Carnap's Logic of Science and Reference to the Present Moment

Florian Fischer

Abstract

The important switch from the so-called old B-theory to the new tenseless theory of time (NTT), which had significant implications for the field of tense and indexicals, occurred after Carnap's era. Against this new background, Carnap's original *inter-translatability thesis* can no longer be upheld. The most natural way out would be to modify Carnap's position according to the NTT; but this is not compatible with Carnap's *metaphysical neutrality thesis*. Even worse, Carnap's work on measurement theory can be used to develop an argument in favour of the A-theory. I argue that there are *tensed basic sentences* which are needed in order to construct a tenseless system and thus cannot be translated without loss of meaning into tenseless ones (old B-theory) or made true by tenseless facts (NTT).

Keywords: *Rudolf Carnap, Philosophy of Time, Tense vs. Tenseless Theory, A-Theory, B-Theory, New Tenseless Theory of Time*

1 Carnap and Tense

This paper brings the work of Rudolf Carnap together with the modern debate about tense in the philosophy of time. It is an interesting fact that these fields have never been put together,[1] despite the fact, or so I believe, that their content is deeply connected. The debate between so-called tensed and tenseless theories is a central issue in contemporary philosophy of time. 'Tensers hold that grammatical tense is semantically irreducible, while detensers hold that tense is semantically reducible' [69, p. 2]. Under the buzz phrase 'tensed versus tenseless theory', I subsume different philosophical positions about the reference to the present moment. This divide places tensed theory, A-theory and indexicality on one side, and tenseless theory, B-theory[2] and non-indexicality on the

other. I will go into the details of some of the positions later; for now, it suffices simply to set out the broad division into two camps. The tensers[3] believe that the (firstly linguistic) reference to the present is meaning-constitutive. This reference can be encoded in the tense or aspect[4] of a sentence or expressed by an indexical like 'now' or 'tomorrow'. The detensers want to get rid of this reference to the present, be it by translation (old B-theory) or by giving tenseless truth conditions (new tenseless theory of time, or NTT for short).

A quick glance at the chronology of publication shows that the relevant philosophical work by Carnap took place significantly earlier than the switch from the old B-theory to the NTT. In 1926 Carnap published his *Physikalische Begriffsbildung* [16]. His *Aufbau* [12] is from 1928, and his considerations about protocol sentences are from 1932 [25]. In 1934, he published his main work in pure syntax [22], while by 1942 his semantic turn had taken place [15]. Prior's *Thank Goodness* argument [60] was published in 1959, only four years before Carnap's intellectual autobiography [14] and 20 years before Perry's *Essential Indexicals* [58]. Mellor's *Real Time* [49] was not published until 1981, and his *Real Time II* appeared as recently as 1998 [50].

A re-evaluation of Carnap's work in this new light is important for at least two reasons: (a) Carnap's position reveals the costs of the NTT. Not all of the old B-theoreticians can easily convert to the NTT, for the NTT is much too metaphysical for the likes of Carnap and makes too many concessions to the A-theory in accepting the impossibility of translation without loss of meaning. (b) The newer debate in the philosophy of time makes us aware of the internal tension in Carnap's work. Carnap wanted to be metaphysically neutral, and thus systematically underestimated the implications of his own findings. In various places, for example, he contended that time has a special empirical status (e. g. [13], [24], [16, p. 14] and [27, p. 78]), but never explored the possible philosophical consequences of this.[5]

1.1   Extracting Carnap's stance on tense

Before we can evaluate the impact of the newer developments in the philosophy of time for Carnap's position, we have to ascertain the status of indexical concepts for his logic of science. Carnap's early work up to *Der logische Aufbau der Welt* [12] differed in some important points from ideas he developed in *Testability and Meaning* [17] or his *Philosophical Foundations of Physics* [27]. So, the first goal of this paper is to provide

a rough reconstruction of Carnap's thoughts on tense.

Carnap upheld the *inter-translatability thesis* throughout his career: 'This neutral attitude toward the various philosophical forms of language, based on the principle that everyone is free to use the language most suited to his purpose, has remained the same throughout my life' [14, p. 18]. Carnap always believed that ultimately one can *choose* between different languages.[6] The logic of science, for example, can be based on a physicalist or a phenomenalist language,[7] [14, p. 18]. These languages are inter-translatable. This is deeply connected with Carnap's belief in conventionalism, the 'philosophical position according to which the truth of a certain proposition [...] is in some sense best explained by appeal to intentional human actions, such as linguistic stipulations' [68, p. 169]. Carnap's so-called principle of tolerance was 'perhaps better called the principle of conventionality' [15, p. 247]. For Carnap, it is only considerations of convenience (or pragmatics) that can decide in favour of one language over another [65, p. i].

Within this context, Carnap also dismissed indexicals as unessential. According to standard definitions, an indexical is a 'linguistic expression whose reference can shift from context to context' [9]; alternatively, 'An indexical expression is one whose extension varies with variation in features of its context of use, but which is otherwise rigid' [42, p. 237]. Following Bar-Hillel, I take the term indexicals to include 'I', 'now', and 'here' as well as 'this' and 'that' [4]. Carnap believed that indexicals can be replaced by time and date specifications and the like, and that they should be so replaced to arrive at an intersubjective description of the world: 'for science, it is possible and at the same time necessary to restrict itself to structure statements' [21, p. 30].

Another main thesis endorsed by Carnap is *metaphysical neutrality*. This thesis stems from logical positivism and is closely connected to the 'empirical sense' criterion. To avoid 'bad metaphysics', Carnap always opted for metaphysical agnosticism. The empiricists/positivists claimed that the only source for our knowledge is the directly given, namely sense-data. Every concept of science should be reduced to the relevant sense data. Carnap's *Aufbau* [12] from 1928 is a detailed execution of this agenda [75, p. 37]. All scientific statements should be able to be proven wrong (falsified) or right (verified) by reference to sense data. If successful, the *Aufbau*'s program would also show that, besides the positivist's given, no other source of knowledge is needed [12, §5].

The program of the *Aufbau* is not to be understood as logically necessary. Quite the contrary, it includes a lot of systematic choices. Carnap

chose the object domain and decided to take an auto-psychological phenomenalist basis [12, §64], which means that, ultimately, the experiences of an individual subject lie at the basis of his constructional system. A constructional system 'attempts a step-by-step derivation or "construction" of all concepts from certain fundamental concepts, so that a genealogy of concepts results in which each one has its definite place' [21, p. 5]. In Carnap's methodological solipsism, cultural objects are based in other minds, which are themselves based in physical objects, which again themselves are based in phenomenal ones via *quasi-analysis*,[8] according to their order of epistemic priority.[9] Carnap opted for the 'inter-translatability' [12, p. 57] of the physical and the phenomenological. He believed it to be possible to construct the physical objects via 'quasi-analysis' from a phenomenological basis: 'According to the conception of epistemic priority in the *Aufbau*, the world of science was recoverable from the resources of individual epistemic subjects alone' [75, p. 37].

Intersubjectivity was a main criterion for Carnap's logic of science. He thought that indexicals were incompatible with intersubjectivity and thus devised a method for getting rid of them.

> [E]ach scientific statement can in principle be so transformed that it is nothing but a structure statement. But this transformation is not only possible, it is imperative. For science wants to speak about what is objective, and whatever does not belong to the structure but to the material (i. e. anything that can be pointed out in a concrete ostensive definition) is, in the final analysis, subjective. One can easily see that physics is almost altogether desubjectivized, since almost all physical concepts have been transformed into purely structural concepts. [21, p. 29]

Carnap's *Logical Syntax of Language* [22] transposed his previous work to the methodological level [43, p. 21]. Carnap did not claim that words do not have a meaning, but he systematically excluded the meaning and hence '[n]o reference to the meaning of the signs and expressions is made in logical syntax' [47, p. 554]. Carnap also expelled indexicals in this so-called syntactical period, and proposed a translation scheme. The *coordinate replacement thesis* was the plan to replace 'name-languages' with 'coordinate languages' [21]. The replacement has to take place since 'the method of designation by proper names is the primitive one; that of positional designation corresponds to a more advanced stage of science and has considerable methodological advantages over the former' [14, p.

12].[10] Carnap's method of uniquely designating structural descriptions from the *Aufbau* [12, sec. 16] is applied in the *Logical Syntax of Language* in order to eliminate indexicals in favour of non-indexical descriptions.

In chapter B of *Logical Syntax of Language* [22] Carnap is concerned with the 'syntax of any language'. There he completely dismisses indexicals such as 'now':

> In case of sentences in which words like 'I', 'you', 'here', 'now', 'to-day', 'yesterday', 'this' (in the sense of "the one present") and so forth occur, the logical character is not only dependent upon the preceding sentences, but also upon the extra-linguistic situation — namely, upon the spatio-temporal position of the speaker.

> In what follows, we shall deal only with languages which contain no expression dependent upon extra-linguistic factors. The logical character of all the sentences of these languages is then invariant in relation to spatio-temporal displacements; two sentences of the same wording will have the same character independently of where, when or by whom they are spoken. In the case of sentences having extra-syntactical dependence, this invariance can be attained by means of the addition of person-, place-, and time-designations. [22, p. 168].

But as Carnap's major disciple Yehoshua Bar-Hillel remarks, it 'is quite clear that this qualification restricts highly the applicability of Carnap's general syntax to ordinary languages. The overwhelming majority of the natural language sentences are indexical, i.e. dependent upon extra-linguistic factors' [5, p. 524].

Indeed, not long after the publication of *Logical Syntax* Carnap came to the conclusion that the one-sided restriction to syntax may have been fruitful, but was also very austere: 'this method studies only the forms of the expressions, not their meanings' [22, p. 52]. A calculus can be interpreted and applied to objects and the syntax must thus be complemented with a semantics. Taking semantics into account restricts the conventionalist freedom, however, since possible interpretations have to be considered [43, p. 21]. Carnap did indeed become more interested in the meaning of expressions after this 'semantic turn', but he did not lift the ban on indexicals.

Besides this, Carnap was concerned with time in the context of measurement and with indexicals in the context of the protocol sentence

debate. Both will be discussed later in the paper. For now we need
only observe that Carnap shunned indexicals throughout his career. He
either systematically excluded them, or voted for replacing them with
allegedly more reputable time-designations. Carnap thus clearly belongs
in the camp of the (old) B-theory, believing that tensed sentences can
be translated without loss of meaning into tenseless ones.

1.2   Translatability of tensed sentences and the NTT's metaphysical commitment

The opposing view, that the meaning of a tenseless sentence differs from
the meaning of its tensed counterpart, did have some proponents even in
Carnap's time. From within Carnap's close social environment, this posi-
tion was maintained by Moritz Schlick. The so-called *protocol sentences
debate* within the Vienna Circle revolved exactly around this topic.[11]

> If I make the confirmation "Here now blue", this is not the
> same as the protocol statement "M. S. perceived blue on the
> nth of April 1934 at such and such a time and such and such
> a place." The latter statement is a hypothesis and as such
> always characterised by uncertainty. The latter statement
> is equivalent to "M. S. made ...(here time and place are to
> be given) the confirmation 'here now blue."' And that this
> assertion is not identical with the confirmation occurring in
> it is clear. [2, p. 226]

Protocol sentences were supposed to be the rock on which knowl-
edge, and especially scientific knowledge, should be built. They had to
be objective, intersubjective and free of indexicals, as they ought not to
depend on the individual person/scientist. In *Über Protokollsätze* [19]
Carnap thus opted for the supposedly objective approach of date and
time indication instead of the indexical 'now'. Schlick, however, argued
that these protocol sentences cannot be justified. The sentences that
are needed to build a system of knowledge — sentences such as 'M.S.
perceived blue on such and such date at such and such time at that lo-
cation' — are only hypotheses. They are not the immediately given, the
positive of the positivists. The only things which are given, according
to Schlick, are expressed in sentences like 'Here now blue' which he calls
Konstatierungen (confirmations). Konstatierungen are not apt to build
a system of knowledge, as they cannot even be written down: 'A gen-
uine confirmation cannot be written down, for as soon as I inscribe the

demonstratives "here", "now", they lose their meaning' [2, p. 226]. Thus a dilemma arises for the foundations of scientific knowledge. Schlickian confirmations are available but insufficient, whereas Carnapian protocol sentences would be sufficient but are not available.

The participants of the Vienna Circle became mired in the debate about the status of the protocol sentences. No agreement could be reached, and the question was put on hold and then never resumed [43, p. 16]. This is a historical fact, not a systematic insight, and the systematic quarrel is still not settled today. It is nonetheless remarkable that Schlick, Carnap's contemporary, had already made the case for irreducible indexicals[12] that are not replaceable by times and dates: 'Neither can they be replaced by an indication of time and place, for as soon as one attempts to do this, the result, as we saw, is that one unavoidably substitutes for the observation statement a protocol statement which as such has a wholly different nature' [2, p. 226].[13] If Schlick is right, then tensed and tenseless sentences are not on a par. Tensed sentences are not incomplete sentences at all but, quite to the contrary, contain a special form of knowledge (*Erkenntnis*[14]) that cannot be incorporated in tenseless sentences. Interestingly, the fatal blow for the old B-theory occurred much later.

The old B-theoreticians had held a translatability thesis: All tensed sentences are translatable without loss of meaning into tenseless sentences. Frege had proposed a *date indication analysis*, stating that the tensed sentence 'It is raining now' actually means, say, 'It is raining at Thursday 13 May 2014' [36, p. 297] or [35]. Russell opted for a *token-reflexive analysis*, according to which the sentence should be translated as 'It is raining at the time point that is co-temporal with this utterance' [66, p. 108].

Prior [60] and Perry [58] famously stated that reference to the present moment is both important for our actions and not translatable without loss of meaning into tenseless concepts and sentences. Today, the irreducibility of tensed sentences and beliefs has been accepted all but universally,[15] and 'recent defenders of the tenseless view have come to embrace the thesis that tensed sentences cannot be translated by tenseless ones without loss of meaning' [56, p. 58].

Prior claimed that reference to the present is relevant for actions and that tensed sentences cannot be translated without loss of meaning. His example is the relief or joy someone feels, when, say, an important test is completed. According to Prior, the decisive factor for feeling the joy is that one believes that the test is *now* completed. It is not enough,

say, to believe that the test ends at 2:00 p. m. and that 2:15 p. m. is later than 2:00 p. m., because all that is known before the test is taken but doesn't trigger the joy.

> One says, e. g. "Thank goodness that's over!", and not only is this, when said, quite clear without any date appended, but it says something which it is impossible that any use of a tenseless copula with a date should convey. It certainly doesn't mean the same as, e. g. "Thank goodness the date of the conclusion of that thing is Friday, June 15, 1954", even if it be said then. (Nor, for that matter, does it mean "Thank goodness the conclusion of that thing is contemporaneous with this utterance". Why should anyone thank goodness for that?) [60]

Perry uses a different example to argue for the same conclusion: A tardy professor 'who desires to attend the department meeting on time, and believes correctly that it begins at noon, sits motionless in his office at that time. Suddenly he begins to move. What explains his action? A change in belief. He believed all along that the department meeting starts at noon; he came to believe, as he would have put it, that it starts *now*' [58, p. 4].

Prior's and Perry's arguments changed the debate radically; afterwards, virtually nobody believed that tensed sentences can be translated into tenseless sentences without loss of meaning. Mellor thus proposed another method instead: he stated that tensed sentences can be given tenseless truth conditions. In his first attempt, published as *Real Time* [49], Mellor understood the meaning of a tensed sentence as a function from utterances to truth conditions. Due to strong critique[16] he later changed his position. In *Real Time II* [50] the meaning of a tensed sentence is a function from time points to truth conditions. The new B-theoreticians still call their view tenseless, but this tenselessness now concerns the structure of the world.

> The problem [. . .] is to determine whether this aspect [i. e. being tensed] is a feature of reality that is described or merely a feature of the statement by which it is described. Is reality itself somehow tensed [. . .] or is it merely that we describe a tenseless [. . .] reality from a tensed [. . .] point of view? [34, p. 261]

The shift from the old to the new tenseless theory was thus a shift from philosophy of language to metaphysics.[17]   Old B-theoreticians

claimed that tensed sentences are either incomplete (they need the addition of an explicit time and date, like a 2-place relation needs a second relatum) or are linguistically on a par with tenseless ones (the tense being just a façon de parler). The truthmakers of the sentences did not really play a role. True, the position one took regarding tensed sentences was *de facto* also often mirrored in the position one held regarding the nature of time,[18] but there did not need to be a systematic link between the two: 'Presentism and becoming have also been associated with the idea that tensed language does not have tenseless truth conditions. However, this is not a necessary connection' [45, p. 326].

It might be controversial, but I think that the NTT wedded language to metaphysics. Nowadays, one can only truly be called a B-theoretician if one holds a tenseless **world** view.[19] Mellor [50] claims that tenseless facts are not only sufficient as truthmakers for tensed sentences, but *necessary*. This can be seen as a cost of the NTT[20], since it might deter philosophers of language who shun metaphysics from the NTT. Carnap, for example, systematically excluded semantics during his syntactic period [22], while Otto Neurath in *Protokollsätze* [53] and *Radikaler Physikalismus und wirkliche Welt* [54] opted for the dismissal of any reference to the language-external 'reality' and the restriction of philosophical attention to language-internal questions [3, p. 146 et sqq.]. Influenced by Neurath, Carnap (e. g. [25]) focused on coherence inside a language system instead of truth as correspondence with the 'world' [43, p. 16].[21] Mellor's NTT is not an option for such philosophers, who don't believe in facts (whether they be tensed or tenseless) or who want to be metaphysically neutral. It is thus not available to Carnap, since it is compatible neither with his *metaphysical neutrality thesis* nor with his *inter-translatability thesis*.

2 Inter-Carnapian tensions and Carnap's unintended argument for the tensed theory

As we have seen, Carnap's inter-translatability thesis cannot be held in the universal form. The old B-theory and with it the hope of translatability without loss of meaning between tensed and tenseless sentences had been abandoned after Prior's and Perry's famous arguments. It is, however, also not possible to transfer Carnap's work to the NTT, which is the successor theory to the old B-theory. The NTT may be on the tenseless side of the divide but its specific metaphysical character contradicts Carnap's much-beloved metaphysical neutrality thesis. This is

no surprise, however. In 2.3 I will sketch a transcendental argument in favour of the A-theory, which relies on Carnap's considerations about time measurement (2.1) and Russell's achievements in the field of indexicals (2.2). The argument also reveals tensions within Carnap's work, which help to explain why he and the NTT form such an odd couple.

2.1 Carnap on time measurement

Carnap laid down some interesting thoughts about time measurements in *Philosophical Foundations of Physics* [27], later reprinted as *An Introduction to the Philosophy of Science* [11]; these thoughts go back to his *Physikalische Begriffsbildung* [16]. Duration is a quantitative magnitude, more precisely an extensive magnitude. According to Carnap, extensive magnitudes can be measured with the aid of three-rule schemas, consisting of (1) The rule of equality, (2) The rule of additivity, and (3) The unit rule.[22]

'Three-rule schemas apply to situations in which two things can be combined or joined in some way to produce a new thing, and the value of magnitude M for this new thing will be the sum of the values of M for the two things that were joined' [27, p. 77]. Carnap, following Carl Gustav Hempel, insisted that *combination* refers to a physical operation in this context, which has to be distinguished sharply from arithmetical addition [27, p. 72]. The measurability with a three-rule schema applies to all extensive magnitudes, but time intervals have a special status because of their physical peculiarities: 'We cannot manipulate time intervals in the way we can manipulate space intervals, or, more accurately, edges of solid bodies representing space intervals. There are no hard edges of time that can be put together to form a straight line' [27, p. 78]. Carnap tried to acknowledge the special status of time intervals by the introduction of a conceptual scale. In the context of time measurements he understood ∘ in the rule of additivity $T(a \circ b) = T(a) + T(b)$, with T being the temporal length, as a *conceptual* operator.

Both other rules (equality and unit) are grounded in periodic processes, according to Carnap. Carnap distinguished two sorts of periodicity: 'In the weak sense, a process is periodic simply if it recurs again and again and again' [27, p. 80]. The strong sense requires 'that in addition to being weakly periodic, it is also true that the intervals between successive occurrences of a certain phase are equal' [27, p. 80]. Prima facie one would expect that time measurements need strong periodic processes. There is, however, a problem with this requirement, which

Carnap had clearly spotted: 'We cannot know that a process is periodic in the strong sense unless we already have a method for determining equal intervals of time' [27, p. 80]. This is a vicious situation: we need the rules of equality and unit to build a system of time measurement, but we need a system of time measurement to establish the rules of equality and unit. Or so it seems.

Carnap proposed a solution to this conundrum which is centred on the equivalence of processes. He elucidated process equivalence with the example of the swinging of a certain short pendulum P, which is compared with the swinging of a longer pendulum P′. 'In view of the fact that the periods of the two pendulums are not equal, how do we compare the two? We do it by counting the swings of both pendulums during a longer time interval. [. . .] We may observe, however, that the coincidence is not exact. After ten swings of the short pendulum, the long one already started on its seventh swing' [27, p. 82]. Note that 'already started on its seventh swing' only makes sense if the two intervals started *at the same time.* I will come back to this; let us first go through Carnap's resolution of the alleged vicious circle. To handle the case of the not-exact coincidence, Carnap proposed to observe the pendulums for a longer time interval: 'In this way we can sharpen our comparison as much as we please' [27, p. 82]. On this basis he can now specify process equality: 'If we find that a certain number of periods of process P always match a certain number of periods of process P′, we say that the two periodicities are equivalent' [27, p. 83].

Process equality alone does not suffice as a solution to the conundrum, however; an empirical fact is also needed, namely that there is one 'large class of periodic processes that are equivalent to each other in this sense', and that '[a]s far as we know, there is only one large class of this kind' [27, p. 83]. At this point Carnap's conventionalism kicks in: 'We cannot say that the pendulum is the "right" choice as the basis for our time unit and my pulse beat the "wrong" choice' [27, p. 83]. Carnap equipped us with a method for measuring duration without presupposing equal temporal length. This enables us to measure time as a quantitative concept.

2.2 *An unlikely ally for the tensed theoreticians: Russell*

Russell provides a valuable source for our study of tense and indexicality. In 1940 Russell was arguing along the same lines as Carnap. He claimed in *Inquiry into Meaning and Truth* that indexicals are 'not needed in any

part of the description of the world, whether physical or psychological'
[66, p. 108]. Later, in 1948, Russell explicitly changed his mind and
thus objected to Carnap's position. Russell was now concerned with
indexicals because of their importance for knowledge and especially sci-
entific knowledge: they are indispensable, he claimed, 'in stating the
basis of empirical knowledge in immediate experience' [31, p. 119]. Rus-
sell posited the following four characteristics of indexicals in his book
Human Knowledge [31, p. 123]:

1. **Coordinate replacement** Indexicals, as well as strict names, can
   be progressively replaced by coordinate descriptions, but only up
   to a certain point.

2. **Indispensability** Indexical expressions cannot be entirely elimi-
   nated. They are indispensable to human discourse, including any
   science that requires human observation.

3. **Interdefinability** Each indexical expression can be defined in terms
   of another (or a combination of others).

4. **Reducibility** All indexical expressions can be reduced to one basic
   type, although this basic type need not be one in particular.

Scientific concepts must ultimately terminate in ostensive definitions,
according to Russell, and thus 'indexicals are not completely eliminable'
[31, p. 119]. Russell's coordinate replacement thesis for indexicals goes
back to Carnap's *Logical Syntax of Language* [22]. Contrary to Carnap,
however, Russell thought that this program works only up to a certain
point: 'We cannot wholly dispense with proper names [indexicals] by
means of coordinates'.[23] Farrell-Smith is very explicit about the limita-
tions that Russell imposes on the coordinate replacement thesis:

> Coordinates describe a point in space-time. They locate
> it by means of reference to axes and distance from the origin
> of axes. But, Russell asks, how do we designate the axes and
> the origin? We cannot go on indefinitely giving a descrip-
> tion of the origin of each system in terms of another system.
> Ultimately we must be able to say, 'This is the origin.' In
> other words, we must be able to name the origin, in contrast
> to merely describing it. [31, p. 119]

We can apply Russell's findings on space straightforwardly to the
case of time. We need a way of referring to the point of origin outside of

the time and date system. Only then can such a system be established.
Without it, the term 'point in time' is meaningless: if we do not have
a way of 'knowing some places otherwise than by latitude and longi-
tude, latitude and longitude become unmeaning' [67, p. 77]. Unless the
whole system should become free-floating, we 'must have some method
of identifying a place [a time] without mentioning the coordinates' [67,
p. 78].

> Then, since the assignment of coordinates requires as-
> signing an origin and axes, the question arises as to whether
> the origin can be defined. [Russell] answers that it must be
> defined by reference to something observable. Theoretical
> constructs like the sun obviously will not do. [31, p. 119]

The limitations this introduces to the time case are pretty obvious.
'Theoretical constructs' like the Big Bang cannot serve as the origin;
rather, we need something directly observable. '[U]nless we already
have some non-descriptive way of fixing this framework, i.e. some way of
"naming" its origin, we face a regress that detaches scientific knowledge
from its empirical basis' [31, p. 119].

2.3   The argument in favour of the A-theory

We have seen that Carnap's original inter-translatability thesis had to be
dropped due to the developments in the philosophy of tense. Section 1.2
argued that Carnap can also not be on the side of the NTT, the successor
theory of the old B-theory. A tension seems to arise, since some of
Carnap's statements clearly place him on the tenseless/B-theoretic side
of the divide, as we have seen in 1.1.

A closer inspection will reveal that the incompatibility of Carnap's
position with the B-theory is not surprising.[24] In his considerations
about time measurement, Carnap emphasised that the term "longer"
does not have a meaning without the complete three-rule schema: 'We
do not know what you mean by 'longer'. We are trying to lay down rules
for the measurement of time so that we will be able to give meaning to
the term "longer"' [27, p. 81].

Parallel to this, I will argue that time and date indications do not
have a meaning without a tensed anchor point. If the argument goes
through, it will show that the tensed and tenseless approaches are not
on a par. The asymmetry towards the tensed is not in line with Carnap's
inter-translatability theses, but it fits well with what he says in various

other places (e. g. [13], [24], [16, p. 14] and [27, p. 78]) where he defends a special status for time. Thus, it would hint at the inner tension within Carnap's work. This tension cannot be dissolved by identifying different periods in Carnap's work. Carnap first developed his thoughts about time measurement in a small volume called *Physikalische Begriffsbildung* [16] from 1926, a full forty years before *Philosophical Foundations of Physics* [27]. It is thus safe to say that he held these views throughout his career.

I will first go through the premises, then I will sketch[25] the argument and comment on it.

(Presup.): I restrict the argument to the debate between A- and B-theory, a restriction which might be questioned. If the argument goes through it would help the A-theorists a good deal as it does not rely on the *experience* of time, which is as often consulted as an aid for the A-theory as it is problematic [39].

(Carnap 1): Carnap thought that in 'the case of sentences having extra-syntactical dependence, [. . .] invariance can be attained by means of the addition of person-, place-, and time-designations' [22, p. 168]. He thus believed that the indexical 'now' can easily be replaced by a B-theoretic time-designation and should be replaced.

(Carnap 2): Carnap emphasised the difference between time and space, as 'We have two separate events, each with a certain length of time, but there is no way to bring them together. [. . .] we cannot shift events around as we can shift the edges of physical objects' [27, p. 78]. Time plays a special role for Carnap.

(Carnap 3): Carnap showed how to reach a definition of duration via the 'one large class of periodic processes that are equivalent to each other' [27, p. 83]. This premise has the form of an implication. If an origin is supplied, Carnap's specification of duration can be used to build a B-theoretic system of times.

(Russell 1): Russell claimed that '[w]e cannot wholly dispense with proper names [indexicals]' [67, p. 78]. Russell thought that indexicals were interdefinable. Given some (suitable) indexical basis we can define the remaining indexicals. This is a systematic point for Russell, i. e. he doesn't claim that there is one particular indexical which is the *objective*

basis: Russell's claim can rather be understood the other way around, namely that we can never completely leave the realm of the indexical.

(Russell 2): Russell argued that we cannot go on indefinitely giving a description of the origin of each system in terms of another system. Ultimately we must be able to say, 'This is the origin' [31, p. 119].

(B-theory): A B-theoretic time specification consists of a time and date indication.

(Systematicity): A time and date specification only makes sense within a given system of time. For example 'It rained at three o'clock on the 7th of April' only makes sense in respect to a calendaric system, like ours.

(Argument - short): The shortest way to set up the argument in favour of the tensed/A-theory side of the divide is to take (Carnap 2) and (Russell 1) and conclude that 'now' is the basic indexical.

This is the shortest but arguably also the most uncertain form of the argument. (Russell 1) clearly states that we cannot wholly dispose of indexicals. It is unclear however if (Carnap 2) is really enough to establish that time is fundamental in the sense required. If time is fundamental and we cannot wholly dispense of indexicals, then 'now' has to be the basic indexical.[26] The argument is valid but maybe not sound, i. e. some of the premises may be false. The premise (Carnap 2) is its potential weak spot. Acknowledging a special role for time is not enough; rather, the fundamentality of time must be established. If this short argument goes through it can easily be extended to contradict (Carnap 1). Since 'now' is the basic indexical it is thus not dispensible; but this is exactly the opposite of what (Carnap 1) claims. Note that Russell's considerations from *Human Knowledge* are not sufficient to set up the argument, since Russell did not believe in any priority among the indexicals.

A longer version **(Argument - long)**: (Russell 2) states that each system needs an external anchor. As an instance of that, a system of time needs an external anchor. Now this anchor can either be specified indexically/A-theoretically or non-indexically/B-theoretically. A B-theoretic specification consists of a time indication (B-theory), but this in turn only makes sense within a given system of time (Systematicity). So, on pain of circularity, the origin of a system of time cannot be specified B-theoretically. It thus has to be specified A-theoretically.

The heart of (Argument - long) is that a system of time cannot be specified by a date and time indication on pain of circularity. A time and date indication only makes sense in reference to an existing system of time and thus cannot be used to build a system of time. Of course, a pre-existing system of time could be used to build up another system of time. I could, for example, use the calendar system of the ancient Greeks with the original Olympic Games as the origin, to specify our calendar system with the birth of Christ as the origin.[27] But ultimately one has to come to an external anchor, and this is what (Russell 2) states. As this is a systematic point, not a mere contingency, it justifies the modal claim that a system of time **cannot** be specified by a time and date indication (ultimately). This modal strength then justifies the claim that the origin (ultimately) has to be given in indexical terms. As we are talking about a system of time, the indexical in question is 'now', i. e. the A-theoretic way of specifying the origin.

This argument can easily be extended to contradict (Carnap 1). As a system of time needs an indexical anchor, we cannot completely dispose of indexicals (if we want to set up a system of time at all, that is). But there is also a constructive part. Carnap's construction of duration via equivalent processes may help us to build an intersubjective system of temporal location, once we have amended it with a tensed A-theoretic origin. This actually is Carnapian in spirit. In his example from *Philosophical Foundations of Physics* [27, p. 82], the scientist starts both pendulums in his present and thus both processes start at the same time.

To sum up, the construction of any time and date system requires an anchor point, prior (constructively prior, not temporally prior) to this system. This anchor can only be understood as tensed, or so I have argued. If the argument goes through then tensed and tenseless theories of time are not on a par. Granted, one could still choose between the different tenseless theories by convenience, but a tensed anchor is mandatory for there to be a system of time at all.[28]

Any system of time order, be it metrical or topological, needs to be pinned to reality, so to speak, in order to have empirical content.[29] 'With tolerance in place, Carnap is prepared to imagine non-empiricist languages, though of course he thinks they are very unwise' [30]. Thus Carnap also has to deem a purely tenseless system of time, without an tensed anchor, 'very unwise'.

The argument is not only about statements occurring in scientific theories, but about the prerequisites for establishing any B-theoretic

time order. This may not be on Carnap's agenda, but still, I think, it is rooted in his systematic thoughts about time measurement. Carnap's early characterisation of a time topology might include a short cut to the result that A-theoretic simultaneity is a precondition of a B-theoretic time order,[30] as Carnap explicitly bases physical simultaneity on local phenomenological simultaneity. In *Physikalische Begriffsbildung* [16, p. 37], Carnap defined simultaneity (i. e. when two events get the same value of time) in the following way: Two events are physically simultaneous if they are perceived together. There Carnap explicitly states that physics presupposes phenomenological simultaneity as a determinable basic relation [16, p. 38].

Be that as it may, right now I am concerned with a more general point. Every B-theoretic system of time order, be it a topology or a metric, needs an anchor outside the system in order to be built in the first place. To arrive at a numeric value for a (B-theoretic) time and date indication, we need to fix an initial point and an ongoing process to specify the time-wise distance to this initial point. Carnap himself writes: 'We don't know of an initial point of the time series. An arbitrarily chosen time point has to be fixed as the point of origin of the time scale, as it is done in the various calendar systems (first year; first day of the year).'[31] The origin thus cannot be specified by a time and date indication, since it is needed to set up a calendar system in the first place. In order to be able to order events in a calender system, people at some point needed to say 'we start counting years **now**', 'this is year one'.

The earlier/later relation is dependent on the A-series of past/now/future, and thus tensed sentences can neither be translated without loss of meaning into tenseless ones nor can they be given tenseless truth conditions. The argument I have sketched does in no way question the usefulness of a tenseless system of times and dates; it seeks only to show that a B-theoretic time and date indication is meaningless without an A-theoretic anchor, just as the term 'longer' is meaningless without a system of time measurement.

Carnap and Russell were concerned chiefly with epistemological questions, but the argument can also be given a more metaphysical[32] gloss: '[T]he philosophy of A-time or B-time, perhaps more than any other area, has shown the continuing relevance of the idea that natural language is, in some carefully qualified sense, a guide to the nature of reality' [41, p. 4]. After all, it was the tenseless theoreticians who strengthened the link between language and ontology by adhering to the NTT, so now

they have to face the music: Our system of knowledge is rooted in irreducible tensed sentences, from which tenseless date and time indications can be derived. This is not a choice of convenience but something that is necessitated by the requirements of construction. If our knowledge has something to do with the structure of the empirical world, how could there be only tenseless facts in the empirical world? To clarify where the onus of proof falls: The tenseless theoretician acknowledges the irreducibility (i. e. the non-translatability and indispensability) of tensed sentences but thinks she can still dispense with tensed facts by positing tenseless facts as truthmakers. The existence of tenseless facts is a heavyweight ontological claim, according to Chalmers's categorisation in [28]. The B-theoreticians acknowledged the necessity of tensed beliefs for our actions. If now the existence of a system of tenseless earlier/later depends on the A-series of past/present/future, as I have tried to show, then the odds for tenseless facts as truthmakers for empirical sentences are bad.[33] However, this is not to deny the utility of a tenseless system of times and dates. Carnap made an important contribution on how to construct such a system, namely by using periodic processes and, most conveniently, the class of equivalent processes.

3   Concluding remarks

This paper focused on the interrelations between the modern philosophy of time and Carnap's work. Carnap held an inter-translatability thesis throughout his career. He believed that, ultimately, one can choose between different languages, because one can translate sentences between different languages, such as the physicalist's or the phenomenalist's language, without loss of meaning. This includes the translation of indexicals into time, date and name indications without loss of meaning.

Exactly the same translatability of tensed sentences into tenseless counterparts was adhered to by the old B-theoreticians. Nowadays, the old B-theory has been given up for good. After Prior's and Perry's famous arguments, virtually no one now champions the old B-theory. Carnap's inter-translatability thesis can no longer be upheld. The NTT, founded by Mellor, is the centerpiece of modern tenseless theories: but Carnap cannot stomach the NTT, since it is too metaphysical for him. According to Mellor, tenseless facts and only tenseless facts are apt truthmakers for tensed sentences. This contradicts Carnap's metaphysical neutrality thesis.

It is no surprise that Carnap and the NTT do not fit well together. To

show this, I have tried to extract an argument against the tenseless theory out of Carnap's own remarks concerning time measurement. Carnap devised a clever way to measure duration as a metrical property, without succumbing to the lurking vicious circle. To build a system of times and dates, an origin must also be specified. Any B-theory requires such a system of time: the old B-theory on the level of language, and the NTT on the level of truth-makers. On pain of circularity, the origin cannot be specified B-theoretically and thus must be specified A-theoretically. This is backed up by Russell, one of the most prominent old-B-theoreticians, who claimed that indexical expressions cannot entirely be eliminated. A tenseless system of time and date indications requires a tensed anchor point to have empirical content.

This not only shows that Carnap's ideas do not fit well with the NTT, but also that there are pre-existing tensions within Carnap's work. On the one hand Carnap wanted to get rid of all indexicals in his quest for intersubjectivity; on the other hand he was well aware that '[w]e cannot manipulate time intervals in the way we can manipulate space intervals' [27, p. 78].

Acknowledgements

Notes

1 I know of one paper which contains the words 'Carnap' as well as 'tense', but it has nothing to do with our topic: Arthur Prior's example just happens to be 'Professor Carnap will fly to the moon' [59, p. 268]. In addition, Arthur Pap [57] speaks of 'tense versus tenseless' in the context of Carnap's *Testability and Meaning* [17] but he conflates tense with time: 'tensed, and hence time-referent form' [57, p. 565]. As will become clear later, in the debate in the philosophy of time both sides agree that there is some kind of time reference; they disagree, however, about whether this essentially involves a reference to the present (tensed theory) or not (tenseless theory).

2 'The old B-theory says that tensed/indexical sentences are tenseless/non-indexical sentences in disguise, and hence that tensed sentences have tenseless truth conditions. The new B-theory denies that tensed/indexical sentences are tenseless/non-indexical sentences in disguise, but agrees that tensed sentences have tenseless truth conditions' [69, p. 11].

3 According to Peter Ludlow, 'tensers think that propositions (or in any case bearers of truth) shift in truth-value over time [. . .], while detensers put a time index in propositions and argue that propositions are anchored to a time [. . .] in such a way that the proportions are eternal' [46, p. 691]. As so often happens, in the debate between tensers and detensers the devil lies in the details. Ludlow [46] gives a good overview of the possible positions and their problems. For our purpose it is sufficient to get clear on the broader picture. In using tensed talk, for detensers 'we are just talking about a series of tenselessly existing events ordered by the earlier-than/later-than relation' [46, p. 690], whereas for tensers 'we are talking about some important temporal feature of the world (for example a tensed fact — like the fact that it rained yesterday — that currently obtains)' [46, p. 690]. I will switch freely between the terms 'tensed theory', 'tensers', and 'A-theory' (as well as their counterparts) in this paper; whenever a specific linguistic or ontological reading is meant, I'll make this clear.

4 Many of the features which traditionally have been assigned to tense by linguists now are considered aspectual. 'Tense and aspect are, to be sure, closely related: both have to do with time, and both are, generally speaking, expressed grammatically by modifications of the verb' [40, p. 2–3]. Aspect has long been neglected outside linguistics. Antony Galton remarks that Prior had worked out a tense logic in 1955 [61], the idea of which had already been stated by Findlay in 1941 [33], and yet his own logic of aspect was published as recently as 1984.

5 Carnap's discussion with Einstein about 'the Now' may be a good illustration of this attitude. 'Once Einstein said that the problem of the Now worried him seriously. [. . .] But I definitely had the impression that Einstein's thinking on this point involved a lack of distinction between experience and knowledge. Since science in principle can say all that can be said, there is no unanswerable question left' [14, pp. 37–38]. It seems that Carnap thought that there was just no need to wonder further.

6 'This neutral attitude toward the various philosophical forms of language, based on the principle that everyone is free to use the language most suited to his purpose, has remained the same throughout my life. It was formulated as "principle of tolerance" in Logical Syntax and I still hold it today' [14, p. 17]. Carnap's original formulation of the *Principle of Tolerance* runs as follows: 'It is not our

business to set up prohibitions, but to arrive at conventions' [22, p. 51]; or, a bit later in the same book, 'In logic there are no morals. Everyone is at liberty to build his own logic, i. e. his own form of language, as he wishes' [22, p. 52]. This famous principle is not quite the same as the *inter-translatability thesis* as the latter is a prerequisite of the former. Only if the languages are inter-translatable may we freely choose between them. Note that the other direction doesn't hold: one can think of different languages as inter-translatable and still be an eliminativist. Holger Andreas claims that this is the stance adopted by Carnap in his *Aufbau* [12]. Carnap's goal was to provide rules for translating sentences containing non-basal concepts into sentences containing only basal concepts. The non-basal concepts are then eliminated in favour of the basal ones [1, p. 43].

7 According to phenomenalism, physical objects are not themselves given but 'are reducible to or definable in terms of the occurrence and obtainability of' [7] sensory experience. Whereas 'the thesis *physicalism* maintains that the physical language is a universal language of science—that is to say, that every language of any sub-domain of science can be equipollently translated into the physical language' [22, p. 320].

8 Carnap's (in)famous method of quasi-analysis constructs physical objects from the contents of elementary experiences, which he took to be unanalysable and holistic. [1], [48] and [32].

9 Here it is important for us to distinguish the metaphysical project from the epistemic, as Carnap wanted to stay metaphysically neutral. 'This epistemological reading is compatible with Carnap's very strict exclusion of questions of ontology as bad metaphysics: the choice of the basis is a matter of choosing a language' [55, p. 2].

10 Carnap's own example of color nicely elucidates this point. 'In physics, we apparently have a property description when the color names ("blue", "red", etc.) are used. In present-day physics, descriptions of this kind are nothing but abbreviations, since they presuppose wave theory and since the color names can be translated into expressions of this theory (i. e. rates of oscillation). However, formerly, these property descriptions revealed the incomplete character of the theory of light, since they were not transformable into relation descriptions.' [21, p. 21].

11 For an introduction to the protocol sentences debate, see [74, p. LVI]. This volume also features the original papers by Carnap and Schlick in chapter 5.

12 Of course this claim by Schlick is not without its own prehistory. Schlick's work, however, is far less philosophically reprocessed than one would assume, given his status as founder of the Vienna Circle [72, p. 9].

13 An observation statement is a statement expressing a direct observation. Carnap understood direct observation as perception that is unaided by technical instruments and inferences [27, Ch. 23]. For criticism of this characterisation see [1, ch. 2.1].

14 Schlick's paper is consequently called *Das Fundament der Erkenntnis.* [71].

15 According to Cord Friebe, Sebastian Rödl [64] may be "the village of indomitable Gauls" with respect to this claim [38, ch. A.2.1].

16 A discussion of the theory in Mellor's *Real Time* can be found in [56]. There, advocates as well as enemies of the *New Theory of Time* have their say.

17 I take the old B-theory to be metaphysical neutral, if not anti-metaphysical. The logical empiricists believed that the surface structure of sentences is not identical to their logical deep structure and that thus logical analysis is necessary to unravel the semantics of our messy language (e. g. [62, p. 170]). For example Quine, a champion of the old B-theory, subscribed – at least for a time – to the 'empiricists' anti-metaphysical program' [30]. But people might think differently about the old B-theory. If the the old B-theory, is already a metaphysical view, as, one could argue, with the translatability of tensed into tenseless sentences comes the obligation to also give tenseless truth conditions, then Carnap may not even be compatible with the old B-theory. This however does not undermine my general point that Carnap's views are not only in tension with the B-theory but that arguments for the A-theory can be built upon them.

18 [73, p. xiii] for example speaks of ' "tensed" theories of time, in particular presentism' which illustrates the entrenchment of this debate.

19 Nathan Oaklander states that '[t]ensed discourse is indeed necessary for timely action, but tensed facts are not' [56, p. 58]. Oaklander's claim does not amount to an argument *for* a tenseless theory, however. If 'the truth conditions of tensed sentences **can** be expressed in a tenseless metalanguage that describes unchanging temporal relations between and among events' [56, p. 58, my emphasis], this only makes a tenseless theory a viable option: without this 'can', a tenseless theory could not be held after Prior and Perry's famous arguments. Consequently the NTT'ler want more and claim that tenseless facts are necessary as truth-makers for tensed sentences. We will not go into this here, but e. g. Mellor's [50] arguments seem to only affect *non-pure* presentism [29]. If this is the case, then pure presentism might contest the necessity of the tenseless truthmakers.

20 I do not want to claim, that metaphysics is *per se* a bad thing. To say it with the words of Jiri Benovsky 'What I aim at here is to provide myself and my reader with tools that enable us to evaluate the cost-benefit ratio of the different views under consideration' [6, p. 8]. What may seem as a cost to one person may be seen as a virtue by another. Nevertheless it is important to make the implications of philosophical positions explicit. On top of that I take agnosticism to be a meta-theoretical value, i. e. I take a philosophical position that is less committing to be superior. It's a variant of Occam's razor: Do not subscribe to anything, which is not necessary. In this sense the NTT's metaphysical commitment might *ceteris paribus* be seen as a cost.

21 As a consequence, Carnap concentrated on methods of justification ([26], [23] and [20]) and testability ([17] and [18]) rather than truth in the following.

22 Carnap's complete account of measurement need not concern us here. I will highlight the bits, which are important for our present purpose in due course. The reader, who wants to know more about the three rules or other aspects of Carnap's thoughts on measurement, is referred to Carnap's *An Introduction to the Philosophy of Science* [11], which is easily accessible.

23 [67, p. 78] Russell uses the term 'name' here, but what he refers to are indexicals. 'This' and 'that' are his prime examples.

24 Well, *partly* not surprising. On the one hand Carnap really believed that sentences with indexicals can and should be translated into their B-theoretic counterparts. On the other hand, as I will show, there are opposing tendencies in Carnap's work, which can be used to base an argument in favour of the A-theory.

These two tendencies – towards the A- and towards the B-theory – are temporally overlapping and can thus not be explained away trying to identify different phases in Carnap's work.

25 The way I present the argument, it is confined to Carnap's thoughts about measurement. Newer developments in measurement theory may change its systematic premises. I thank an anonymous referee for insisting on this point. This paper seeks to show the systematic impact of newer developments in the philosophy of time on the position that Carnap held, and a similar impact by the newer measurement theory is also plausible. I think that the transcendental argument is independent of this, but I can't show this here.

26 Charlie Dunbar Broad [10, p. 58]), William Lane Craig [29, p. 118] and Thomas Müller [51, p. 206] also come to the conclusion that 'now' is (one of) the basic indexical(s). They state for example that 'here' is derivative of the indexicals 'now' and 'I', since 'here' actually means 'where I'm now'.

27 The two ways of specifying the origin are also distinguished by Nicholas Rescher: 'The distinction between dates and pseudo-dates points to the existence of two very different chronological dating-procedures, depending upon whether the fundamental reference-point — the "origin" in mathematical terms — of the chronological scheme is a chronologically stable date or a chronologically unstable pseudo-date. If the "origin" is a pseudo-date, say "today", we shall have a style of dating all of whose chronological specifiers are pseudo-dates, e.g. tomorrow, day-before yesterday, four days ago, etc. If, on the other hand the "origin" is a genuine date, say the founding of Rome, or the accession of Alexander, we shall have a style of dating all of whose dates are of the type, e.g two hundred and fifty years 'ab urbe condita'.' [63, p. 79]

28 Truls Wyller [78] [76] [77] [79] agrees that localisations like 'X years before the birth of Christ' are only apparently indicator-free [76, p. 74]. He is very explicit about the need for an indexical anchor: 'The reference to the earthquake in San Francisco is only a help for temporal localisation if I know when the earthquake did take place. This knowledge can't consist of further references to 'objective' circumstances. In order for me to know when a certain event took place, such reference-chains must have an indexical anchor somewhere. [. . .] The same thing holds for conventional systems of dates, like the reference to the birth of Christ. This birth can only be used for temporal localisation, as such as it today marks a time point so and so many years ago.' (Translation FF. [76, p. 74]. Albeit Wyller uses this in an argument for an different, more radical, conclusion: He argues for transcendental idealism. 'In transcendental idealism, space and time are held to be nothing but forms of human experience. Accordingly, without the existence, somewhere in the universe, of human beings, there would be no space and time' [77, p. 325].

29 Truls Wyller agrees with this and may even go one step further, since he claims that empirical events are only locations if they are embedded into an indexical frame of reference: 'Ihren Status als Lokalisationen gewinnen empirische Ereignisse allerdings erst durch ihre Eingliederung in ein indexikalisches Bezugssystem' [76, p. 74].

30 For the identification of B-time with time order, see [37] in this volume.

31 [16, p.40] translation by FF. The German original is: 'Wir kennen keinen Anfangspunkt der Zeitreihe. Es muß daher ein willkürlich gewählter Zeitpunkt als

Nullpunkt der Zeitskala festgesetzt werden, wie es in den verschiedenen Kalendersystemen geschieht (Anfangsjahr; Anfangstag des Jahres).'

32 The existence of tensed facts is not to be equated with presentism. According to presentism, the present is privileged in the strongest way possible, since 'only currently existing objects are real' [73, p. 11]. Kit Fine however argues that 'it may be allowed that there are tensed facts (or the like) but denied that the present time is in any way privileged.' [34, p. 262], i.e. that there are tensed facts without presentism.

33 I do not claim that all facts are tensed. Perhaps mathematical statements need tenseless facts as truthmakers. I just want to argue that not all tensed sentences can have tenseless truthmakers.

Florian Fischer
University of Bonn
Institut für Philosophie
Am Hof 3 - 5
53113 Bonn
<fischerf@uni-bonn.de>
<http://science-of-deduction.de>

References

[1]   Holger Andreas. *Carnaps Wissenschaftslogik*. Paderborn: Mentis, 2007.

[2]   A. J. Ayer. *Logical Positivism*. Free Press Paperback. New York: Free Press, 1966.

[3]   A. J. Ayer. *The Foundations of Empirical Knowledge*. London: Macmillan, 1940.

[4]   Yehoshua Bar-Hillel. "Indexical Expressions". In: *Mind* 63.251 (1954), pp. 359–379.

[5]   Yehoshua Bar-Hillel. "Remarks on Carnap's Logical Syntax of Language". In: *The Philosophy of Rudolf Carnap*. Chicago, La Salle: Open Court, 1963, pp. 519–543.

[6]   Jiri Benovsky. "Four-Dimensionalism and Modal Perdurants". In: *Topics on General and Formal Ontology*. Ed. by Paolo Valore. Polimetrica International Scientific Publisher, 2006, p. 137.

[7] Laurence BonJour. "Epistemological Problems of Perception". In: *The Stanford Encyclopedia of Philosophy*. Ed. by Edward N. Zalta. Spring 2016. 2016.

[8] Thomas Bonk. *Language, Truth and Knowledge. Contributions to the Philosophy of Rudolf Carnap*. Dordrecht, Boston, London: Kluwer Academic Publishers, 2003.

[9] David Braun. "Indexicals". In: *The Stanford Encyclopedia of Philosophy*. Ed. by Edward N. Zalta. Spring 2015. 2015.

[10] C. D. Broad. *Scientific Thought*. Abingdon-on-Thames: Routledge and Kegan Paul, 1923, pp. 406–411.

[11] Rudolf Carnap. *An Introduction to the Philosophy of Science*. Mineola, New York: Dover Publications, 1995.

[12] Rudolf Carnap. *Der Logische Aufbau der Welt*. Hamburg: Meiner Verlag, 1928.

[13] Rudolf Carnap. "Der Raum: Ein Beitrag zur Wissenschaftslehre". In: *Kant-Studien* 56 (1922).

[14] Rudolf Carnap. "Intellectual Autobiography". In: *The Philosophy of Rudolf Carnap*. Ed. by Paul Arthur Schilpp. Chicago, La Salle: Open Court, 1963.

[15] Rudolf Carnap. *Introduction to Semantics (Studies in Semantics, vol. I)*. Cambridge: Harvard University Press, 1942.

[16] Rudolf Carnap. *Physikalische Begriffsbildung*. Wissen und Wirken. Karlsruhe: G. Braun, 1926.

[17] Rudolf Carnap. "Testability and Meaning". In: *Philosophy of Science* 3.4 (1936), pp. 419–471.

[18] Rudolf Carnap. "Testability and Meaning (Part 2)". In: *Philosophy of Science* 4.4 (1937), pp. 1–40.

[19] Rudolf Carnap. "The Elimination of Metaphysics Through Logical Analysis of Language". In: *Logical Empiricism at Its Peak: Schlick, Carnap, and Neurath*. Ed. by Sahotra Sarkar. Vol. 2. New York: Garland Publishing, 1996, pp. 10–31.

[20] Rudolf Carnap. "The Logical Foundations of Probability". In: *Journal of Philosophy* 60.13 (1963), pp. 362–364.

[21] Rudolf Carnap. *The Logical Structure of the World*. Chicago, La Salle: Open Court, 1969.

[22] Rudolf Carnap. *The Logical Syntax of Language*. London: K. Paul, Trench, Trubner & Co., Ltd., 1937, pp. 303–304.

[23] Rudolf Carnap. "Truth and Confirmation". In: *Readings in Philosophical Analysis*. Ed. by Herbert Feigl and Wilfred Sellars. Des Moines: Appleton-Century-Crofts, 1949, pp. 119–127.

[24] Rudolf Carnap. "Über die Abhängigkeit der Eigenschaften des Raumes von denen der Zeit". In: *Kant-Studien* 30.1-2 (1925), pp. 331–345.

[25] Rudolf Carnap. "Über Protokollsätze". In: *Erkenntnis* 3.1 (1932), pp. 215–228.

[26] Rudolf Carnap. "Wahrheit und Bewährung". In: *Actes du Congrès International de Philosophie Scientifique* (1936), pp. 18–23.

[27] Rudolf Carnap and Martin Gardner. *Philosophical Foundations of Physics*. Vol. 966. New York: Basic Books, 1966.

[28] David John Chalmers, David Manley, and Ryan Wasserman. *Metametaphysics: New Essays on the Foundations of Ontology*. Oxford: Oxford University Press, 2009.

[29] William Lane Craig. *The Tensed Theory of Time: A Critical Examination*. Dordrecht, Boston, London: Kluwer Academic Publishers, 2000.

[30] Richard Creath. "Logical Empiricism". In: *The Stanford Encyclopedia of Philosophy*. Ed. by Edward N. Zalta. Spring 2014. 2014.

[31] Janet Farrell-Smith. "Russell on Indexicals and Scientific Knowledge". In: *Rereading Russell: Essays on Metaphysics and Epistemology*. Ed. by C. Savage and C. A. Anderson. Minneapolis: University of Minnesota Press, 1989, pp. 119–137.

[32] Uljana Feest. "Science and Experience / Science of Experience. Gestalt Psychologie and the Anti-Metaphysical Project of the Aufbau". In: *Perspectives on Science* 5 (2006), pp. 1–25.

[33] J. N. Findlay. "Time: A Treatment of Some Puzzles". In: *Australasian Journal of Philosophy* 19.3 (1941), pp. 216–235.

[34] Kit Fine. "Tense and Reality". In: *Modality and Tense*. Oxford: Oxford University Press, 2006.

[35] Gottlob Frege. "Der Gedanke". In: *Logische Untersuchungen*. Ed. by Günther Patzig. Göttingen: Vandenhoeck, 1918, pp. 30–53.

[36] Gottlob Frege. "The Thought: A Logical Inquiry". In: *Mind* 65.256 (1956). Ed. by Peter Geach, pp. 289–311.

[37] Cord Friebe. "Time Order, Time Direction, and the Presentist's View on Spacetime". In: *Kriterion* (2016).

[38] Cord Friebe. *Zeit – Wirklichkeit – Persistenz. Eine präsentistische Deutung der Raumzeit.* Paderborn: Mentis, 2012.

[39] Akiko M. Frischhut. "What Experience Cannot Teach Us About Time". In: *Topoi* (2013).

[40] Antony Galton. *The Logic of Aspect: An Axiomatic Approach.* Oxford: Clarendon Press, 1984.

[41] Aleksandar Jokic and Quentin Smith, eds. *Time, Tense, and Reference.* A Bradford Book, 2003.

[42] Jaegwon Kim and Ernest Sosa, eds. *A Companion to Metaphysics.* Blackwell Companions to Philosophy. Oxford, Cambridge, Massachusetts: Blackwell, 1995.

[43] Lothar Krauth. *Die Philosophie Carnaps.* Library of Exact Philosophy 1. Luxemburg: Springer, 1970.

[44] Theo A. F. Kuipers. *Handbook of the Philosophy of Science. General Philosophy of Science – Focal Issues.* Amsterdam: Elsevier, 2007.

[45] James Ladyman. "Ontological, Epistemological and Methodological Positions". In: *General Philosophy of Science.* Ed. by Theo A. F. Kuipers. North Holland, 2007, pp. 303–376.

[46] Peter Ludlow. "Tense". In: *The Oxford Handbook of Philosophy of Language.* Ed. by Ernest Lepore and Barry Smith. Oxford: Oxford University Press, 2006, pp. 689–715.

[47] Barbara MacKinnon. *American Philosophy: A Historical Anthology.* Albany: State University of New York Press, 1985, pp. 219–225.

[48] Ulrich Majer. "Carnaps Übernahme der Gestalttheorie in den Aufbau im Lichte heutiger, vor allem computationaler Theorien des Sehens". In: *Language, Truth and Knowledge: Contributions to the Philosophy of Rudolf Carnap.* Ed. by Thomas Bonk. Alphen aan den Rijn: Kluwer Academic Publishers, 2003, pp. 65–73.

[49] David Hugh Mellor. *Real Time.* Cambridge: Cambridge University Press, 1985.

[50] David Hugh Mellor. *Real Time II.* London: Routledge, 1998.

[51] Thomas Müller. *Arthur Priors Zeitlogik: Eine problemorientierte Darstellung.* Paderborn: Mentis, 2002.

[52] Thomas Müller, ed. *Philosophie der Zeit: Neue analytische Ansätze*. Klostermann, 2007.

[53] Otto Neurath. "Protokollsätze". In: *Erkenntnis* 3.1 (1932), pp. 204–214.

[54] Otto Neurath. "Radikaler Physikalismus und wirkliche Welt". In: *Erkenntnis* 4.1 (1934), pp. 346–362.

[55] Ilkka Niiniluoto. "Carnap on Truth". In: *Language, Truth and Knowledge: Contributions to the Philosophy of Rudolf Carnap*. Ed. by Thomas Bonk. Alphen aan den Rijn: Kluwer Academic Publishers, 2003, pp. 65–73.

[56] Nathan L. Oaklander and Quentin Smith, eds. *The New Theory of Time*. New Haven: Yale University Press, 1994.

[57] Arthur Pap. "Reduction Sentences and Disposition Concepts". In: *The Philosophy of Rudolf Carnap*. Ed. by Paul Arthur Schilpp. Chicago, La Salle: Open Court, 1963.

[58] John Perry. "The Problem of the Essential Indexical". In: *Nous* (1979), pp. 3–21.

[59] Arthur N. Prior. "On the Unity of Professor Carnap". In: *Mind* 73.290 (1964), pp. 268–269.

[60] Arthur N. Prior. "Thank Goodness That's Over". In: *Philosophy* 20 (1959), p. 17.

[61] Arthur N. Prior. *Time and Modality*. Santa Barbara: Greenwood Press, 1955.

[62] Willard Van Orman Quine. *Word & Object*. The MIT Press, 1960.

[63] Nicholas Rescher. "On the Logic of Chronological Propositions". In: *Mind* 75.297 (1966), pp. 75–96.

[64] Sebastian Rödl. *Kategorien des Zeitlichen: Eine Untersuchung der Formen des endlichen Verstandes*. Frankfurt am Main: Suhrkamp, 2005.

[65] Edmund Runggaldier. *Carnap's Early Conventionalism*. Studien zur österreichischen Philosophie 7. Amsterdam: Rodopi, 1984.

[66] Bertrand Russell. *An Inquiry into Meaning and Truth*. London: Allen & Unwin, 1950.

[67] Bertrand Russell. *Human Knowledge: Its Scope and its Limits*. New York: Simon & Schuster, 1948.

[68]   Sahotra Sarkar and Jessica Pfeifer. *The Philosophy of Science: An Encyclopedia*. London: Routledge, 2006.

[69]   Thomas Sattig. *The Language and Reality of Time*. Oxford: Clarendon Press, 2006.

[70]   Paul Arthur Schilpp. *The Philosophy of Rudolf Carnap*. Chicago, La Salle: Open Court, 1963.

[71]   Moritz Schlick. "Über das Fundament der Erkenntnis". In: *Erkenntnis* 4.1 (1934), pp. 79–99.

[72]   Carsten Seck. *Theorien und Tatsachen: Eine Untersuchung zur wissenschaftstheoriegeschichtlichen Charakteristik der theoretischen Philosophie des frühen Moritz Schlick*. Paderborn: Mentis, 2008.

[73]   Theodore Sider. *Four Dimensionalism: An Ontology of Persistence and Time*. Oxford: Oxford University Press, 2001.

[74]   Michael Stöltzner and Thomas Uebel. *Wiener Kreis: Texte zur wissenschaftlichen Weltauffassung von Rudolf Carnap, Otto Neurath, Moritz Schlick, Philipp Frank, Hans Hahn, Karl Menger, Edgar Zilsel und Gustav Bergmann*. Vol. 577. Hamburg: Meiner Verlag, 2009.

[75]   Thomas Uebel. *Empiricism at the Crossroads: The Vienna Circle's Protocol-Sentece Debate*. Chicago, La Salle: Open Court, 2007.

[76]   Truls Wyller. "Die Alternativ- und Perspektivlosigkeit der indexikalischen Zeit". In: *Philosophie der Zeit: Neue analytische Ansätze*. Ed. by Thomas Müller. Frankfurt am Main: Klostermann, 2007.

[77]   Truls Wyller. "How Big? How Fast? Transcendental Reflections on Space, Time and World Models". In: *Philosophy* 84.3 (2009), pp. 325–339.

[78]   Truls Wyller. "Indexikalität und empirische Objektivität". In: *Zeitschrift für philosophische Forschung* 49.4 (1995), pp. 553–570.

[79]   Truls Wyller. *The Size of Things: An Essay on Space and Time*. Paderborn: Mentis, 2010.