a basis for founding a novel epistemic and methodological division of the sciences into originary historical sciences and causal theoretical sciences.

1. Introduction

Some of the most groundbreaking and surprising scientific discoveries that fundamentally revised the knowledge of the past have been of origins. Darwin's discoveries of origins of species are but the most obvious. The scientific discoveries of the common origins of language families, which Darwin used as analogies to explain the origins of species, the origins of ancient texts that were copied and edited numerous times, such as the Bible; the origin of the continents—the supercontinent Pangea; the origin of the universe—metaphorically referred to as the "Big Bang;"

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the origins of galaxies, stars, planets, and solar systems, and the origins of ideas such as totalitarianism have been as important, surprisingly, and significant for our temporal orientation as the Darwinian origins of species. Scientific discoveries of origins are historically recent—none older than the second half of the eighteenth century. They are ongoing. For example, geneticists recently discovered the origins of Eurasian humanity in interbreeding between African Homo Sapiens and Neanderthals (Reich 2018, pp. 25–49; Hajdinjak et al. 2021) It is highly likely that scientific searches and discoveries of origins will continue progressively (Reich 2018, pp. 274–82). For example, one of the most intriguing scientific questions that will likely continue to receive much attention is of the origin of life, whether there was one origin or multiple origins, and what was or were those origins.

Despite the considerable scientific interest and success in the discovery of origins, philosophy of science and epistemology miss systematic analyses of origins, origination, and the originary sciences that infer origins.[1] This article attempts to fill in this lacuna and analyzes origination in science by founding the philosophical analysis on what is common to paradigmatic cases of scientific inferences of origins.

Philosophical conceptual analysis clarifies meanings, preempts confusions between apparently similar concepts, and ensures conceptual

1. Chinese philosophical traditions distinguished origination from causation: "the Chinese had the notion that the many emerged *from* the one. The one is the origin (*pen*); the many, born of the one, is the end (*mo*). The origin and the end, the one and the many are not disjointed like cause and effect, but fluid like the Great Tao" (Lai 1977, p. 253) This concept of origin is "biogenerative" (Lai 1977), corresponding with ancestor and descendants or tree trunk and its branches. There are some similarities between this tradition and scientific concepts of origins that include biological ancestors and use tree-like models to represent the relations between origins and their descendants. Yet, the ontology, methodologies, and epistemic assumptions that underlie scientific inferences of origins are different. Intellectual traditions that originated with Nietzsche and reached Foucault and Bernard Williams have been interested in origins of "genealogies," but only in metaphorical, non-scientific, senses (Tucker 2021). There are elaborate metaphysical discussions of "origin essentialism." But "essential origins" do not correspond with origins in science and do not entail a particular epistemology for their discovery (Ereshefsky 2014, pp. 724–725; Pedroso 2014; Sartorelli 2016).

In contemporary philosophy of science, Sober has examined exhaustively inferences of origins in phylogeny and particularly in cladistics (e.g., Sober 1988; Sober and Steel 2014, 2017). But scientific origins and originary inferences can be found in a much broader scope of sciences. Janssen (2002) discussed the inference of common origins in broad terms that resemble parsimonious inter-theoretical reduction to best explanations that also serve as evidence, referring to the concept of origin only in a footnote (p. 469n23). Tucker (2020) reduced the inference of common cause to that of common origin.

distinctions do not duplicate redundantly distinctions already captured by established concepts. The glaring philosophical focus on causation may have obscured the presence of origination in the scientific background. Origination and origins need to be distinguished conceptually and epistemically from causation and causes. Obviously, scientists have chosen to designate some past events as origins and others as causes. Darwin chose to author The *Origin* of Species and not "The *Cause* of Species." Scientists study the origin of the universe, the Big Bang, and not its cause, a topic of different, rather speculative, theories. Political theorists and historians Hannah Arendt (1951) and Francis Fukuyama (2011) wrote books respectively about the *Origins of Totalitarianism* and the *Origins of Political Order*, not about the causes of totalitarianism and political order. Studies of the causes of totalitarianism or political order would likely inquire theoretically which types of conditions give rise to totalitarianism or political order, rather than attempt to trace the historical sources of totalitarianism and political order, where these ideas came from, as Arendt and Fukuyama did respectively (cf. Tucker 2012).

The main, original, thesis here is elementary, yet has broad, elaborate, and fruitful consequences for understanding the originary sciences and for resolving philosophical problems by demonstrating that they result from conceptual conflations of causation with origination: Scientific origin is an *information source* that transmits encoded information signals to receivers. Originary sciences identify information preserving receivers, decode the signals, and use them to infer their origin. *Ceteris paribus*, the richer the signals, the more determined is the inference of their origins. This general characterization fits all the paradigmatic cases of origination such as the Big Bang, horizontal gene transfer, the origin of the Polynesian potato, and human-Neanderthal hybridization. These cases of origination demonstrate the differences between origination and causation: Some causes are not origins. Origination supervenes on causation, but has different properties. These properties protect theories of origination from the kind of counterexamples and counterintuitive results that challenge comparable theories of causation. The distinct epistemology of origination may serve as a basis for founding a novel philosophical division of the sciences into originary historical sciences and causal theoretical sciences.

2. Origin vs. Cause

Scientific origin is an information source that transmits encoded signals to receivers. In the absence of superluminal information transfer via measurement (Clifton et al. 2003), receivers must succeed origins. During transmission, information passes through a period of latency when it is not expressed.[2] Scientists infer the existence of origins, their properties, and identity from decoding the information stored in receivers. There are numerous types of information signals, codes, and transmission channels: origins of species transmit DNA to their descendants, the origin of the universe transmitted background radiation detected by contemporary scientific instruments, and originary languages transmitted their grammar, syntax, and vocabulary to succeeding languages. Information signals are mixed with varying levels of noise and have different levels of equivocation—loss of signal. Different information channels preserve or lose information at different rates. For example, evolutionary processes tend to preserve information that has no selective advantage or disadvantage; more than information that is under selective pressure (cf. Sober and Steel 2014). Information transmissions have reliabilities or fidelities, the ratio of preserved information stored in a receiver at the end of the transmission to the information the origin transmitted. Beyond these basic theoretical characteristics of information that originated in intellectual history from Claude Shannon's (1964) information theory, theories of information are contested in science and philosophy. Floridi (2016, pp. 2–3) denied the existence of one reductive, all-encompassing, concept of information. He considered it a "Cinderella-like" concept, invisible, overworked, yet indispensable. Scarantino and Piccinini described information as a "mongrel concept" whose "different uses reveal a plurality of notions …, each in need of a separate account" (2010, p. 314). Ladyman et al. (2007, p. 216) ascribed the "conceptual anarchy" of information to divergent theoretical interests in physics, communication theory, biological order, and the metaphysical unification of the sciences. It is however unnecessary to delve deeply into information theory to use this conceptual "Cinderella" to perform the work required to sustain a theory of origination, because a theory of origination may cohere with different information theories that only share Shannon's broad theoretical background. It is neither necessary nor helpful to dive into debates in the philosophy of information that would distract from the main originary task of this essay. This kind of treatment

2. If there is simultaneous causation (cf. Rosenberg 1998; Buzzoni 2014), it distinguishes causation from origination because origins cannot skip latency to be simultaneous with their receivers. Quantum entanglement may be interpreted as simultaneous causation (Carvacho et al. 2017), but it cannot transmit information superluminally (Clifton et al. 2003). Cognitive linguistic analysis allows "extended causation" that can allow causes to be co-temporal with their effects, or to use the terminology, the "linguistic antagonist" and "agonist" can be co-temporal (Talmy 2018). The concept of causation in cognitive linguistics is however distinct of its use in philosophy since cognitive linguistics attempts to theorize the linguistic use of cause while philosophy of science attempts to study the concept of cause or the meaning of cause in the sciences.

of the concept of information is common in philosophy, e.g., the use of information theory for understanding the transmission of information from genetic origins to descendants (unlike the transmission of instructions through RNA) is established, unproblematic, and least controversial in the philosophy of biology because it remains sufficiently abstract to fit different information theories (Bergstrom and Rosvall 2011; Shea 2011). Many successful and central philosophical theories rely on undefined "conceptual variables," when it is not desirable or feasible to commit to a systematic theory of everything. For example, theories of Physicalism, Naturalism, and Panpsychism, bracket as variables, respectively, ultimate physics, what is nature, and the mind.

Causation is also philosophically contested. But origination will be shown to be demonstrably equally distinct of causation irrespective of which major theory of causation is assumed. Causation may be conceived as a disjunctive theoretical concept: causation is either as conceptualized by conditional theories *or* by regulatory theories *or* by process theories *or* by counterfactual theories, without endorsing or rejecting any of these theories. Accordingly, this essay first examines the differences between origins and causes according what all theories of causation agree on. Then, subsequent sections distinguish properties of causes according to each of the main four theories of causation from the properties of origins.

Dretske argued for a complete separation between information and causation, implying a sharp distinction between origination and causation: "Questions about the flow of information are, for the most part, left unanswered by meticulous descriptions of the causal processes at work in the transmission of a signal. One can have full information without causality, and one can have no information with causality. And there is every shade of gray between these two extremes" (Dretske 1981, p. 33). If Dretske is right, some causes should not be origins, and some origins should not be causes. The former is easy to prove because some causes do not transmit information to their effects. The "perfect crime," "an illegal episode whose aftermath contains no information about the identity of the causally responsible agent," when "equivocation is maximized" (Dretske 1981, p. 31), is an effect that has a cause—the perpetrator, but no origin because it preserves no information about the perpetrator. In standard cosmological theories, singularities, like the Big Bang, are cosmic "perfect crimes" because though they may have had causes, they destroy all information and so have no origins.[3] If the cause of the Big Bang was a quantum

3. There are alternatives untested theories that suggest that some information, for example gravitational waves, can be transmitted through singularities. If the standard view of singularities is revised, this example would apply only to the current, by then obsolete, theory of singularities.

fluctuation in a vacuum of an infinitely random system with a pre-existing random "stuff" (Collier 1999, p. 224), this fluctuation is the cause, but not an origin, of the Big Bang because information cannot be transmitted through a singularity. By contrast, the Big Bang and subsequent cosmic inflation is the origin of our universe because it transmitted information to the present through signals, background radiation, whose decoding allows astrophysicists to infer its origin.

To take another scientific example for causes that are not origins, the *genealogy* of an individual organism is causal: it maps its ancestors. Genealogy is distinct of genetic ancestry, the origins of an individual genome, the ancestor genomes that transmitted information, DNA, to that genome. For humans, genealogical causes and genetic origins coincide only in the first few ancestral generations. Since the number of genetic splices received from ancestral origins grows only arithmetically whereas the number of causal ancestors grows geometrically, there are more genealogical (causal) than genetic (originary) ancestors the further back the genealogic past is traced. Ten generations back, each human has at most 2^{10} (1024) genealogical ancestors who *caused* them (the number of causes-ancestors may be lower if some ancestors caused a descendant more than once in different lineages), but at most only 757 genetic origins, since humans can receive only 757 stretches of DNA from that generation of ancestors. Therefore, as many as 267 causal genealogical ancestors were not genetic origins, did not pass their DNA to their tenth-generation genealogical descendants. Twenty-four generations back the gap between causation and origination widens since then each human has at most 2^{24} (16,777,216) genealogical causes, but at most only 1,751 genetic origins. Our ancestral causes and genetic origins tend to converge again at the dawn of humanity because the ancestral human population was very small (Reich 2018, pp. 10–14), though not every member of that ancestral group is an origin of contemporary humanity if their DNA was lost in history (cf. Pedroso 2014, p. 75).

Generally, there are more causes than origins because each state of the universe caused its next states, but information signals that origins transmit are lost to equivocation and mixture with noise. Consequently, there are natural limits to knowledge of the past (Turner 2007; cf. Sober and Steel 2014; Currie 2021). For example, each state of society causes its subsequent state. But the evolution of society destroys information in the process of social evolution. The best sociological survey of contemporary societies around the Mediterranean would not suffice for the inference of the history of the Roman Empire because the information signals of Roman origins intermixed with noise and were lost to equivocation over fifteen centuries. The writings of Roman historians preserved information from their Roman origins more reliably because their copied texts were not as corrupted by noise and equivocation.

It is more difficult to examine whether there are origins that are not causes. Dretske thought so. He argued that since information signals eliminate alternative possibilities, "an event may carry information about events to which it stands in no regular causal relationship" (Dretske 1981, p. 31). However, the information that a signal carries and receivers store about events with which they had no causal relation does not originate with the events with which they have no causal relationship, which therefore are not their origins.

There may be conflicting intuitions about whether information transmission from origin to receiver is causal when there is no known causal net that connects origins with receivers. Arguably, there must have been some such a causal net, or the information could not have been transmitted from origin to receivers. Since this conclusion is grounded in metaphysical convictions about reality whose "structure" is necessarily "cemented" by causation, it is impossible to challenge it with thought experiments that would receive alternative metaphysical interpretations according to preexisting conflicting philosophical intuitions.[4]

This article proposes instead that origination is distinct from causation but supervenes on it. Changes on the level of origination necessitate changes on the level of causation because the information has to be transmitted somehow. But changes on the level of causation do not entail changes on the level of origination, for example, because the received information may be causally overdetermined by different signals from the same origin. It is possible to trace the channels of transmission of information

4. There are science-fictional thought experiments that describe origination without causation in plots where information is clearly transmitted in circumstances where a causal relation between origin and receiver was impossible. Poul Anderson (1957) imagined the discovery that the landscape and light that Leonardo Da Vinci painted in his late fifteenth-century *Virgin of the Rocks* depict in detail a particular lunar landscape under earthlight. In this narrative, the moonscape was the origin of Leonardo's painting; it transmitted very rich information signals to Leonardo's canvas. But within the limitations of Renaissance era technology, there was no possible causal mechanism that could have caused Leonardo to observe the moon from its surface. Similarly, the plot of Stanley Kubrick's movie *2001: A Space Odyssey* (1968) culminates with a "voyage to infinity" that transports an Astronaut across the universe to a baroque-style room. The origin of the room's design style is obviously the French baroque. But a causal process of information transfer would have necessitated an impossible faster than light causation. These fictional narratives may illustrate at most imaginary possible worlds of origination without causation. But these are not scientific examples. As in other philosophical thought experiments, the obvious conceptual distinctions that one philosopher intuits may not be obvious to others, without an agreed procedure for deciding between conflicting intuitions.

from origin to receivers without reducing them to a lower causal level that may be unknown or radically underdetermined: "[T]he fact that physical systems are required to store or to transmit information does not imply that information in itself is a physical entity" (López and Lombardi 2019, p. 4). For example, the originations of horizontal gene transfer (HGT) among species of multicellular eukaryotes[5] supervene on unknown causal mechanisms. "As a consequence of HGT, organisms harbor genes that have taken different evolutionary routes, and the history of a gene can significantly deviate from the history of the organism itself" (Andam et al. 2010, p. 590). The "history of the gene" is originary in the sense that it transmits information in the form of genetic materials from an origin species to a receiver species. Geneticists have speculated about possible causal mechanisms that originary HGT may supervene on, including conjugation, cell fusion, transduction, gene transfer agents, transformation, intracellular or endosymbiotic gene transfer, and introgression. But though geneticists know and can prove horizontal genetic origination, the causal mechanism any token HGT supervened on is unknown or radically underdetermined.

The principal method for detecting horizontal gene transfer is through the identification of *phylogenetic conflict* between the originary genetic transmission and the causal reference tree:

> "Often the *reference tree* is assumed to represent the *vertical evolution of the organisms* … Deviations from the branching pattern of the *reference tree* identify potential HGT events, and provide *information* about the organisms between which genes were exchanged. *Species trees* are often built using well-conserved housekeeping or informational genes, such as ribosomal proteins. … The canonical method for detecting HGT events uses phylogenetic conflict comparing the *gene history* to the *species history*. Substantial and statistically supported conflict in the branching patterns of the gene and species trees can identify possible gene donors or the gene exchange partners if the direction of transfer cannot be interpreted" (Soucy et al. 2015, p. 473; italics mine).

"Gene history" is originary. "Species history" is causal.

5. HGT in simple organisms such as bacteria and viruses does not often preserve information about origins and is difficult to distinguish from similar endo-mutations "because most transfers occur between closely related organisms and are difficult to distinguish owing to the genetic similarity of the host and the recipient genomes" (Soucy et al. 2015, p. 475). Such gene transfers "may create a signal that in some instances might be indistinguishable from a pattern generated through vertical inheritance" (Andam et al. 2010, p. 592).

Another example for origination that supervenes on unknown causation is of the Pre-Columbian Polynesian Potato. Its origin is certain: South America more than 100,000 years ago, because Polynesian potato seeds collected by Captain Cook's expedition diverged genetically from South American potatoes more than 100,000 years ago. (Muñoz-Rodríguez et al. 2018) But there are only speculations about possible causal mechanisms that could have brought the potato to Pre-Columbian Polynesia, by wind, sea, birds, or seafarers, and so on.

Related origination that supervenes on unknown causation is of the Polynesian word for sweet potato, "kumala." Coastal South American languages used similar words to refer to the potato, for example, "cumal" in the language of the Cañari people of Ecuador (Ioannidis et al. 2020, p. 575). The linguistic origin, the etymology, of the Polynesian word for potato is close to certain, but the causal chain it supervened on is unknown. Genetic analysis of Easter islanders revealed a genetic mark of the Zenu people, the Pre-Columbian inhabitants of present-day Colombia. It indicates an originary hybridity with Polynesian genes at about 1200 AD. The Zenu word for potato may have been transmitted along with Zenu genes. But the causal chains are underdetermined since Zenu may have reached Eastern Polynesia from contemporary Ecuador, or the Polynesians who discovered and settled New Zealand and Hawaii may have reached South America, interbred with the locals, and found their way back to Polynesia, or maybe the linguistic transmission was separate from the genetic hybridization and supervened on some other causal mechanism.

3. Process Causation Is Irreducible to Origination

If some causes are not origins because they do not transmit information to their effects, and if origination supervenes on causation, origination is conceptually distinct from causation. This distinction would be challenged if causation is reducible to information transmission—origination (Ladyman et al. 2007; Collier 1999; Illari 2011; Illari and Russo 2016a, 2016b; Andersen 2017), or vice versa, if information transmission-origination is reducible to causation (López and Lombardi 2019). Process theorists of causation, who consider causes and effects aspects of ontologically primary processes, were intrigued by the prospect of using information transmission to distinguish real from apparent causal processes. Phil Dowe and Wesley Salmon proposed that true causal processes transmit, or would transmit counterfactually, some conserved quantity of a variable property. They did not specify the property, but relegated its discovery to future physics (Dowe 2009). There are only a few conserved quantities of properties that conceivably may serve as causal markers "such as charge, mass, momentum and so on. But in the vast majority of cases of causality in the special sciences, these are not the relevant properties… the special sciences concern themselves with measurements of quite different kinds of properties" (Illari 2011, p. 98). Collier (1999) proposed that information may be the elusive preserved property that underlies causation. Illari (2011) concurred because in her opinion information transmission is sufficiently general to have different "modes," yet is specific to scientific domains. The temporal and local non-contiguity of information transmissions facilitates the reduction of causation to information transmission, "if the identical bit of information can be transmitted across a space–time gap" (Illari 2011, p. 112). Later, Illari and Russo (2016b) reversed this position to stipulate continuity of structure at any point during the process of information transmission. Collier (1999, p. 224) similarly vacillated between stipulating locality and contiguity and accepting the possibility of non-contiguous inter-temporal information transmission. Be that as it may, information is a poor candidate for a preserved property underlying causation because there is no conservation of information. When an origin transmits information signals, it does not lose information, nor does the quantity of information received by one receiver come at the expense of those received by others (Krajewski 1997, p. 194). Collier acknowledged that equivocation and admixture with noise can decrease the total quantity of transmitted information. The total quantity of information can also increase, for example, in a classroom or when books gain readers. Consequently, Collier (1999, p. 237) weakened the information preservation condition to suggest that only some information that conserves some of the form of the cause is preserved in any causal process, just enough to exclude coincidental formal similarities. Yet, this criterion would not suffice to identify causal markers because some causes, such as the perfect criminal, do not transmit information. Causation cannot be reduced to origination.

Some process theories of causation stipulate causal contiguity, causes and effects are parts of a space-time "worm." Information transmission, however, is not contiguous because it goes through a latency period. Lack of contiguity does not block the inference of origins, for example, the inferences of the origins of HGT, the Polynesian potato, and the Indo-European languages, for which there is no direct evidence prior to written forms of Hittite, Sanskrit, and Greek. Even when there is sufficient evidence, tracing contiguous causal processes of information transmissions from origins to receivers may be redundant, in contexts where the supervening originary level is the locus of interest in a context. For example, bibliophilic research may trace the physical copy of Hume's *Treatise* that awoke Kant from his dogmatic slumber and caused his philosophy. This may be of interest to antiquarians or book collectors, but historians of philosophy and ideas are interested in the ideational origins of Kant's philosophy, not its physical causes.

Origination processes are not challenged by the classic challenge to process theories of causation, how to distinguish real from apparent processes, since if the processes are of origination rather than causation, the question is whether there was a transfer of information from origin to receiver or whether their informational correlation is coincidental. Scientists use evidence for information transmission to trace the information back from the receivers to infer a likely origin or exclude another putative origin (Tucker 2004, pp. 92–140). If there is insufficient evidence for tracing back the information transmission, as in HGT in simple organisms (Soucy et al. 2015, p. 475), there is originary underdetermination.

4. Conditionality of Origins vs. Conditional Causal Theories

Some theories of causation explicate it as a type of conditional relation: the existence of the effects is conditional on that of the causes in some complex way (e.g., Mackie 1974). Received information is also conditional, but on its origins. The two kinds of conditionality are distinct because the existence of the effect is conditional on its causes, while the information receivers store is conditional on their origins. Krajewski (1997, pp. 196–197) distinguished similarly what he termed "energetic causes," from "informational causes." In his example, a software program is an "informational cause" of a functioning computer, while electricity is its "energetic cause," as DNA is an informational cause of an embryo, and the mother's blood its energetic cause. Krajewski also considered musical scores and texts informational causes, respectively, of concerts and published books. Krajewski's informational causes have similar extensions to those of origins.

When receivers and effects have similar extensions, the effect-receiver's stored information may be conditional on its origin, while its existence may be conditional on its cause. For example, in intellectual historiography, it may be inferred that Carnap was the origin of Quine's philosophy while Whitehead was its cause, because the first's philosophy had a decisive influence on the content of Quine's philosophy, while Whitehead's process philosophy had no such influence. Still, Whitehead secured for Quine his position at Harvard, thereby providing him with necessary resources for the development of his philosophy.

The articulation of the distinctions between causes and other conditions has challenged conditional theories of causation (e.g., Mackie 1974). As Coleridge put it in 1817 "the air I breathe is the condition of my life, not its cause." The distinctions between causes and conditions are controversial, complex, and context dependent. Conditional theories of causation stipulated pragmatic, interventionist, objective, subjective, and anthropomorphic criteria for distinguishing causes from other conditions. For example, Hart and Honoré (1985) argued that causes, unlike other conditions, express volition, or are abnormal, or are manipulable in a context. Dray (1980, 1989) showed that historians use conflicting value laden normative judgments to distinguish causes that assign historical responsibility and blame from conditions that do not. The elucidation of causal gradation, the distinctions between more or less important causes, proved as complex and challenging (Hammond 1977; Martin 1989, pp. 53–84).

The distinction between origins and conditions, and between more and less important origins, in fields like the history of ideas and evolutionary biology is considerably simpler. Origins, like Carnap's philosophy, transmit information to receivers, such as Quine's philosophy. Other conditions, such as Whitehead's feathering a professional nest for Quine, do not transmit information. When hybrid biological, linguistic, intellectual, and cultural receivers have multiple origins, it is possible to grade them according to their proportional contribution to the preserved information. For example, the genomes of contemporary Eurasians have on average 2% Neanderthal origin and 98% modern human-African origins (Reich 2018). Though Sartre began *Being and Nothingness* with a quote from Hume, Hume's philosophy was not a significant origin of existentialism in comparison with the thinking of Husserl and Heidegger.

The independence of receivers is also easier to explicate and prove than the independence of effects. Causal independence is often interpreted as a conditional independence between two effects with a common cause that satisfy "screening conditions" (Bovens and Hartmann 2003; Pearl 2009, p. 30). Understanding and measuring screening conditions has proven difficult and consequently led to different and conflicting philosophical interpretations. But inferences of common origins from receivers in phylogeny, the history of ideas, historical linguistics, and so on do not require causal independence, but rather a much simpler and easier to ascertain informational independence: the absence of transmission of information between receivers and the information channels that connect them to common origins. Independent receivers that preserve information from a common origin, such as the genomes of two species that have not exchanged genes since they had a last common ancestor, suffice for the inference of that common origin. Independent receivers may condition and cause each other's existence, as long as there are no information flows between them (Tucker 2020). For example, symbiotic species favor each other's existence, cause each other, but do not transmit information to each other in HGT.

Vice versa, receivers are dependent when information is exchanged between them or the information channels that connect them to their origins, for example, when they or their ancestors interbred.[6] Information flow networks models may look like trees when receivers are independent, or like bushes when dependent, for example, in horizontal gene transfers.

5. Irregular Origins vs. Causal Regularity Theories

Regularity or invariance theories of causation consider type-type causal regularities or invariances necessary for distinguishing causal chains from mere successions of events. Davidson claimed that statements of token-token causation entail commitments to implicit, and not necessarily known, laws (Davidson 1980, pp. 149–62; Psillos 2009, p. 147). Even Woodward (2004, p. 20) who thought causation precedes laws of nature, maintained like Davidson that it is "necessary to appeal to claims about type causal relationships … to elucidate token-causal claims … token or singular causal claims always should be understood as committing us to the truth of some type-level causal generalization" (Woodward 2004, p. 72).

Origination is more parsimonious than causation in neither necessarily assuming, nor entailing, nor universally requiring type-type regularities. Sometimes, regularities about types of origins sending types of information signals to types of receivers are present, known, and useful for the inference of origination. But the ontology of origin and origination does not imply that regularities must always govern the transmission of information, let alone that these regularities be known, and assumed in the inference of origination. Information flows do not have to be ontologically or epistemically regulated. For example, the inference of originary relation between

6. Dretske's (1981, p. 38) assertion of a "ghost" information channel *between* receivers of signals from a common origin is, well, "spooky." He claimed that a television receiver transmits information, via non-causal informational "ghost channels, " about other receivers of the broadcast. López and Lombardi (2019) retorted that a manipulationist theory (Woodward 2004) of information transmission excludes "ghost channels" between such television sets because turning off one television set would not affect the information received by the other. By contrast, a change in their common origin (e.g., the news anchor scratches her ear), manipulates the information signals received by the two televisions. This is correct, but has limited applicability because past origins can be manipulated only counterfactually; it is impossible to "turn off" the Big Bang to measure if background radiation stops, or sterilize an ancestral life form to see if and how the history of life would change. Alternatively, and more usefully, Dretske's two televisions case may be analyzed as an inference from what one television receiver receives, what is received by the other set, in two stages: first the tracing back of the signal to its origin, the broadcast, and then the inference from that origin and the reliabilities of transmission channels of the probability that other receivers receive the same signals. There is no "television entanglement," nor supraliminal transmission of information in a "ghost channel," because the television sets do not send signals to each other.

genomes in HGT relies on a comparison between genetic sequences, not on type-type regularities. Origination in the history of ideas assumes no type-type regularities. Intellectual traditions are "unregulated" information flows. For example, Schlick's philosophy was an origin of Carnap's philosophy that was an origin of Quine's philosophy that was an origin of Davidson's, because each demonstrably preserved information from its intellectual origin, evidenced in footnotes, textual references, similar terminology and philosophical themes, selection of problems, methodologies, external evidence for the relations between the philosophers, and so on, and not because there is a theory of intellectual evolution that connects them, let alone predicts the next stages in the evolution of this tradition.

Other inferences of origination may require the assumption of theoretical regularities, for example, the decoding of information signals in energized neutrinos, cosmic rays, background radiation, and red shifted galaxies, to infer their respective origins, supernovae and collisions between stars and black holes, the expansion of the universe, and the early universe. Applied information theories or techniques sometimes identify which receivers are most likely to preserve the most reliable information from their origins, e.g., the inner ear bone for ancient DNA (Reich 2018), and how to extract and decode it. Generally, evolutionary traits that do not affect reproduction either adversely or favorably preserve information more reliably than traits that are subject to evolutionary selection (Sober and Steel 2014). The classification of traits as likely or not to be subjected to the forces of natural selection may require background knowledge that can be theoretical. For example, historical philologists prefer to compare features of language that rudimentary inductive generalizations revealed at the turn of the nineteenth century that are most likely to preserve information from their origins: grammatical structures and words that refer to fauna, flora, geographical places, and immediate family members. Similarly, folk psychological generalizations about memory and cognitive biases generated the historiographic preference for primary sources as the most reliable receivers of information from originary historical events. Yet, it is also possible to infer the origins of historiographic testimonies without such folk psychological generalizations by simply comparing independent testimonies and inferring that what they all cohere on preserves information from their common historical origins because there is no better alternative explanation of the surprising coherence.

Ceteris paribus, there is a simple linear relation between the quantity of information receivers preserve from an origin and the determination of properties of that origin; the more information transmitted from an origin is preserved, the more can be known about the origin. When receivers do not preserve sufficient information for identifying a particular origin, they may infer a probability distribution over a scope of possible origins. For example, humans and apes preserved enough information about their last common ancestor to infer many of the properties of that originary species, but not enough to determine all its identifying properties (cf. Sober and Steel 2017; Tucker 2004, pp. 111–17).

Origins and receivers are exclusively *tokens* (cf. Sober 1988; Cleland 2002). Since originary inferences do not require necessarily knowledge of regularities or invariances of corresponding types, standard challenges to invariance causal theories from unique or singular causes that appear not to be "covered" by known or even knowable regularities do not apply to singular originary inferences. If wrongly categorized cases of "singular causation" are discovered to be in fact cases of singular origination, they have no case to answer, because origination and its inference do not necessarily require regularities or invariances in all cases. Flows of information may suffice to justify connecting singular origins with singular receivers.

By contrast, inferences of causes from their effects do not necessitate decoding. If inferences of causes from their effects must rely on regularities or laws, *ceteris paribus*, the more information rich are descriptions of effects, the less determined are the regularities that should participate in the inference of causes, because the narrower is the range of events that can be used to corroborate or confirm the regularities. *Ceteris paribus*, the more precise, "fine grained," the descriptions of causes and effects, the less similar they are to other token events, and the more difficult it becomes to confirm regularities about them, as regulatory theories of causation require. Singular causal statements about unique events may then be unjustifiable. Vice versa, the less precise and informative are descriptions of causes and effects, the broader is the scope of possible confirming cases for regularities that govern them, but the less useful they are for justifying token causation or for inferring token causes from their effects because they are uninformative and inaccurate. For example, some social science theories, e.g., about "revolutions," are general enough to be confirmable, but too uninformative and imprecise for the justification of singular causal explanations of unique historical events, such as the French Revolution (Tucker 2004, pp. 240–256; Psillos 2009, pp. 144–148; Tucker 2012).

Yet, originary inferences may serve to confirm singular cause-and-effect sequences when the cause-effect sequence is an origin that sent information signals to receivers. A singular causal proposition may be justified by the information it transmitted to receivers. An originary cause-effect sequence that transmits information to receivers may be represented by bracketing:

Origin[cause-effect] → information signals → receivers

For example, geological and evolutionary singular cause and effects sequences are inferred from the geological and fossil records. In historiography, historians may justify asserting a causal link between motivation and decision if the decision maker transmitted the cause-effect sequence reliably, for example, in a personal diary, the transcript of a meeting, or in a personal letter. Causal generalizations from psychology or rational choice theory may be redundant for justification of such historiographic originary causal sequences (cf. Tucker 2004, pp. 185–191).

6. Originary vs. Causal Counterfactuals

Counterfactual theories of causation are a popular alternative to regulatory and conditional theories. Yet, they generate challenging anomalies and apparently counterintuitive implications. A counterfactual theoretical interpretation of origination—had the origin not transmitted the information, the receiver would not have stored it—is immune of comparable challenges. Truth conditions of originary counterfactuals are clearer and easier to determine than truth conditions of causal counterfactuals because it is easier to infer the results of an originary counterfactual, what information would have been stored at the receivers had the origin not transmitted the information it actually did, than it is to assess the outcomes of causal counterfactuals. Originary counterfactuals measure the degree of similarity between the actual and counterfactual information in receivers. For example, Davidson dedicated a book to Quine with the originary counterfactual: "without whom not." Without Quine's philosophy as an origin, Davidson's philosophy would not have been anything like what it became. Without Neanderthal hybridization, the genome of Eurasians would have been about 98% similar to what it is now. Had the universe been stable rather than expanding, there would be no observations of red-shifted galaxies.

Originary counterfactuals do not have the well-known counterintuitive implications that challenge counterfactual theories of causation from omissions, preventers, delayers, hasteners, transitivity, overdetermination, and preemption (Lewis 1973, 1986). Omissions are problematic for counterfactual theories of causation because everyday notions of causation consider omissions causes, whereas causal counterfactuals do not (Lewis 2004, pp. 99–104; Hall 2004b; Maar 2016). However, since "signals carry incremental natural information by changing the probability of what they are about, relative to background data" (Scarantino 2015, p. 423, cf. Dretske 1981), if the omission of a signal in a context reduces prior uncertainties, it is a signal from an origin. For example, much of the information the news media transmits is by omissions because "no news is good news"; when the front page of a quality newspaper conveys no information about major catastrophes, it signals the elimination of the possibility that major catastrophes happened recently. The recent world that has not gone through a catastrophe is the origin of the lack of signal for catastrophe.

Similarly, the absence of certain chemicals from geological strata preserves information that there was no volcanic activity during the geologic era that originated those geological formations. The prior probabilities of eliminated originary alternatives (that there was a catastrophe or that there was volcanic activity) quantify how much information the originary omission transmitted.

Causal transitivity has counterintuitive results for counterfactual theories of causation, e.g., Nazism caused the Second World War. The Second World War caused the defeat of Germany. The defeat of Germany caused the creation of NATO, *ergo* Nazism, by transitivity, caused NATO. Some defenders of counterfactual theories of causation bit the counterintuitive bullet to accept transitive causation. Others, disaggregated the concept of cause to develop a pluralistic account, allowing one type of cause to be transitive (Lewis 2004, pp. 93–9; Hall 2004a, 2004b). Origination is unproblematically transitive: if A is the origin of B (A transmits information to B), and B is the origin of C (B transmits information to C), then A is a transitive origin of C to the precise extent that the information that A transmits to B is received by C. The ratio of received to transmitted information sent by an origin is the reliability or fidelity of the signal in relation to that origin. If the reliability of receiver B in relation to origin A is R_1 and the reliability of receiver C in relation to its origin B is R_2 then the transitive reliability of receiver C in relation to distant origin A is simply R_1R_2. This is apparent in phylogenic relations between ancestral and descendant species and in the historiography of intellectual traditions.

Conditions that prevent, delay, or hasten the transmission of information from origin to receivers do not transmit information, and therefore are not origins. By contrast, "preventers," "delayers," and "hasteners" appear counterintuitively to satisfy causal counterfactual criteria (cf. Collins 2004; Hall 2004a, 2004b).

Overdetermination and preemption may challenge counterfactual theories of origination, though not to the extent they do counterfactual theories of causation. When multiple independent origins send the same information to receivers, they are overdetermined. For example, when both parents possess a genetically dominant trait (e.g., brown eyes) in two copies, its transmission to their descendants is overdetermined. An origin may preempt other origins if, had that origin not transmitted the information to receivers, other origins would have. For example, Pheidippides' testimony was the origin of knowledge of the victory in the battle of Marathon in Athens. He preempted the next runner from the battle who would have transmitted the same information. Still, the more information origins transmit to receivers, the more sensitive the receivers are to their particular origins and, *ceteris paribus* the lower is the probability that origins may overdetermine or preempt. For example, whole genomes, unlike single genes, are information path dependent, and not overdetermined (Ereshefsky 2014). Counterfactual theories of causation cannot use the fine-grained properties of information rich receivers to limit the scope of overdetermination and preemption as easily. For example, since Julius Caesar's death on the Ides of March was overdetermined by 23 assassins, individual assassins cannot satisfy counterfactual causal conditions. The assassination attempt against Israel's ambassador to London, Shlomo Argov, in 1982 preempted other causes that Israeli Defense Minister Ariel Sharon would have used as alternate *causa belli* for invading Lebanon (in the false expectation of bringing its civil war to an end with a Christian-Maronite victory and pro-Israeli government), so it cannot satisfy the counterfactual causal dependency condition. Philosophers proposed elaborate methods to overcome, or at least bypass, such challenges (Collins 2004; Hall 2004a, 2004b; Schaffer 2004), such as describing effects as "fine-grained" or "fragile" to avoid causal overdetermination and preemption (Lewis 1986, 2004, pp. 85–88; Paul 2000; Coady 2004; Maar 2016). "Alternations" in preempting causes may distinguish them from preempted causes when they affect fragile effects (Lewis 2004). But the conceptualization of effects as "fragile" is challenging, especially when effects like biological extinction, pregnancy, or death allow only binary values and so cannot be fine-grained or fragile to preempt preemption or determine overdetermination. Lewis' characterization of fragility is vague, partly because he wanted to avoid deciding whether the counterfactual event is a version or a variation on the factual one or just different. Lewis' theory further generates counterintuitive "false positives" that categorize influences as causal. If, however, "fragile" is conceptualized as information rich, and attached to a receiver rather than to an effect, the problem dissolves. Fragility is then clearly a change in the information received from an origin. For example, if Caesar's corpse was a receiver of information transmitted by 23 sharp and pointed origins, the information preserved in the corpse in the form of stab wounds would have been different had there been counterfactually fewer assassins, though as an effect, Caesar would have been just as dead.

7. Conclusion: Originary vs. Causal Sciences

The historical sciences are founded on inferences of origination and origins. For example, knowledge of human history "depend[s] on the development of systems to record events and hence accumulate and transmit information about the past. No records, no history, so history is actually synonymous with the information age" (Floridi 2010, p. 3). Human history before the invention of writing is inferred from other types of information signals such as artefacts, languages, and DNA. Similar distinctions have been made between theoretical sciences of types and historical sciences of tokens (Sober 1988; Cleland 2001, 2002, 2009, 2011; Tucker 2004, 2012; Turner 2007). For example, theoretical biology is interested in DNA as a theoretical type, whereas Phylogeny is interested in token historical individual genomes. Theoretical physics is interested in types of particles and theories that model their behavior. Cosmology of the early universe is interested in how tokens of these particles behaved and interacted in the extreme conditions following the Big Bang. The distinction between originary and causal sciences absorbs the distinctions between historical and theoretical sciences, and replaces obsolete distinctions between sciences according to their domains, e.g., human vs. natural, or their goals, e.g., understanding vs. explanation or ideographic description vs. nomothetic discovery of laws (cf. Tucker 2012). The distinction between originary and causal sciences cuts through established academic-disciplinary boundaries to base the distinction between the sciences on firm epistemic foundations and on actual scientific methods and practices. The above distinct characteristics of origination in comparison with causation, and consequently of the originary vs. causal sciences, may be summarized in the following table.

The unique properties of origination shield its theories from the kinds of challenges faced by the four main theories of causation (conditional, regulatory, process, and counterfactual). The discovery that some conventionally considered causes are actually origins because they transmit information to receivers dissolves the apparent theoretical difficulties attached to conceiving them as causes. To be clear, scientists or philosophers cannot choose whether to construct a sequence of events as causal or originary because origins and causes have different properties that allow identifying them distinctly, even when some of their extensions overlap. When origination was considered as causation, the conflations generated philosophical problems that would disappear once origins and origination are recognized distinctly for what they are.

A research program into the philosophy of the originary sciences extends Dretske's (1981) classical program for reorienting the theory of knowledge from the causes of knowledge to the information flows that generate it. Dretske's reconceptualization of classical problems in epistemology in terms of the flow of information simplified and dissolved them. He proffered a theory of knowledge with fewer anomalies and deeper insights into the nature of knowledge. The study of origination promises similar progress in the philosophy of the historical sciences.

Table 1. Distinctions between Origination and Causation

Distinguishing Criterion	Origination	Causation
Information	Origins always transmit information to receivers. Inference of origin requires decoding received signals.	Effects may not preserve information from causes. Causal inference does not necessitate decoding.
Contiguity	Origins and receivers are separated by latency. *Contiguity* is *unnecessary* for the inference of origins.	Effects may conserve properties of causes contiguously. *Contiguity* may be *necessary* for inferences of causes from effects.
Conditionality	*Information* in *receivers* is conditional on their *origins*.	The *existence* of *effects* may be conditional on their *causes*.
Independence	Independent receivers do not receive *information* from each other.	Independent effects are conditionally independent of each other.
Regularities	Regularities are helpful but sometimes unnecessary for the inference of Origination. *Ceteris paribus*, the more *information rich* receivers are, the more *determined* are inferences of their origins.	*Type-type regularities* may be necessary to distinguish causation from succession. *Ceteris paribus*, the more *information-rich* are causal propositions, the more *underdetermined* are regularities that justify them.
Counterfactuals	Originary counterfactuals are consistent with omissions and are transitive. Preventers, delayers, and hasteners are not origins. Originary overdetermination and preemption are rare.	Omissions and transitive causes may not satisfy causal counterfactual conditions. Preventers, delayers, hasteners, overdetermination, and preemption challenge causal counterfactuals.

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