Arthur Prior Centenary Conference
Balliol College, Oxford, 21 – 22 August, 2014
Temporal logicand Occurrence Logic. Some Remarks in Honour of A N Prior
by Hans Götzsche, Aalborg University

Abstract

Introduction

In my presentation I attempt to sketch out how the tense logic developed and elaborated by A. N. Prior can be perceived and utilised by an alternative approach to the question of how time is logically conceptualised by human beings. I start out with a few epistemological contemplations about the notion of 'time', then I test the idea that tense logic can, somehow, be seen in parallel, or maybe merged, with the kind of logic invented by me: Occurrence Logic (see Götzsche 2013), and my main reference to tense-logic is Prior's seminal chapter 'Precursors of Tense-Logic' in Prior (1967).

'Time'

I am fully aware of the fact that the concept of 'time' has been debated for millenia – and I shall not attempt to try to solve the problem and answer the question: what is time? – but, anyhow, I would like to offer some fundamental deliberations. When doing this, I shall not take any stance in the debate concerning the standard view on the problem:

> All agree that space and time differ in their dimensionality, and all agree, even in a relativistic context, that the temporality of the world is not a spatial dimension.
> (SREP p. 1019)

I shall only point to the option that what we call time can be conceptualised by an alternative kind of logic. So, from the tradition I would like to pick up a few noteworthy formulations concerning time:

> La nozione della successione produce quella del *tempo*, il qual non è che una successione continua di momenti
> 'the notion of succession produces that of *time*, which is nothing but a continuous succession of moments'
> (Soave 1804 p. 212)

We may not know what 'moments' are, but the meaning of the phrase assumes that 'time' is an effect of something else, and not *vice versa*. Immanuel Kant has it that

> Die Zeit ist kein diskursiver, oder wie man ihn nennt, allgemeiner Begriff, sondern eine reine Form der Sinnlichen Anschauung.
> (Kant 1781 (1924) p.104)

meaning that 'time' is no entity in an ontological sense but a 'pure perceptual form [produced by] the senses'. In a modern context one seems to be presented with a combination of the Italian and the German approach:

> DEFINITION 2.1 (flow of time). A (discrete) *flow of time* $(T, <)$ is a pair consisting of a non-empty set T of time points, and a binary relation $<$ on $T \times T$, called the *immediate successor relation* that is irreflexive, antisymmetric and antitransitive.
> (Engelfriet and Treur 2002 p. 391)

Apparently the authors assume (like Kant) that 'time' is a mental entity, viz. a set (*T*) and a set-theoretical 'binary relation', and (like Soave) that 'time' is organised as successions of something. Whether 'time points' are equivalent to 'moments' we do not know. If one accepts the idea that we may neither be able to know what 'time' is 'out there' we may, on the other hand, relate our notion of 'time' to 'things':

Things somehow persist through time.
(Lewis 2002 p. 1)

I shall not go into the details of Lewis's approach, only point to the fact that he apparently assumes the existence of 'time' as something that things 'persist through'. Instead I would like to turn the issue on its head: the problem is not that, seemingly, things persist through time but how we can know for sure that time has passed if things persist. Therefore, in Lewis's context, the crucial question is: has time passed when things do not persist, ie. when they change. But then we are back at the standard view, viz. 'the temporality of the world is not a spatial dimension', and in this context I do not want to make any ontological (or metaphysical) claims. But if we assume a purely logical view a few observations may be appropriate.

Assume we had no time measurement devices, how could we know (logically) that time has passed? Then, accept a few stipulations:

- What is in logic and epistemology often called 'states of affairs' of the real world (whatever that is) could be called LOCAL UNIVERSES (LUs).
- LUs are made of ENTITIES and PROPERTIES (E&Ps) and can be represented by coordinate systems of some kind, which might, hypothetically, be seen as spatial systems.
- (In due course (at least aspects of) LUs must be assumed to be represented in the minds of human beings, and these representations can be called MENTAL UNIVERSES (MUs) processed by the brain's memory functions, MEMORY (of an individual) understood as ACCUMULATED EXPERIENCE. But this is not relevant for the logical line of reasoning.)

If this conceptual framework is accepted the question above about time can be rephrased: assume two LUs, LU_1 and LU_2 (for convenience two static scenarios like 'the glass is [not] on the table'), how can we know that the difference between them is time? We know that if LU_1 and LU_2 are SIMILAR (or IDENTICAL, ie. incorporate the same E&Ps) to each other then we will not be able to tell the difference, not even a 'time' difference. We also know that if LU_1 and LU_2 are DISSIMILAR (having different E&Ps) we will still not be able to tell the 'time difference' (for instance as 'before' and 'after') unless the occurrence of entities and/or properties in at least one of them indicates STRUCTURAL RELATIONS (e.g. causal relations, whatever that is) between the two LUs. If in LU_1 'the glass is not on the table' and in LU_2 'the glass is on the table' the E&P-difference indicates that somebody has put the glass on the table, or taken it away, and maybe other clues indicate which scenario is the most probable. In any case the logical relationships between different occurrences of entites and/or properties can be expressed by what I call an OCCURRENCE LOGIC (Occ Log).

A Logic of Occurrence

In general the vocabulary and the rules of the combinatorial system introduced in Götzsche (2013) under the label EFA(X)3 correspond to, and are in accordance with, some truth-functional relations established in traditional symbolic logic, but the basic idea in Occ Log is that we can do without truth-functions. As is well known one of the predicaments of theories of time is the fact that we cannot determine the truth-value of propositions about the future, and that the truth-value of propositions about the past may be rather intricate. Instead I would like to propose the idea that one

could develop a logic (as a basis of a formal (combinatorial) system) the capability of which is to represent the occurrence of things and their interrelations.

The occurrence of entities may be represented by, for instance, a rule expressed in EFA(X)3 by the formula z > y (y occurs *in case and only in case* z occurs) in the combinatorial system, and the formal system is, in due course, based on a certain kind of logic (an Occurrence Logic) expressed in a format like this:

z °> y, y occ *icc* z occ[1] (i.e. y occurs *in case and only in case* z occurs)[2]

In this format it has been utilised for developing the combinatorial system mentioned above and used for Natural Language syntactic analysis only and, following the rule, one is allowed to infer from the occurrence of the linguistic expression y to the occurrence of the linguistic expression z (but not the other way around). The Occ Log z °> y expression has, so far without any reference to formal logic, been labelled Strong Implication. It should be noted that z and y are not propositions but symbols (representing linguistic items in the EFA(X)3 system for syntactic analysis implemented in Götzsche (2013)), which either are present (occur) or are absent in certain functions in the formal system according to the rule combining the symbols. So the formula does not by itself express any kind of propositional (truth-value) semantics. In linguistics, what I needed was a symbolism that could express the fact that an item, say y, would only occur (be present, appear) in case another item, say z, occurred (was present, appeared), and I chose the Occ Log expression z °> y and the EFA(X)3 expression z > y as part of actual syntactic calculuses.

Prior's ''Precursors of Tense-Logic'' (in Prior 1967)

In his 1967 chapter 'Precursors of Tense-Logic' Prior discusses both Findlay's and McTaggart's contributions to tense logic and I shall take up two essential topics. A basic question seems to be whether the so-called temporal A-series or the B-series can be derived from each other. What I will emphasize is the fact that the word *change* is found a (fairly high) number of times, both in quotations and in Prior's own formulations. In accordance with my thoughts on the notion of 'time' above I shall propose that the notion of 'change' (even though it is controversial in the standard view on time) is made the point of departure when considering the potential for relating tense logic and Occ Log. Thus I take it for granted that the following statement stands for Prior's own view:

> One might answer, I suppose, that the word 'change' is defined precisely in terms of differences in truth-value between propositions which mention different positions in the B-series, and not ... in any other series.
> (Prior 'Precursors, … ' (in Prior 1967) pp. 3-4)

The problem inherent here is the fact that the notion of 'change' by definition presupposes the notion of 'time' (B-series), but, as pointed to in the 'Time' section above this is hardly conclusive; and a solution to the problem may not be a matter of truth-values. Instead CHANGE may reasonably be defined as

- the dissimilarity between (at least) two LUs: in case, and only in case, LU_z differs from LU_y regarding some but not all E&Ps one of them can, potentially, be said to be a change of the other.

[1] The symbol '°' in combination with Occ Log operators, and with traditional logic operators, denote the Occ Log functions of the operator (connective) in question.
[2] The expression 'in case' does not imply any kind of propositional (truth-value) context like 'it is the case that … ' or 'it is true that … '. It only has to do with whether items actually occur or not.

In the real world we may assume that there is a STRUCTURAL RELATION between them indicating what effected what, but in a logical context if the rule z °> y applies one can justifiably say that one of them occur BEFORE the other, which then occurred AFTER the first one.

The reason is that if one is licensed to establish a rule saying that an event, y (as part of LUy), takes place in case and only in case another event, z (as part of LUz), takes place, then it follows (by necessity) that z took place before y and that y took place after z (in a timeframe understanding: the time of LUz precedes the time of LUy). At least according to the natural laws of the known universe.

In a scenario saying that

the car hit the pedestrian (event z)
the pedestrian died at the hospital (event y)

then, provided the two tokens of the expression *the predestrian* are co-referential and the rule applies (viz. event y takes place *in case and only in case* event z takes place) one will need no notion of causation or any other 'extra relation' in order to claim that event z took place before event y – unless one is in favour of some kind of backwards causation; which some philosophers are, but not this philosopher. Actually nothing is said about the cause of the pedestrian's death – he may have died from cancer – only that, if the rule applies the pedestrian would not have died at hospital had he not been hit by the car.

The same line of reasoning can be applied to two states instead of two events.

So, we end up with something that looks very much like a B-series' 'earlier' and 'later', and it can, of course, be subjected to formal analysis; which is beyond the scope of this presentation.

But it means that an elaborated Occurrence Logic may express the same logical structures as tense logic, and the future task will be to test to what extent the formalisms of tense logic may be substituted by Occurence Logic formalisms.

Preliminary References

Apresjan, Valentina: 'The "Russian" attitude to time', in Filipović, Luna & Kasia M Jaszzolt (2012), *Space and Time in Languages and Cultures. Language, culture and cognition*. John Benjamins Publishing Company: Amsterdam / Philadelphia. (B), pp. 103-120.

Chan, Ho Leung, Jessica Finberg, Willie Costello & Yasuhiro Shirai: 'L2 acquisition of tense-aspect morphology', in Filipović, Luna & Kasia M Jaszzolt (2012), *Space and Time in Languages and Cultures. Linguistic diversity*. John Benjamins Publishing Company: Amsterdam / Philadelphia. (A), pp. 181-205.

Engelfriet, Joeri and Jan Treur (2002): 'Linear Brancing Time and Joint Closure Semantics for Temporal Logic', in *Journal of Logic, Language and Information*, Volume 11, No. 4, Autumn 2002.

Filipović, Luna & Kasia M Jaszczolt (2012): *Space and Time in Languages and Cultures. Linguistic diversity*. John Benjamins Publishing Company: Amsterdam / Philadelphia. (A)

Filipović, Luna & Kasia M Jaszczolt (2012): *Space and Time in Languages and Cultures. Language, culture and cognition*. John Benjamins Publishing Company: Amsterdam / Philadelphia. (B)

Götzsche, Hans (2013): *Deviational Syntactic Structures*. London / New Delhi / New York / Sydney: Bloomsbury Academic.

Jacquette, D. (ed.) 2002: *A Companion to Philosophical Logic*. Oxford: Blackwell Publishing.

Kant, I. 1781 (imprint of the 1924 edt.) : *Kritik der Reinen Vernunft*. Wiesbaden: VMA-Verlag.
Lewis, David (1973): *Counterfactuals* Oxford: Blackwell Publishing.

Lewis, David (2002): 'Tensing the copula', in *MIND*, Volume 111, Number 441, January 2002.

Lucas, John Randolph (1989): *The Future*. Oxford: Basil Blackwell.

Prior, Arthur N. (1955 (1963)): *Formal Logic*. Oxford: The Clarendon Press (Oxford University Press).

Prior, Arthur N. (1957): *Time and Modality*. London: The Clarendon Press.

Prior, Arthur N (1967): *Past, Present and Future*. Oxford.

Prior, Arthus N. (1976): *Papers in Logic and Ethics*. London: Duckworth.

the shorter routledge encyclopedia of philosophy (SREP), Routledge (2005).

Soave, Francesco (1804): *Istituzioni di logica, metafisica ed etica, Volume II*. Pavia: Nella Stamperia degli Eredi Di Pietro Galeazzi.

Wallington, Alan (2012): 'Back to the future', in Filipović, Luna & Kasia M Jaszzolt (2012), *Space and Time in Languages and Cultures. Language, culture and cognition*. John Benjamins Publishing Company: Amsterdam / Philadelphia. (B), pp. 83-99.

Warmelink, Lara, Aldert Vrij, Samantha Mann & Pär Anders Granhag: 'Spatial and Temporal Details and Intentions: A Cue to Detecting Deception', in *Applied Cognitive Psychology* 27 pp. 101-106.

Øhrstrøm, Peter & Per Hasle (1995): *Temporal Logic*. Dordrecht /Boston / London: Kluwer Academic Publishers.