

Topologies of Time in the 1920s: Reichenbach, Carnap, Lewin

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In the early 1920s Hans Reichenbach, Rudolf Carnap and Kurt Lewin developed three different, but interrelated accounts of the topology of time. The notion of genidentity, or identity through time, plays a fundamental role in all three cases. Common to these accounts is also the idea that time order can be shown to be founded on certain structural properties of the world, but this same aim is pursued in different fashions. This paper examines the analogies and the differences in these three early versions of the topology of time and shows how, assigning genidentity a specific meaning, the three constructions reveal a different level of ontological complexity one with respect to the other. Finally, the fate of the concept of genidentity is followed in Reichenbach's posthumous work, and from there to some more recent accounts.

In his attempt to axiomatise relativity theory, both in his paper "Bericht über eine Axiomatik der Einsteinschen Raum-Zeit-Lehre" (1921) and in his more famous monograph *Axiomatik der relativistischen Raum-Zeit-Lehre* (1924), Reichenbach presented a distinction between light axioms and material axioms, a distinction that was purported to found and clarify the structural relations of the causal series of events of which reality is composed. Here, the topology of space follows as a result of the topology of time, and the concept of '*spatially nearer than*' is reduced to the concept of '*temporally earlier than*'. The aim of this work was to determine the properties of the type of order characterising the causal series, namely time, and to consider the spatial order only after giving a definition of simultaneity for *distant* events. In this framework, the concept of prime signal is crucially assumed as the basis of the topological construction.

Shortly after, but independently from Reichenbach, Carnap published the article "Über die Abhängigkeit der Eigenschaften des Raumes von denen der Zeit" (1925) in which he proposed a space-time topology by means of the theory of relations, ultimately based on the two unanalysable relations "K" and "Z", where "K" stands for the "coincidence relation" and "Z" for the relation of "temporal antecedency along the same world line". From these two basic relations, Carnap derived a third one, "W", defined as "effectual connection" (Wirkungsverknüpfung) and more simply identifiable with the concept of signal. Whilst starting from a different approach, this work also intended to show that the topological properties of space can be derived from those of time, when considering, in particular, spatial neighbourhood as a temporally short *effectual* connection.

In a paper published in the *Zeitschrift für Physik* and entitled "Die zeitliche Geneseordnung" (1923), the Gestalt psychologist Kurt Lewin elaborated an original description of time order in mereological terms, where the key concept was the concept of genetic series (Genesereihe) and its related notion of genidentity. This topology's restricted application was to define the time order that is expressed only between the series of real events that are in *existential* relationship one with the other or among themselves in a (causal) net.

Lewin's topology, that was well known to both Reichenbach and Carnap, tackles the issue of the most fundamental relation that is required in order to define the basic features of a temporal topology, with the minimal amount of assumptions. Namely, it

deals with the most primordial level, the level of the pure existential relations through time as such. Carnap's account lines up with Lewin's in that the temporal topology is constructed on unanalysable relations. However, it is more sophisticated and takes a further step in elaborating on the notion of genidentity, giving rise to the relation "Z", with the addition of the second essential relation "K" and eventually deriving the relation "W".

Reichenbach's study is the most complex one. Differently from Carnap's and Lewin's attempts, the basis of his construction is not anymore unanalysable, and it represents the physical token case of the more general type of relations that Lewin and Carnap have structured. This failure in reducing the concept of prime signal to its more fundamental constituents will have important repercussions in Reichenbach's later work, *The Direction of Time* (1956).

This paper analyses and assesses these early philosophical interpretations of the topology of time.

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