9
What is time?

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> If no one asks me, I know: if I wish to explain it to one that asketh, I know not
> (Augustine, *Confessions* 10.14; Pusey trans., 1948)

Time is one of the most enigmatic notions philosophers have ever dealt with. Once subjected to close examination, almost any feature usually ascribed to time leads to a plethora of fundamental and hard to resolve questions. Just as philosophers of the eighteenth century attempted to take account of revolutionary developments in the physical sciences in understanding space, life, and a host of other fundamental aspects of nature (see Jones, Chapter 8, Gaukroger, Chapter 28, and Smith, Chapter 29, in this volume) they also engaged in fundamental and fruitful controversies about the nature of time spurred by Newton and others (see Schliesser, Chapter 2, and Schabas, Chapter 30, in this volume). In this article, I will attempt to trace the general outlines of these controversies. Special attention will be given to a question that was central for many eighteenth-century philosophers and is somewhat less prominent in contemporary, twenty-first-century[1] debates on the nature of time, i.e. whether time can be reduced to, grounded by, or explained through other more basic elements.

The concept of time is commonly discussed – both in eighteenth- and twenty-first-century philosophy – in analogy to space. Here I will attempt to focus on time and address the analogies to space only when relevant. This attitude is motivated both by the need to provide as detailed an account as possible of time in the allocated textual space, and by the various dissimilarities between space and time. While space and time can be fruitfully compared and contrasted, the use of metaphors taken from one domain to clarify features belonging to the other domain has the real potential of leading us astray by unconsciously and seamlessly taking metaphorical language in a literal sense.

In the first part of this essay, I will discuss the famous debate between Newton, Leibniz, and Clarke on the nature of space and time. The second part will address Hume's understanding of time and the relation between time and causation. In the third and final part, I will discuss Kant's views on the relation between time and causality, place them in the context of his predecessors, and then examine Salomon Maimon's attempt to revive the Leibnizian program of reducing time to concepts, within the framework of Kantian philosophy, broadly conceived.

Newton and Leibniz

Newton's celebrated *Principia* opens with eight definitions of fundamental physical terms. Immediately following the eighth definition, Newton adduces a scholium explicating his understanding of the nature of time (and space).

> Thus far it has seemed best to explain the senses in which less familiar words are to be taken in this treatise. Although time, space, place, and motion are very familiar to everyone, it must be noted that these quantities are popularly conceived solely with reference to the objects of sense perception. And this is the source of certain preconceptions; to eliminate them it is useful to distinguish these quantities into absolute and relative, true and apparent, mathematical and common.
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> Absolute, true, and mathematical time, in and of itself and of its own nature, without reference to anything external, flows uniformly and by another name is called duration.[2] Relative, apparent, and common time is any sensible and external measure (precise or imprecise) of duration by means of motion; such a measure – for example, an hour, a day, a month, a year – is commonly used instead of true time.
>
> (Newton 1687: 64)

The first paragraph in the excerpt above discloses Newton's awareness of the difficulty of conceptualizing time in a clear and precise manner. But already in the paragraph that follows, he turns to describe absolute and true time in enigmatic terminology that could hardly be read not metaphorically. For, what does it mean that "time *flows* uniformly"? If time flows like a river, then where, when, and at what rate does time flow? And how do we measure this rate?

Newton is quite clear in explaining his understanding of true time as absolute and independent of the motions and things that occur in time: "All motions can be accelerated and retarded, but the flow of absolute time cannot be changed. The duration or perseverance of the existence of things is the same, whether their motions are rapid or slow or null" (Newton 1687: 66). Yet, Newton repeatedly attempts – and fails – to answer the most basic question: "what is time?" Thus, shortly after the previous passage, Newton writes: "For times and spaces are, as it were, the places of themselves and of all things. All things are placed in time with reference to *order of succession* and in space with reference to *order of position*" (Newton 1687: 66, italics added). What does it mean that time is "the place of itself and of all things"? And how can one explain the notion of time through succession without committing an obvious circularity? Can we explicate succession without reference to time?

In spite of his failure to provide an explanation of time, Newton does not seem content with leaving time as a primitive, unexplainable, notion, and over and over attempts to answer the question in a slightly different manner. In an intriguing draft from the early 1690s, he writes: "Time and Place are common affections of all things without which nothing whatsoever can exist" (in McGuire 1978: 117). The view of time and place as the common affections of all things is quite interesting, yet it immediately invites the question: what distinguishes time from place? Newton's apparent

answer – "All things are in time as regards duration of existence, and in place as regards amplitude of presence" – is of little help, since "duration" is hardly explicable without reference to time, and "amplitude of presence [*amplitudinem praesentiae*]" is highly vague (and may well involve the notion of space).

Shortly after this passage, Newton again invokes the flow of time: "For the Duration of a thing is not its flow, or any change, but permanence and immutability in *flowing time*. All things endure in so far as they remain the same at any time. <The duration of each thing flows, but>[3] its <enduring> substance does not flow, and is not changed with respect to before and after, but always remains the same" (in McGuire 1978: 117, italics added). We are faced again with the metaphor of the flow of time. A beautiful metaphor. Wonderful for poetry, less so for philosophy or science.[4]

Leibniz's account of space and time is commonly contrasted with Newton's. Indeed, it is likely that Leibniz's account was developed, at least in part, in reaction to Newton, as I will shortly show. It is noteworthy that Leibniz's views on the nature of space and time underwent significant changes (Cover 1997: 303; Vailati 1997: 112). Here, I will concentrate primarily on Leibniz's late views, roughly in the last twenty years of his life (1696–1716), when his views of space and time as mere relations, are most fully developed.

For Leibniz, space and time are heterogeneous. They are not species of any common genus: "[T]ime and space are quite heterogeneous things, and we would be wrong to imagine some common real subject I-know-not-what which had only continuous quality in general and whose modifications resulted in time and space" (Leibniz 1765: GP V, 56–57; Ariew and Garber trans., Leibniz 1989: 303).

What are they then? In his celebrated correspondence with Samuel Clarke, Newton's friend and philosophical ally, the issue of the nature of space and time takes a primary role (along with questions about the nature of God's volition and the proper interpretation of the principle of sufficient reason). In his third letter to Clarke (§4), Leibniz writes:

> As for my own opinion, I have said more than once that I hold space to be something merely relative, as time is, that *I hold it to be an order of coexistences, as time is an order of successions*. For space denotes, in terms of possibility, an order of things which exist at the same time, considered as existing together, without entering into their particular manners of existing. And when many things are seen together, one perceives this order of things among themselves.
>
> (Leibniz and Clarke 1717: Leibniz's Third Letter §4 [GP VII, 363]; Ariew and Garber trans., Leibniz 1989: 324–25 – italics added)

Indeed the view of space as the *order of coexistence* (or of possible[5] coexistences) and of time as the *order of successions* is asserted numerous times in Leibniz's writing of this period,[6] and it contrasts nicely with Newton's assertion that "[a]ll things are placed in time with reference to *order of succession* and in space with reference to *order of position*" (Newton 1687: 66). For Newton, space and time are ordered "containers" in which all things are placed, but the very existence of space or time is not at all dependent on the things that populate it. For Leibniz, space and time are nothing but the relations among things. In the absence of things (i.e. in an empty world)

space and time would not obtain at all.[7] Thus, Leibniz argues that time instants "considered without the things, are nothing at all" (Leibniz and Clarke 1717: Leibniz's Third Letter, V §6 [GP VII, 364]; Ariew and Garber trans., Leibniz 1989: 325).

Looking more closely at Leibniz's view of space as the "order of coexistence" or "the order of things, which exist at the same time" it appears that Leibniz explains his notion of space by appealing to temporal notions ("coexistence," "existence at the same time"). Does that mean that Leibniz takes time to be more fundamental than space? But then when we scrutinize Leibniz's view of time as the "order of succession," it appears as if Leibniz is providing a patently circular explanation of time, since it seems unlikely that we can explain succession without a reference to time. Or perhaps can we?

This blatant circularity of Leibniz's account of time drew the attention of quite a few scholars. In order to avoid ascribing such circularity to Leibniz, Nicholas Rescher suggested that Leibniz distinguished between two kinds of temporal orders.

> Leibniz's standard definition of time as the order of non-contemporaneous things would be vitiated by an obvious circularity if it did not embody a distinction between intra- and inter-monadic time, carrying the latter back to (i.e., well-founding it within) the former.
>
> (Rescher 1967: 92)

The ground floor of Leibniz's late ontology consists of God and created monads. These monads are simple, non-extended, substances whose internal structure consists of monadic states and appetition, which makes the monad pass from one state to another (*Monadology* §15, in Ariew and Garber trans., Leibniz 1989: 215). According to Rescher's suggestion, temporal relations among monads (inter-monadic time) should be grounded in the *internal* temporal order within each monad. While this suggestion is quite intriguing, it seems to achieve very little since it leaves the more basic, intra-monadic time, unexplainable, and if one is satisfied with primitive, unexplainable, intra-monadic time, she may just as well accept inter-monadic time as primitive.

A second venue through which one may attempt to vindicate Leibniz's understanding of time is by appealing to passages in Leibniz's late writing in which he suggests that temporal relations are grounded in the more basic relation of *incompatibility*. Thus, in the 1715 *Initia rerum mathematicarum metaphysica* (*Metaphysical Foundations of Mathematics*), Leibniz writes:

> *If a plurality of states of things is assumed to exist which involve no opposition to each other, they are said to exist simultaneously*. Thus we deny that what occurred last year and this year are simultaneous, for they involve incompatible states of the same thing.
>
> (GP VII, 17; Loemker trans., Leibniz 1969: 666)[8]

This passage seems to assert that monadic states are *simultaneous*, if and only if, they are logically *compatible* (the first sentence of the passage asserts the right-to-left side of the biconditional, the second sentence an equivalent to the left-to-right side). Grounding simultaneity/non-simultaneity in compatibility/incompatibility relations

brings about two urgent conspicuous problems. First, it is not at all clear that we can explain compatibility without reference to time (since having contradictory properties at different times is *not* contradictory). Second, and even more troubling, it seems that incompatibility, being a symmetrical relation, cannot explain the asymmetry of temporal relations. In other words, the incompatibility of two states of the same monad rules out their simultaneity, but it does determine which state precedes the other. Thus, it seems that incompatibility *alone* is insufficient to explain time.

A third venue which can be discerned in Leibniz's late writing on time is the reduction of temporal relations to either (a) *causality* or (b) *ground-containment* relations. Thus, the passage just quoted from the *Initia rerum* continues:

> If one of two states which are not simultaneous involves a reason for the other, the former is held to be *prior*, the latter *posterior*. My earlier state involves a reason for the existence of my later state. And since my prior state, by reason of the connection between all things, involves the prior state of other things as well, it also involves a reason for the later state of these other things and is thus prior to them. *Therefore whatever exists is either simultaneous with other existences or prior or posterior.*
>
> (GP VII, 18; Loemker trans., Leibniz 1969: 666)

This passage has been interpreted by various scholars as either offering a reduction of time to *causality* (van Fraassen 1970: 38; Winnie 1977; Cover 1997: 309), or to *ground-containment* relations (Arthur 1985). Cover argued, convincingly in my mind, that for Leibniz, causes and reasons are thoroughly assimilated (Cover 1997: 308), and therefore in the following, I will not distinguish between the two.

There are several significant problems with the suggestion that Leibniz reduced time to causal relations.[9] First, we may wonder what is the precise nature of this reduction (see Cover 1997: 290–96). If we understand it to mean that at the foundational level of Leibniz's ontology there are *only* causal, but no temporal, relations, we will have to explain several central texts of Leibniz in which he describes monads – his most real and fundamental entities – in terms that clearly involve time, such as "change or passage" (*Monadology* §15), "memory" (*Monadology* §19), or even "future" in a 21 January 1704 letter to De Volder (letter 29 [GP II, 261–65]; Loemker trans., Leibniz 1969: 533). Second, a reduction of time to causal relations requires that causes will always precede their effects in time (for otherwise, causality alone could not explain the spread in time of cause and effect). While the view that the cause *must* precede (in time) its effect is widely accepted today (perhaps following Hume), it was not in Leibniz's time. Descartes, Spinoza, and even Kant allow for causation that is either simultaneous or not in time at all.[10] If cause and effect do *not* have to be located in different times, causation would not suffice to explain the temporal order of states. Third, assuming that we are able to explain away the variety of texts, which seem to show that temporal relations obtain even at the ground level of Leibniz's ontology, we are likely to face pressure from the opposite side. If we ground time in a causal order that is time-free, it is not clear that we could explain what is sometimes called "the dynamic nature of time." Causal relations may explain the asymmetry of time,[11] but there is more to time than mere asymmetry (cf. Maudlin 2007: 110). Unlike the variety of

other asymmetric orders, time involves a certain sense of *alteration*, or change. For this reason, some scholars pointed out that Leibniz posits, at the ground level of his ontology, the dynamic notion of *appetite* (*Monadology* §15) which makes the monad pass from one state to another (Arthur 1985: 276). But then, we may fall again to our first problem, since time (appetite) would be present at the ground level of our ontology and our explanation of time will turn again to be circular.

It seems that there are at least three requirements for a proper explanation, or reduction, of time: (i) the explanans must *not* involve the notion of time (for otherwise, the explanation would be circular) (ii) the explanans must account for the asymmetry of time, and (iii) the explanans must account for the dynamic nature of time. There seems to be a tension between the first and third requirement with regard to the question of whether the dynamic nature of time should be included in the explanans: (i) presses against, while (iii) presses in favor of such an inclusion.

Another way to make the same point is to distinguish between two elements of time: asymmetry and change. It is one thing to explain asymmetry, but it is far more difficult to explain change (without assuming change in the explanans). Obviously, these problems are essential to the issue and should haunt any attempt – not only Leibniz's – to explain time.

Hume

A major principle underlying David Hume's conception of time is his celebrated "copy principle": "all our simple ideas in their first appearance are deriv'd from simple impressions" (Hume 1739–40: 1.1.1.7; SBN 4; cf. 1.2.3.1; SBN 33; and Baxter 2008: 131, 144). Applying the copy principle to our idea of time, Hume writes: "The idea of time is derived from the successions of our perceptions of every kind, ideas as well as impressions" (ibid.: 1.2.3.6; SBN 35). Before we turn to examine more closely Hume's explication of time, let us have a quick look at Hume's famous theory of causation (another implication of his copy principle), and particularly his view of the relation between temporal succession and causation.

Following an extensive critical discussion of our beliefs about the nature of causation in his *Treatise of Human Nature*, Hume arrives at a twofold definition of causation:

> We may define a *cause* to be "An object precedent and contiguous to another, and where all the objects resembling the former are placed in like relations of precedency and contiguity to those objects that resemble the latter." If this definition be esteemed defective, because drawn from objects foreign to the cause, we may substitute this other definition in its place, viz. "A *cause* is an object precedent and contiguous to another, and so united with it that the idea of the one determines the mind to form the idea of the other, and the impression of the one to form a more lively idea of the other."
>
> (Hume 1739–40: 1.3.14; SBN 151)

The precise role of each of these two definitions has been a subject of recent scholarly inquiry (see, for example, Garrett 1997: 96–117). Both formulations refer to a

constant successive conjunction of similar events. Obviously, there are many further questions that must be answered before we can fully evaluate this account (for example, "How similar should the cause and effect be?"). Still, for our purposes, it would suffice to note that the effect must *follow the cause in time*. In fact, Hume's temporal atomism (Hume 1739–40: 1.2.2.4; SBN 32) allows him to hold that the effect follows the cause in the very *next moment* (Garrett 1997: 115). Thus, it seems that for Hume, causal orders supervene on temporal orders.[12] There is nothing wrong with this view, but the story gets more complicated (and interesting) once we realize that Hume rejects the conceivability of empty time (Hume 1739–40: 1.2.4.2; SBN 39–40), and that his theory of time is, like Leibniz's, a variant of the relationist family.[13] Let us have a look at Hume's explanation of how we form our idea of time.

> As 'tis from the disposition of visible and tangible objects we receive the idea of space, *so from the succession of ideas and impressions we form the idea of time*; nor is it possible for time alone ever to make its appearance, or be taken notice of by the mind. A man in a sound sleep, or strongly occupied with one thought, is insensible of time; and according as his perceptions succeed each other with greater or less rapidity, the same duration appears longer or shorter to his imagination. … Wherever we have no successive perceptions, we have no notion of time, even though there be a real succession in the objects. From these phenomena, as well as from many others, we may conclude, that time cannot make its appearance to the mind, either alone or attended with a steady unchangeable object, but is always discovered by some *perceivable* succession of changeable objects.
>
> (Hume 1739–40: 1.2.3.7; SBN 35 – italics added)[14]

> The ideas of space and time are, therefore, no separate or distinct ideas, but merely those of the manner or order in which objects exist; or, in other words, it is impossible to conceive either a vacuum and extension without matter, or a time when there was no succession or change in any real existence.
>
> (Hume 1739–40: 1.2.4.2; SBN 39–40)

For Hume, our idea of time is an abstract, or general, idea derived from particular cases of perceptions, which succeed each other (Hume 1739–40: 1.2.3.6; SBN 35). Thus, for example, when we experience the impressions of five notes played by a flute, we derive our idea of time not from any single impression, but rather from the sequence (Hume 1739–40: 1.2.3.10; SBN 36–37). When we do not experience succession, we do not perceive time at all.

Hume's explanation of the emergence of our idea of time, while clearly interesting, invites several further fundamental questions. What is the reason for the succession of our perceptions? What is the nature of the "real succession in the objects" (Hume 1739–40: 1.2.3.7; SBN 35) which may take place even when we do no perceive change? Is this objective succession of objects explainable (or accessible) at all? And finally, why do certain successions of perceptions – for example, when we look at a street from left to right – not make us believe that the order of our perceptions reflects the real temporal order of things? (We do not believe that the houses on the left side of the street exist before those on the right side.)

Hume's account of causation as grounded in constant temporal succession may seem, and indeed be, a promising alternative and reversal of Leibniz's view on the relation between time and causation, but just like Leibniz, Hume leaves many, too many, questions unanswered. Some, though not all, of these questions will be taken up by Hume's prominent successor, Immanuel Kant, in his own attempt to explain the objectivity and coherence of our notion of time.

Kant and Maimon

Kant begins his major work, the *Critique of Pure Reason* (first edition 1781; second, revised edition 1787) with a discussion of the nature of space and time. For Kant, time and space are not qualities of things in themselves, but rather features cast by our cognitive system on everything we perceive and experience. Time and space are *intuitions* (*Anschauungen*), i.e. non-conceptual representations which we cognize without any mediation (Kant 1781/1787: A19/B33), or more specifically, a priori intuitions, i.e. intuitions which we do not acquire from experience, but rather are the conditions through which we (i.e. human beings) can have experience at all. In the Transcendental Aesthetic part of the *Critique of Pure Reason*, Kant attempts to prove these features, arguing that were we not to have an a priori intuition of time, we could not experience any succession (or simultaneity) of external objects, and that therefore (pace Hume), time cannot be an idea we develop from experiencing the succession of objects (A30/B46). Furthermore, Kant argues (against Leibniz) that we can represent time empty of any appearances in it, but we cannot represent appearances, removed from time (A31/B46). Relying on these two arguments, Kant claims to establish the apriority of time. Against any attempt to conceive time as a general *concept* (rather than intuition), Kant argues that finite times are just parts of one and the same infinite time, while the relation between a general concept and its instantiations is not one of whole to part (B47/A32). As if pressed to tell us more about the nature of time as intuition, Kant writes that "time is nothing other than the form of inner sense, i.e., of the intuition of our self and our inner state" (B 49/A33).

Kant's view of time as intuition, rather than concept, seems to undercut any attempt to explain or reduce time, and secure its primitive, inexplicable nature. Nevertheless, as we advance further in the *Critique of Pure Reason*, it becomes clear that time has a very central role in Kant's system, and the very delicate play between time-determinations and the twelve *categories* – Kant's a priori concepts which are the conditions for any thought at all – appears to underpin the entire system. Indeed, for Kant, the intuition of time is more extensive than space, since space is the a priori condition for experiencing *outer* appearances, while time the condition of *all appearances* in general, both outer and inner (B50/A34).

For Kant, intuitions and concepts are generated by distinct faculties: *sensibility* (*Sinnlichkeit*) and *understanding* (*Verstand*), respectively. The heterogeneity of intuitions and concepts is stressed when Kant discusses the question of what explains the possibility of applying the concepts of the understanding to sensible intuitions (B176). According to Kant, these are certain time-determinations, which he calls "schemata," that secure the possibility of such application. Thus, the schema of the category of

cause is "the succession of a manifold, insofar as it is subject to a rule" (B183). The schema of the category of actuality is "existence at determinate time," and the schema of the category of necessity is "the existence of an object at all times" (B184). In this manner, time serves as the scaffolding and condition for the application of the categories. Yet, for Kant, the categories also have a mirror-role in the construction of *objective* time order, a claim he develops in the Analogies of Experience section of the *Critique of Pure Reason*.

If we return to the question, which we raised in our discussion of Hume – why do we believe that certain perception of successions are objective, while others are not (e.g. the succession of my perceptions of the houses in a street when I look from left to right) – Kant would argue that only through the category of causation is the subjective time order we perceive transformed into an objective time order, i.e. an order of succession according to a rule (B238–40). The order of succession we experience when we survey the street from left to right is not necessary (on other occasions we experience the successions in reverse order). In other words, such a succession of perceptions does not involve the notion of any necessary connection between the succeeding representations (i.e. a notion of causation), and in the absence of this notion, we would not judge the temporal order of our perceptions as objective. In this sense, it seems that, in Kant, there is a certain mutual dependence between time-determinations and concepts, rather than reduction of the one to the other.[15]

Kant's dualism of concepts and intuitions has been the target of several arguments by Salomon Maimon, the philosopher whom Kant considered the sharpest of his critics.[16] Thus, Maimon would argue that if intuitions and concepts were truly heterogeneous, we could not explain their systematic cooperation. The necessary agreement of intuitions and concepts can be explained if we assume an infinite intellect as the ultimate source of all intuitions.

> Kant claims that sensibility and understanding are two completely different faculties. But I argue that an infinite thinking being must think them as one and the same power [*Kraft*] despite the fact that we must represent them as two different faculties in us, and that for us sensibility is incomplete understanding.
>
> (Maimon 1790: 181)

For Maimon, any non-conceptual element in our cognition (i.e. the intuitions of space and time) is just an indication of the incompleteness of our knowledge of objects (Maimon 1794: 134). The more we develop our intellect the more we are able to explain *conceptually* what appears to us as brute intuition.

The attempt to reduce time and space to concepts should appear familiar to the reader. Clearly, Maimon was attempting to smuggle a rationalist Trojan horse into Kant's castle. Indeed, Maimon openly announces: "Kant asserts that [time and space] are the forms of our sensibility, and here I am of completely the same opinion as him. I add only that these particular forms of our sensibility have their ground in the universal forms of our thought in general" (Maimon 1790: 6). Leibniz argued against Newton and Clarke, that time is a mere relation, grounded in the causal relations that obtain among substances. Maimon adopts a similar strategy. For him, however,

the reduction obtains *within* thought, i.e. between the two layers of cognitions, concepts and intuitions, which Kant considered utterly heterogeneous.

We have seen that Leibniz barely developed and systematized his claim that time can be reduced to conceptual relations. In Maimon, we find several attempts to reduce temporal relations to the Kantian categories. Thus, for example, Maimon writes:

> Just as the actual existence of the various features of an object, has its ground in the ideal coexistence, i.e. logical connection of these features in an infinite capacity of cognition, so the regular succession of various phenomena one upon another must also have its ground in the infinite capacity of cognition which thinks of this regular succession of the phenomena in terms of logical antecedent and logical consequent.
>
> (Maimon 1793: 55)[17]

Like Leibniz, Maimon never developed fully the suggestion to reduce time to concepts. He seems to consider several paths, but none was brought to completion.[18]

Conclusion

In this short study, we have encountered a series of failed attempts to explain the nature of time by some of the brightest philosophical minds of the eighteenth century. We have learned a lot from these failures, which not only drew our attention to the complexity and importance of the issue, but also pointed out many of the problems facing the various attempts to provide a philosophical account of time. Our investigation stressed the need to elucidate what we are really after when we search for an explanation of becoming, i.e. what should count as a non-circular and adequate explanation of time. It is noteworthy that this fundamental and simple question is still very much with us today, after another two centuries of becoming, reflections on becoming, and refutations thereof.

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Notes

1 For a helpful survey of contemporary philosophy of time, see Markosian 2010. Discussions of the causal theory of time (roughly, reducing time to causality) were much more common in the 1970s. See, for example, van Fraassen 1970.

2 There seems to be a slight yet important change in the sense of *tempus* between Newton and his predecessors. For Descartes (1644: AT VIIIA, 27 [pt. 1, §55]) and Spinoza (1677b: Epistle 12) time (*tempus*) is merely the *measure* of duration (*duratio*). Newton seems to take *tempus* and *duratio* as interchangeable.

3 < > marks interpolation in the manuscript.

4 For an insightful defense of the passage (though not the flow) of time, see Maudlin 2007: 110–42.

5 The inclusion of *possible* existences is meant to secure space's continuity "which is uniform and indifferent to every division." See Leibniz's 1702 "Reply" to the Rorarius article in Bayle's *Dictionary* (GP VI, 568; Loemker trans., Leibniz 1969: 583).
6 See, for example, Leibniz's 1702 "Reply" to the Rorarius article in Bayle's *Dictionary* (GP VI, 568; Loemker trans., Leibniz 1969: 583), Leibniz's 26 May 1712 letter to Des Bosses (Letter 93 [GP II, 444–45]; Ariew and Garber trans., Leibniz 1989: 201), and his 20 June 1703 letter to De Volder (Letter 25 [GP II, 248–53]; Ariew and Garber trans., Leibniz 1989: 178).
7 Or, as Leibniz asserts in his fourth letter to Clarke (§41): "If there were no creatures, space and time would only be in the ideas of God" (Leibniz and Clarke 1717: 4th Letter §41 [GP VII, 376–77]; Ariew and Garber trans., Leibniz 1989: 331). For Newton, God himself is present in time and his eternity is just existence in all times. See McGuire 1978: 121. On the ideality of relations, in general (and not only space and time), in Leibniz, see Mugnani 2012, esp., 181–84.
8 Cf. Leibniz's 1702 "Reply" to the Rorarius article in Bayle's *Dictionary* (GP VI 568; Loemker trans., Leibniz 1969: 583): "Time is the order of possibilities that are inconsistent but nevertheless have connection," and his 20 June 1703 letter to De Volder (GP II 253; Ariew and Garber trans., Leibniz 1989: 178): "Time is the order of inconsistent possibilities." Notice that incompatibility account of time frequently appears together with the causation/ground-containment account of time, as in the *Initia rerum*.
9 I will not address here the issue of the compatibility of the reduction of time to causality with Leibniz's view of monads as causally independent (*Monadology* §11). Leibniz's doctrine of the pre-established harmony (notice the "the connection between all things" phrase in the *Initia rerum* passage above), combined with the interpretation of inter-monadic causation as mere *façon de parler*, seems to go a long way toward adequately addressing this issue. See Cover 1997: 307.
10 For Descartes, see the first set of replies, Descartes 1641: AT VII, 108. For Spinoza, see his claim that "God is not before his decrees," i.e. his effects (Spinoza 1677a: pt. 1, prop. 33, schol. 2). In Spinoza, *causa immanens* is a species of the efficient cause that is not in time. See Melamed 2012: 382. For Kant, see 1781/1789: A203.
11 Assuming we rule out self-causation, and similar scenarios.
12 For Hume's argument against simultaneous causation, see Hume 1739–40: 1.3.2.7.
13 See Hume (1739–40: 1.1.5.5): "After identity the most universal and comprehensive relations are those of *space* and *time*, which are the sources of an infinite number of comparisons, such as *distant*, *contiguous*, *above*, *below*, *before*, *after*, etc." Cf. Baxter 2008: 131.
14 Cf. Hume (1739–40: 1.2.3.11): "The idea of duration is always derived from a succession of changeable objects, and can never be conveyed to the mind by any thing steadfast and unchangeable. It inevitably follows from thence, that since the idea of duration cannot be derived from such an object, it can never in any propriety or exactness be applied to it, nor can any thing unchangeable be ever said to have duration."
15 Whether this mutual dependence is consistent is an issue I cannot address here. Some scholars, however, take Kant's Second Analogy as offering a causal theory of time. See Cover 1997: 306n30. For a helpful discussion of Kant's response to Hume on the issue of causation, see DiPierris and Friedman 2008.
16 See Kant's letter to Herz (26 May 1789), in Maimon 1790: 231. For an introduction to the philosophy of Maimon, see Melamed and Thielke 2012.
17 The translation is quoted from Atlas 1959: 242.
18 For the relationship between time and the categories of substance and accident, see Maimon 1790: 17. For Maimon's critique of (and suggested alternative to) Kant's Second Analogy, see Maimon 1790: 101.

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Further reading

See, particularly, R. T. W. Arthur, "Leibniz's Theory of Time," in K. Okruhlik and J. R. Brown (eds.) *The Natural Philosophy of Leibniz* (Dordrecht: Reidel, 1985), 263–313; D. L. M. Baxter, "Hume's Theory of Space and Time in Its Skeptical Context," in D. Norton and J. Taylor (eds.) *The Cambridge Companion to Hume* (Cambridge: Cambridge University Press, 2008), 105–46; J. Cover, "Non-basic Time and Reductive Strategies: Leibniz's Theory of Time," *Studies in History and Philosophy of Science* 28 (1997): 289–318; G. De Pierris and M. Friedman, "Kant and Hume on Causality," in E. N. Zalta (ed.) *The Stanford Encyclopedia of Philosophy* (Fall 2008 ed.) <http://plato.stanford.edu/archives/fall2008/entries/kant-hume-causality/>; E. Vailati, *Leibniz and Clarke: A Study of Their Correspondence* (Oxford: Oxford University Press, 1997).