Empiricism and Relationism Intertwined: Hume and Einstein's Special Theory of Relativity*

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ABSTRACT: Einstein acknowledged that his reading of Hume influenced the development of his special theory of relativity. In this article, I juxtapose Hume's philosophy with Einstein's philosophical analysis related to his special relativity. I argue that there are two common points to be found in their writings, namely an empiricist theory of ideas and concepts, and a relationist ontology regarding space and time. The main thesis of this article is that these two points are intertwined in Hume and Einstein.

Keywords: Hume, Einstein, History of Special Relativity, Space and Time.

RESUMEN: Einstein reconoció que su lectura de Hume influyó en el desarrollo de su Teoría Especial de la Relatividad. En este artículo yuxtapongo la filosofía de Hume y el análisis filosófico de Einstein en relación a la relatividad especial. Argumento que hay dos puntos en común que pueden encontrarse en sus escritos, a saber: una teoría empirista de las ideas y conceptos y una ontología relacionista en lo que se refiere al espacio y al tiempo. La tesis principal del artículo es que estos dos puntos están en interconexión en Hume y en Einstein.

Palabras clave: Hume, Einstein, historia de la relatividad especial, espacio y tiempo.

1. Introduction

On the 14th of December 1915, Albert Einstein wrote a letter to Moritz Schlick. The main purpose of this short letter was to compliment Schlick about his paper on special and general relativity, which Einstein had read the previous day. Einstein (1998, 220) pointed out that it was "among the best yet of what's been written about relativity. Nothing nearly as clear has previously been written about its philosophical aspects." He acknowledged that Schlick had correctly recognized that his special theory of relativity (henceforth STR) was influenced by Ernst Mach's and David Hume's philosophies. Einstein wrote to Schlick, that it was

> Mach, and, even more, Hume, whose Treatise of Human Nature I studied with passion and admiration shortly before discovering the [special] theory of relativity. Very possibly, I wouldn't have come to the solution without those philosophical studies. (*Ibid.*)

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Although much ink has been spilled about Mach's influence on Einstein's science (e.g. Holton 1968, 1992; Zahar 1977; Feyerabend 1980, 1984; Hentschel 1985; Barbour 2007; Wolters 2012; Berman 2012), the relationship between Hume's philosophy and Einstein's philosophical analysis related to STR is far less well known. Still, in the quote above, Einstein insists that more than Mach, it was Hume who enabled him to put all the decisive pieces of the puzzle together. Later, in a letter to Michelle Besso in 1948, he makes a similar claim:

> How far (Mach's writings) influenced my own work is, to be honest, not clear to me. In so far as I can be aware, the immediate influence of D. Hume on me was great. I read him with Konrad Habicht and Solovine in Bern. (Speziali 1972, 153)

Einstein read the German translation of the *Treatise* in the early 1900's, and discussed it in the "Olympia Academy" reading group in which he participated in Bern (see Howard 2005, 36). Yet his acknowledgement does not specify what it was in Hume's philosophy that he found beneficial to the formulation of STR.

To answer this question, John Stachel (1989, 2002) and John D. Norton (2010) have both provided possible answers. Stachel emphasizes the similarities between Hume's and Einstein's views on space and time.[1] He asks, what Einstein could

> have gotten from Hume? I think it was a relational —as opposed to an absolute— concept of time and space. This is the view that time and space are not to be regarded as self-subsistent entities; rather one should speak of the temporal and spatial aspects of physical processes. (Stachel 2002, 166)

Norton provides another interpretation on the relationship between Hume's philosophy and Einstein's philosophical analysis related to STR. His main thesis is that (the young) Einstein was most influenced by the way Hume (and Mach) saw concepts to be grounded in sense impressions or sensations. The early Einstein implemented empiricism in his argument for the relativity of simultaneity. If the concept of simultaneity is grounded in sensible impressions, such as in visual sensations of immediate light flashes in two mirrors, it follows (given the two postulates of STR and conventional definitions and stipulations) that there is no absolute simultaneity. Different inertial reference frames can observe the timely order of two spatially distant events, the two light flashes, in different order. The revision of the concept of simultaneity defied the absolute Newtonian character of time. As Einstein recognized later in his 1949 autobiographical writing:

> The type of critical reasoning required for the discovery of this central point [the denial of absolute time, or simultaneity] was decisively furthered, in my case, especially by the reading of David Hume's and Ernst Mach's philosophical writings. (Einstein 1949a, 53)

In Norton's interpretation, this "critical reasoning" eventually helped Einstein to reconcile the two postulates of STR, namely the invariance of laws of nature and the constancy of speed of light in vacuum.

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[1] Lenzen (1949, 359) also comments on the similarities between Hume's and Einstein's conceptions of space and time, but he does not mention relationism.

In this article, I shall provide a detailed comparison of Hume's philosophy and Einstein's philosophical analysis related to STR. I argue, as has been suggested by Norton and Stachel, that both Hume and Einstein support an empiricist theory of ideas and concepts and a relationist ontology regarding space and time. However, these previous studies on the topic have regarded the two points as being separate. My interpretation shows that they are instead tightly connected. This new interpretation will provide a better understanding of the connection of Hume and Einstein. Moreover, it will help to clarify the philosophical background assumptions related to the concepts of space and time in Einstein's STR, for which Hume's philosophy is of central importance.

Although I find Hume's and Einstein's views to overlap about the two crucial points, empiricism about ideas and concepts and relationism about space and time, it has to be noted that Hume's and Einstein's conceptions of space and time have important differences. In Hume, they are abstractions from simple perceptions but in Einstein they are physical quantities. Further, Einstein's conventionalism about the origin of concepts instantiates a more mitigated form of empiricism than Hume's copy principle. Einstein frequently emphasizes that concepts are free creations of the human mind, and that they are not deducible from sensations. Hume's case is different, since according to his copy principle simple impressions cause simple ideas—there is a complete isomorphy between the two—and our will regarding this relation is not free.

The goal of my article is not to state that Hume anticipated STR. My purpose is to investigate in what way Hume's copy principle, which is the foundation of his theory of ideas and, hence, his theory of space and time, has similarities compared to the philosophical analysis related to Einstein's STR. I also do not wish to state that Einstein's views on space and time were solely intertwined with his philosophical theory of concepts. Doubtless, as his original 1905 special relativity article "On the Electrodynamics of Moving Bodies" (henceforth EMB) suggests, they were largely influenced by the 19th century electrodynamic physics; I will briefly take this into account. The scope of this article is limited to questions related to STR only. I do not analyze Einstein's views related to his general relativity, or his conception of the existence of atoms, as it would not be relevant to this article.

The rest of this article is structured into the three following sections. In section 2, I argue that although Einstein's special relativity[2] is a product of the 19th century electromagnetic physics, the processes that lead to its formulation do have important philosophical roots, too. As Einstein so overtly acknowledges his debt to Hume, this evinces that the comparison of the philosophical doctrines of Hume and Einstein deserves to be seriously studied. I lead off section 3 by arguing for the similarities (and for some dissimilarities) between Hume's philosophy and the philosophical analysis related to Einstein's STR. I begin my analysis with Hume's copy principle, which is the general epistemic and semantic principle of his philosophy. I claim that Hume's copy principle is similar compared to Einstein's empiricist theory of concepts. Both Hume and Einstein insist that ideas and concepts are justified by and made meaningful by impressions and sensations. However, I ac-

[2] To avoid confusion between the terms "special relativity" and "principle of relativity," I use the anachronistic term "special relativity" regarding Einstein's original publication of 1905, although Einstein did not use this expression (*die spezielle Relativitätstheorie*) until 1915 (Stachel 2002, 192).

knowledge that the level of their empiricism differs. In section 4, I argue that because of their empiricist theories of ideas and concepts, they hold physical objects to be central reference points for the notions of space and time. This leads to the main thesis of my article, which is the following. I argue that these two points, empiricism about ideas and concepts and relationism about space and time, are intertwined in Hume and Einstein: the empiricist theory of ideas and concepts entails that the notions of space and time are intrinsically related to physical objects; in turn, the conception of physical objects can be justified and made meaningful by relevant sensuous impressions, such as vision and touch.

To support my interpretation, I marshal the textual evidence from Einstein's original 1905 publication, his "Contributions to Science" in Carl Seelig's 1981 edition of *Ideas and Opinions*, and from his private writings and correspondence. Regarding Hume, the text that I analyze is mainly his *Treatise of Human Nature*, since this is the book that Einstein refers to in his quotation where he indicates his debt to Hume (see Norton 2010, 374). When needed, I analyze the "Abstract" of the *Treatise* and his later work *An Enquiry concerning Human Understanding*.[3]

2. *On the Relevance of Philosophy to STR*

In his "What is the Theory of Relativity" (1919/1981c, 225), Einstein asserted retrospectively that "the special theory of relativity [...] was simply a systematic development of the electrodynamics of Maxwell and Lorentz." This becomes immediately clear for the reader of Einstein's original publication of STR. In the first paragraph of the abstract of EMB, Einstein presents his famous magnet and conductor thought argument concerning Faraday's law of electromagnetic induction. This intricate argument and its important consequences to the formulation of STR have been carefully reviewed elsewhere (i.e. Earman 1989, 54, Cushing 1998, 229-230, Visser 2011, 11-15, and Norton 2010, 362-365, 2014, 83-85). To put it briefly and succinctly, the crux of the magnet and conductor argument is to argue for the principle of relativity, [4] and to argue against the ether hypothesis, or "the idea of absolute rest," as Einstein (1905/1923, 37) says. The implication of this argument is that electric fields, as well as the dimensions of space and time, are not absolute quantities (see Norton 2014, 85). Rather, these quantities depend on the inertial motions of observers moving with respect to each other, and are thus subject to Lorentz transformations.

Although the original publication of STR ensued from a critical reflection of the 19th century electromagnetic physics, the processes that lead to its formulation do have important philosophical roots, too. This can be explained by Thomas Kuhn's (1996, 88) theory of the development of a science: scientists who introduce a new paradigm into a science work extensively in the old pre-paradigmatic science themselves. Introduction of this new paradigm, as Kuhn puts it, is "both preceded and accompanied by fundamental philosophi-

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[3] References to Hume's *Treatise of Human Nature* and *An Enquiry Concerning Human Understanding* are in accordance with the Hume Society's exhortation. I employ the abbreviations T and EHU as well as the Selby-Bigge/Nidditch (SBN) numbering.

[4] Retrospectively, Einstein (2002, 20) went as far as to claim that "the phenomenon of magneto-electric induction compelled me to postulate the (special) principle of relativity." See also Einstein (1914/1981a, 218, 1940/1981h, 320-321).

cal analyses" (*Ibid.*).[5] This is no doubt the case with Einstein. He worked himself in the old pre-paradigm ether-modeled mechanics (Einstein did believe in the ether for quite a long period of time),[6] which saw electric fields and space and time as absolutes. The introduction of STR was preceded by extensive reading and discussion of philosophy, not only that of Hume's, but, among others, the philosophies of Mach, Mill, Poincaré, Spinoza, Kant, and Avenarius (see Stachel 2002, 125).

Einstein did use philosophical analysis to suit his physical ends. But just to say that he did use philosophical analysis is in itself quite vague. What kind of philosophy? To answer this question, I quote the first chapter of his philosophically oriented text *Physics and Reality* (1936/1981g, 283) at length. In it, Einstein clarifies his position about the need of a certain kind of philosophy to assist physics:

> It has often been said, and certainly not without justification, that the man of science is a poor philosopher. Why, then, should it not be the right thing for the physicist to let the philosopher do the philosophizing? Such might indeed be the right thing at a time when the physicist believes he has at his disposal a rigid system of fundamental concepts and fundamental laws which are so well established that waves of doubt cannot reach them; but, it cannot be right at a time when the very foundations of physics itself have become problematic as they are now. At a time like the present, when experience forces us to seek a newer and more solid foundation, the physicist cannot simply surrender to the philosopher the critical contemplation of the theoretical foundations; for, he himself knows best, and feels more surely where the shoe pinches. In looking for a new foundation, he must try to make clear in his own mind just how far the concepts which he uses are justified, and are necessities.

In the quote above, Einstein suggests that "when looking for a new foundation," the physicist needs to make clear "just how far the concepts which he uses are justified, and are necessities." This indicates that he is essentially interested in epistemological problems. He did value epistemological analysis in his physical research when he was forming a novel physical theory, such as STR (see also Einstein 1949b, 683-684). It should be noted that he did not regard himself as a "systematic epistemologist," but rather an "unscrupulous opportunist." Still his "occasional utterances of epistemological content" can be interpreted as having systematicity, as he himself also allows this in his summary to the volume of Library of Living Philosophers (*Ibid.*, 683).

Interestingly, Hume's *Treatise of Human Nature*, a work that Einstein reported to have studied "with passion and admiration shortly before discovering the [special] theory of relativity," begins with asking essentially the same kind of questions that Einstein dealt with in his more philosophically oriented texts: what are the origin, meaning, and justification of our ideas?[7]

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[5] The examples Kuhn (1996, 88) uses of the sciences preceded and accompanied by philosophical analyses include Newtonian physics, relativity and quantum mechanics.

[6] Einstein had been devising thought experiments about electrodynamic phenomena which include a reference to the ether as early as 1895. See Einstein (1987, 4-6), "On the investigation of the state of the ether in magnetic field."

[7] Einstein's term "concept" (*Begriff*) and Hume's term "idea" cannot be used interchangeably: "concept" is more definitional and conventional, whereas "idea" is given to the mind, and our will regarding it is not free. However, Einstein sometimes conflates the two terms. Although he usually speaks about

In the next section, I begin to draw parallels between Hume's and Einstein's philosophical writings. I shall argue that Hume and Einstein have different positions concerning the origin of concepts but similar views regarding their justification and meaning.

3. *Hume's copy principle and Einstein's empiricist theory of concepts*

In Hume's view, perception begins with impressions. According to the copy principle, all cognitive and meaningful ideas, except for some particular shades of a color (see T 1.1.1.10; SBN 5-6, EHU 2.8; SBN 20-21), are and have to be originally derived from resembling individual sensible impressions (T 1.1.4-1.1.5; SBN 1-10, EHU 2 and 3). David Landy (2012, 25-26), following Don Garrett's (1997, 41) seminal work, argues that if an idea is to be a copy of an impression, two requirements have to be satisfied. First, it must be that an idea is caused by an impression ("being caused" understood in the Humean sense of experiencing the constant conjunction between species of objects). Second, it must be that an idea exactly resembles the impression that caused it. Exact resemblance is limited to simple ideas and their impressions. The application of the copy principle requires that complex ideas can be separated into simple ideas (T 1.1.2; SBN 2; Landy 2012, 26). In turn, these differentiated ideas have their origin in simple impressions.

Einstein shares a theory about concepts which is analogous to Hume's copy principle. This fact is present in a variety of his texts, written between quite vast periods of time, from 1916 to 1949. In the quotes below, it can be seen that Einstein clearly maintains an empiricist theory about concepts (*Begriff*):[8]

> "The concept does not exist for the physicist until he has the possibility of discovering whether or not it is fulfilled in an actual case" (*Relativity. The Special and General Theory*, 1916/2001, 24).
>
> "... the physicist has to limit himself very severely: he must content himself with describing the most simple events which can be brought within the domain of our experience" ("Principles of Research," 1918/1981b, 221).
>
> "The fundamental principle here is that the justification for a physical concept lies exclusively in its clear and unambiguous relation to facts that can be experienced" ("On the Theory of Relativity," 1921/1981d, 241).
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> "Concepts can only acquire content when they are connected, however indirectly, with sensible experience" ("The Problem of Space, Ether and the Field in Physics," 1934/1981f, 270).
>
> "... concept [...] owes its meaning and its justification exclusively to the totality of the sense impressions which we associate with it" (*Physics and Reality*, 1936/1981g, 284).

"concepts" (see Einstein 1918/1981b, 221, 1921/1981d, 241, 1934/1981f, 270, 1936/1981g, 284, 286, 1949a, 13, 1916/2001, 24), in his *Meaning of Relativity* he begins with "investigation of the origin of our *ideas* of space and time" (Einstein 1922/2003, 1, my emphasis). Further, Hume's term "impression" is more extensive than Einstein's "sensation": Hume's "impression" covers also feelings and emotions, not only "sensations," if by sensations is meant "comes from the senses."

[8] Note that I am not saying that Einstein supports an empiricist theory regarding propositions, theories, or laws of nature. My claim is that Einstein is an empiricist regarding concepts. I do not wish to state that his overall epistemology or philosophy of science is empiricist.

> "Science uses the totality of the primary concepts, i.e., concepts directly connected with sense experiences" (*Ibid*., 286).
>
> "all thought acquires material content only through its relationship with that sensory material" ("Remarks on Bertrand Russell's Theory of Knowledge," 1944/1981j, 33).
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> "Concepts [...] get "meaning," viz., "content," only through their connection with sense-experiences" ("Autobiographical Notes," 1949a, 13).

The excerpts above are by and large in line with Hume's copy principle. The difference between Hume's and Einstein's positions in this issue is rather a difference of degree, not kind. In Hume's theory, there is a complete isomorphy between a simple impression and a simple idea. The former causes the latter, and our will regarding this relation is not free. This is what the copy principle actually means, as Landy (2012, 30) clarifies it:

> Consider a standard office copier. What it produces are copies just in case these are caused by the original (they are not produced *ex nihilo*) and exactly resemble that original (they exactly replicate all the relevant intrinsic features of the original).

Einstein denies that concepts could be unequivocally derived from and reduced to sensations. As he and Leopold Infeld write in their *The Evolution of Physics* (1960, 31): "Physical concepts are free creations of the human mind." Concepts require conventional stipulations; they do not grow out to the mind automatically. According to Don Howard, Einstein doubted strongly that there would be "a clean, principled distinction between the empirical and the conventional" (Howard 1994, 48). Hume does allow conventionality in case of complex ideas: we can freely form the idea of a centaur or a golden mountain, since we have acquired the component simple ideas from simple impressions (EHU 2.5; SBN 19). But unlike Hume, Einstein does not think that impressions cause ideas. Hume and Einstein have a different understanding about the origin of ideas.

Einstein's critical remarks concerning metaphysical concepts seem to be more mitigated than Hume's. In the first *Enquiry* (2.9; SBN 21), Hume suggests that if the copy principle is used properly, it is possible to "banish all that jargon, which has so long taken possession of metaphysical reasonings, and drawn disgrace upon them." In Hume's theory, if a given philosophical term is to be meaningful, the term must be employed with an idea which can be reduced to an impression. If this condition is not satisfied, the philosophical term is "altogether insignificant" (T Abstract 7; SBN 649).

In his essay "Remarks on Bertrand Russell's Theory of Knowledge," Einstein discusses specifically Hume's critique of metaphysics:[9]

> As soon as one is at home in Hume's critique one is easily lead to believe that all those concepts and propositions which cannot be deduced from the sensory raw material are, on account of their "metaphysical" character, to be removed from thinking. (1944/1981j, 33)

[9] It must be noted that there is a dispute in Hume-scholarship concerning whether Hume is a metaphysician or not. Baxter (2008) argues that "Hume is a great metaphysician," but Morris (2009) claims that Hume is committed to a "resolutely anti-metaphysical stance." However, Einstein's quotation indicates that *he* took Hume to have been a critic of metaphysics.

Einstein is slightly more careful with his critique of metaphysics than Hume,[10] as he explains:

> In order that thinking might not degenerate into "metaphysics," or into empty talk, it is only necessary that enough propositions of the conceptual system be firmly connected with sensory experiences. (*Ibid*., 34)

He adds that

> by his clear critique Hume did not only advance philosophy in a decisive way but also—though through no fault of his—created a danger for philosophy in that, following his critique, a fateful "fear of metaphysics" arose which has come to be a malady of contemporary empiricist philosophizing (*Ibid*.).

Einstein distances himself from a bundle view of physical objects—"conceiving of the 'thing' as a 'bundle of qualities'"—and from the "fear of metaphysics [...] of contemporary empiricist philosophizing" (*Ibid*.). There is "no metaphysical danger in taking" a physical object to have an independent existence.[11]

According to Howard (1994, 48), Einstein came to realize that an austere empiricism (for example, of Hume or Einstein's positivist interlocutors) would "cripple theoretical physics." Einstein thought that freely creative theoretical thinking is possible, if the produced concepts and their constituent propositions are loosely and holistically consistent with sensible experience. Nevertheless, he does think that the justification for our concepts is in recurring complexes of sensations. In his *The Meaning of Relativity*, Einstein contends that "the only justification for our concepts and system of concepts is that they serve to represent the complex of our experiences; beyond this they have no legitimacy" (Einstein 1922/2003, 2). He adds that "I am convinced that the philosophers have had a harmful effect upon the progress of scientific thinking in removing certain fundamental concepts from the domain of empiricism" (*Ibid.*). When referring to "the philosophers [...] removing certain fundamental concepts from the domain of empiricism," he does not identify any philosopher by name. Since in this context he targets his critique at the *a priori* status of space and time, it is reasonable to assume that he is criticizing Kant's transcendental idealism about space and time. To give an example of the tension between Einstein's empiricist theory of concepts and Kant's transcendental theory, it is useful to shortly quote from the second section of the "Transcendental Aesthetic" of Kant's *Critique*, where Kant discusses the concept of time:

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[10] Einstein himself was not hostile to metaphysics. In the end of his text on Russell's theory of knowledge (1944/1981j, 35), he writes as having being "particularly pleased to note that [...] it finally turns out that one can, after all, not get along without "metaphysics.""

[11] In this sense, there is a difference between Hume and Einstein. For Hume's radical empiricism the question about mind-independent status of physical objects poses a significant metaphysical problem. Jani Hakkarainen (2012) has thoroughly argued that this is a problem about Hume's attitude to skepticism and his view on the relation between skepticism and naturalism (see also Inukai, 2011). Doubtless, this is a problem in Hume's philosophy, but since it does not belong to the main body of this article, I shall pass it without further ado.

> Time is not an empirical concept that is somehow drawn from an experience. For simultaneity or succession would not themselves come into perception if the representation of time did not ground them *a priori*. Only under its presupposition can one represent that several things exist at one and the same time (simultaneously) or in different time (successively) [...] Time is therefore given *a priori*.

Einstein is against Kant's above position. In Einstein's view, time *is* "an empirical concept." Simultaneity or succession *is not* "given *a priori*." [12] To Einstein, the concepts of simultaneity and succession are defined in such a way that they can be tested empirically, and justified with the aid of visual sensations. To put the concept of simultaneity into a more "malleable" form, Einstein went on to "purge" the *a priori* elements from concepts (see section 3.2 of Norton 2010). In his correspondence with Max Born in 1918, Einstein writes that he wishes to "water down the 'a priori' to 'conventional'" (Howard 1994, 52).

Einstein does not think that the source of concepts is impressions, as Hume would (Lenzen 1949, 360). Rather, their origins are in the free creations of the human mind. In this sense, Einstein can be seen to be closer to Kant than Hume. Kant's philosophy emphasizes the active and constructive aspects of perception, whereas Hume's understanding of perception is that it is passive; Hume thinks that senses are inlets through which ideas are conveyed (EHU 2.7; SBN 20, EHU 12.9; SBN 152). Nevertheless, Einstein's rhetoric in his correspondence with Born and Paul Ehrenfest indicates that he is more sympathetic to Humean empiricism than Kantian transcendentalism. He claims that "the details [of Kant's philosophy] do not fit,"[13] and that "it is not as good as his predecessor's Hume's work" (Howard 1994, 52). In 1916, he wrote to Ehrenfest that "Hume really made a powerful impact on me. Compared to him, Kant seems to me truly weak" (*Ibid*., 50). In Hume and Einstein space and time are empirical ideas and concepts. They are not *a priori* preconditions for all possible experience, as Kant thinks.

Mara Beller (2000) has questioned the relevance of Hume's philosophy to Einstein's empiricism. Beller refers to Einstein's article "Remarks on Bertrand Russell's Theory of Knowledge," which she takes to provide evidence against the empiricist reading. She writes the following:

> While Einstein's references to Hume's impact are often treated as a token of Einstein's empiricism, the discussion in this paper leads to a different appreciation of Hume's role in Einstein's critical thinking: "Man has an intense desire for assured knowledge. That is why Hume's clear message seemed crushing: the sensory raw material, the only source of our knowledge, through

[12] Similarly, in his "The Problem of Space, Ether, and the Field in Physics," Einstein (1934/1981f, 271) argues that the concept of a body is not preceded by the notion of space: "Once the concept of the solid body is formed in connection with the experiences just mentioned [sight and touch]—which concept by no means presupposes that of space or spatial relation." He indicates that he has "never been able to understand the quest of the *a priori* in the Kantian sense" (*Ibid*.). Einstein differs from Kant in that he does not think that space (and time) are *a priori* forms of sensibilities which precede all possible experience, such as the experience of bodies. Rather, Einstein clearly contends that a material object precedes the concept of space (and time) (Einstein 1954/1981i, 355; see also Lenzen 1949, 367).

[13] See also Hentschel (1993, 619-621).

> habit may lead us to belief and expectation but not to the knowledge and still less to the understanding of lawful relations (Einstein 1944/1981j, 32)". Hume's impact on Einstein is then not necessarily an influence in the direction of empiricism, as usually assumed. (Beller 2000, fn. 5, 102-103)

I am partially sympathetic to Beller's reading. Einstein distances himself from the view that "the sensory raw material" would be "the only source of our knowledge." This is because according to his view concepts require conventions to be applicable. This is not the case with Hume. However, the passage quoted by Beller does not prove that "Hume's impact on Einstein is then not necessarily an influence in the direction of empiricism," nor does it even prove the weaker claim that there are no similarities between Hume's and Einstein's empiricisms. In the same text, "Remarks on Bertrand Russell's Theory of Knowledge," Einstein (1944/1981j, 33) supports an empiricist theory of concepts, as he writes that "all thought acquires material content only through its relationship with that sensory material." The quotation that Beller has selected concerns Einstein's conception of the knowledge and of the understanding of lawful relations. She is correct that Einstein did not support a Humean understanding of our belief and expectation of lawful relations as being founded on custom and habit. Yet this does not provide evidence that Einstein did not subscribe to an empiricist understanding of *concepts*.

As I have shown in this section, both Hume and Einstein maintain an empiricist theory of ideas and concepts. While Hume espouses radical empiricism, Einstein holds a nuanced view of this philosophical creed, mitigated by his conventionalist theory of concepts. In the next section, I shall argue that because of their empiricisms, they take physical objects to be central reference points for the notions of space and time. This is an important reason why Hume and Einstein take a relationist, and not an absolutist view: we do not have the ideas about space and time themselves, independent of perceptions and relational features of physical objects.

4. The intertwinement: empiricism about ideas and concepts, relationism about space and time

Hume's copy principle applies to objects which are at minimum the scale of what we can perceive by our senses. The mind has a threshold in forming adequate ideas. If ideas represent objects—if they are "applicable to the objects" (T 1.2.2.1; SBN 29)—adequate ideas require objects which are sensible. Because we cannot, by definition, perceive infinitesimally small objects, adequate ideas can represent only finite, perceptibly separable, particular objects (T 1.2.2; SBN 29-33). Since this is the general theory that Hume holds about representational ideas, it must be that ideas of space and time refer to finite, perceptibly separable and particular objects, too.

In Hume, ideas of space and time are abstract ideas. All abstract ideas are particulars, but they may be annexed to general terms which represent a variety of objects (T 1.2.3.5; SBN 34). The ideas of space and time represent individual things, namely discretely disposed points and moments (Falkenstein 2013, 111). Particular points and moments are not identical compared to each other but they resemble each other. Abstract ideas are to be understood in light of mutual resemblance of particulars (Baxter 2008, 18-19).

Hume claims that it is "from the disposition of visible and tangible objects we receive the idea of space" (T 1.2.3.7; SBN 35). He assimilates space to extension. The idea of extension is brought to the mind by two senses: sight and touch. Following his copy principle, Hume insists that "we have therefore no idea of space or extension, but when we regard it as an object either of our sight or feeling," and that "*the idea of space or extension is nothing but the idea of visible or tangible points distributed in a certain order*" (T 1.2.4.16; SBN 37, T 1.2.5.1; SBN 53).

Although Hume thinks that space is fundamentally perceivable extension, it is also a relational term to him. Perceivable objects are configured in a certain way; they can be distant from, contiguous with, above and below each other (T 1.1.5.5; SBN 14). We acquire the idea of space by considering the distance between perceivable bodies: "Upon opening my eyes, and turning them to the surrounding objects, I perceive many visible bodies; and upon shutting them again, and considering the distance betwixt these bodies, I acquire the idea of extension" (T 1.2.3.2; SBN 33). Distance is an instance of extension; it is known via extended bodies. Space in this sense is "known only by the manner, in which distant objects affect the senses" (T 1.2.5.17; SBN 59).[14]

In Hume's theory of time, it is requisite that there appears a change in objects. This change can be experienced either by succession in objects, or change in their state of motion. Conceiving time would not be possible without any "succession or change in any real existence" (T 1.2.4.2; SBN 40, see also Bardon 2007, 58).

Hume's account of genesis of time, or duration, is that we conceive it as "a succession of changeable objects" (T 1.2.3.11; SBN 37). For instance, hearing five successive flute chords and abstracting the order of their succession generates the idea of time to the mind (a single ongoing chord would not be sufficient). Time consists of indivisible and finite moments which are parts of succession. An abstraction of the succession of these moments is the time we experience (Baxter 2008, 17, 22-23). Moreover, Hume contends that time, or duration, can be abstracted from motions of objects. Hume does not accept that a steady, unchangeable object, if it is not a member of succession, could convey the idea of time (T 1.2.3.11; SBN 37). Rather, as the most important factor that needs to be satisfied in order for us to experience time in Hume's theory is change, motion of bodies provides change of place. In this sense, relative motion of bodies, along with succession of objects, such as auditory impressions, is a source for the idea of time.

Hume's conception of time indicates clearly that he is a relationist. "Time is," as he puts it, "nothing but the manner, in which some real objects exist" (T 1.2.5.28; SBN 64). Perception of time is relative to succession and/or motions of objects. Unchangeable objects, such as an ongoing chord or a pair of two motionless bodies could not convey an idea of time to the mind. Perceiving time depends on observer's relation to reference-objects; there is no absolute time independent of this relation. Thus there is no one universal time but many times depending on observer's relations to reference-objects. Hume asserts that we do not have an idea of time itself, independent of successive simple perceptions and relative motion:

> Wherever we have no successive perceptions, we have no notion of time, even tho' there be a real succession in the objects. From these phaenomena, 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

[14] See Boehm's (2012) article on the notion of distance and its relation to extension in Hume.

> unchangeable object, but is always discover'd by some *perceivable* succession of changeable objects (T 1.2.3.7; SBN 35).

We can form adequate ideas about particular objects, their dispositions, intervals, successions, and motions. We cannot form an adequate idea of space and time in themselves; we do not have the ideas of an empty space or changeless time. Hume encapsulates his argument: "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" (T 1.2.4; SBN 39-40, see also Wright 1983, 102).

Einstein's ontology of space and time, just like Hume's, is in connection with his empiricism. In his text "The Problem of Space, Ether, and the Field in Physics," he claims that "in any ontological question, our concern can only be to seek out those characteristics in the complex of sense experiences to which the concepts refer" (1934/1981f, 271). In his 1924 transcript, he makes a specific claim that our concepts "of space and time can only claim validity in so far as they stand in a clear relation to experiences" (Norton 2010, 369). In his *Physics and Reality*, he points out in a critical tone that the absolutist notions of space and time in "classical mechanics" are thought to be "independent of the empirical basis to which they owe their existence" (1936/1981g, 292, see also 1933/1981e 266-267).[15] If one wishes to find a concept that does have experiential, that is, observable and measurable consequences to the notions of space and time, the concept of a body can be regarded as one fruitful option. Einstein, in a Humean way, sees empiricism and relationism to be intertwined.

In his "Relativity and the Problem of Space," Einstein argues that concepts of space and time require a reference-body: "It appears to me, therefore, that the formation of the concept of the material object must precede our concepts of space and time" (Einstein 1954/1981i, 355; see also Lenzen 1949, 367). In a Humean way, he contends that the concept of a body, which is requisite for making judgments about spatial relations, requires tactile and visual impressions. Thus he writes:

> Now as regards the concepts of space: this seems to presuppose the concept of the solid body. The nature of the complexes and sense-impressions which are probably responsible for that concept has often been described. The correspondence between certain visual and tactile impressions [...] are some of those characteristics (Einstein 1934/1981f, 271).

Einstein defines space in terms of a body. A reference-body is requisite to justify the notion of space by an actual measurement: "it is necessary to have a body of reference for the measurement of a distance" (Einstein 1916/2001, 30). He argues that "certain visual and tactile impressions [...] are probably responsible for" the concept of a body, and that "the concept of the bodily object [...] is directly connected with complexes of sense experiences" (Einstein 1954/1981i, 354, see also *Ibid*., 355, 357). The content of this concept is justified by sense-perceptions: "The conception of physical bodies, in particular of rigid bodies, is a relatively constant complex of such sense perceptions" (Einstein 1922/2003, 2).

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[15] Einstein nonetheless recognizes that Newton's concept of acceleration required the reality of space and time, and emphasizes the meaning of these terms in Newton's system (Einstein 1954/1981i, 350). He is also very clear that he did not topple Newton (Einstein 1919/1981c, 227).

Einstein is clear that objects are not in space, but their extension is what enables us to make judgments about space: "Physical objects are not *in space*, but these objects are *spatially extended*. In this way the concept of 'empty space' loses its meaning" (Einstein 1916/2001, x). Edward Slowik (2005) has argued that Einstein's relationism about space is by and large analogous with René Descartes' denial of empty space, or vacuum. Einstein (1916/2001, 140, 157) writes that

> Descartes argues somewhat on these lines: space is identical with extension, but extension is connected with bodies; thus there is no space without bodies and hence no empty space.
>
> Descartes was not so far from the truth when he believed he must exclude the existence of an empty space.

Interestingly, Hume does also make a similar point in the first Book to the *Treatise*: "'tis impossible to conceive either a vacuum and extension without matter" (T 1.2.4.2; SBN 40, see also T 1.2.5.27; SBN 64). We cannot form an "idea of a vacuum, or space, where there is nothing visible or tangible" (1.2.5.1; SBN 53), that is, where there are no points. Hume does not believe that there is "a vacuum" in sense of a "pure extension" (1.2.5.10; SBN 57).

Similarly, a body of reference is needed in order to give a meaning to the concept of time. Importantly, motion is the measurable and observable attribute of a body that is requisite for this concept (Einstein 1905/1923, 39). Einstein's specific definition of time is based on judgments about simultaneous events. As he puts it in EMB:

> a mathematical description of this kind [of time] has no physical meaning unless we are quite clear as to what we understand by "time." We have to take into account that all our judgments in which time plays a part are always judgments of *simultaneous events.* (*Ibid.*)

In his own example, the meaning of a statement "train arrives at the station at seven o'clock" is this: "The pointing of the small hand of my watch to 7 and the arrival of the train are simultaneous events" (*Ibid.*) As simultaneity is relative to the state of motion of the observer, it follows that "every reference-body [...] has its own particular time; unless we are told the reference-body to which the statement of time refers, there is no meaning in a statement of the time of an event" (Einstein 1916/2001, 28-29).

In his *Physics and Reality*, Einstein claims that we do not have the concept of time without "connecting the temporal sequence of experiences with the readings of a "clock," i.e., of a periodically recurring closed system." His position is that a comparison between a sequence of experiences and a closed periodical system is enough for the concept of a time. It is not necessary to have the notion of time in itself, as he argues:

> ... as I see it, it does not mean a *petitio principii* if one puts the concept of periodical recurrence ahead of the concept of time, while one is concerned with the clarification of the origin and of the empirical content of the concept of time (Einstein 1936/1981g, 291).

He does allow that this definition contains arbitrariness, as he puts it in the *Meaning of Relativity*:

> I can, indeed, associate numbers with the events, in such a way that a greater number is associated with the later event than with an earlier one; but the nature of this association may be quite

> arbitrary. This association I can define by means of a clock by comparing the order of events furnished by the clock with the order of the given series of events. (Einstein 1922/2003, 1-2)

The concept of time can be conceived by inventing a series of integer numbers, and by associating these numbers to sensory experiences. To associate smaller numbers with "earlier" and larger numbers with "later" requires invention and an auxiliary convention. The concept of time does not automatically grow out of the givens of sensations (Einstein 1944/1981j, 33).

Both Hume and Einstein regard bodies to be intrinsic reference points for the notions of space and time. The concepts of space and time are in relation to the observable, relational, and measurable attributes of physical objects.[16] Hence the notions of absolute space and time are not justifiable, nor required. As Einstein summarizes his relationist view in the fifteenth edition to his popular book *Relativity. The Special and General Theory*: "I wished to show that space-time is not necessarily something to which one can ascribe a separate existence, independently of the actual objects of physical reality" (Einstein 1916/2001, x).

5. Conclusion

The main thesis of this article is that empiricist theories of ideas and concepts are intertwined with relationist and not with absolutist notions of space and time in Hume and Einstein. This crucial point has been neglected by the previous scholarship done on the topic, so the article contributes to our understanding of the relationship of Hume and Einstein. Inquiring into Hume's theory of perception also clarifies some of the philosophical background assumptions related to the concepts of space and time in Einstein's STR. It is nevertheless important to stress that Hume's and Einstein's views on these issues have important differences—notably, Einstein's theory of concepts emphasizes conventionality, which differs markedly from Hume's radically empiricist copy principle—but they do share a common understanding about the meaning and justification of ideas and concepts. It should be concluded that these empiricist aspects of their epistemologies are intrinsic to their conceptions of space and time.

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[16] Regarding time, it may be added that Hume does not universally think that acquiring its idea requires a physical reference object. Hume asserts a maxim according to which "*an object may exist, and yet be no where*" (T 1.4.5.10; SBN 235). The abstract idea of time can be caused by impressions which are not themselves physical objects. However, Hume's position is not very consistent, as he also claims that impressions "depend upon natural and physical causes" (T 2.1.1.2; SBN 275).

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