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Specification of Tenses in Tichý's Transparent Intensional Logic and Prior's Temporal Logic

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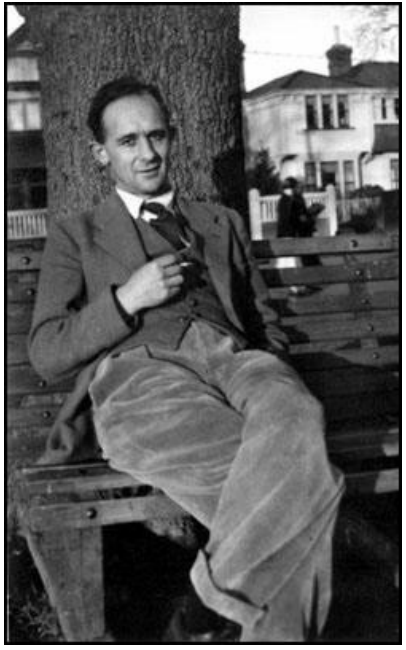

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the structure of the presentation

1. specification of tenses in Tichý's TIL
2. specification of tenses in Prior's Hybrid Temporal Logic
3. comparison of Tichý and Prior's approach

specification of tenses in Tichý's TIL

- 'The Logic of Temporal Discourse' (1980)
- Tichý in his paper argued that logics of tenses were still at the starting line of their development
  1. the systems of logic that dealt with tenses lacked, an adequate theory of truth-conditions for temporal propositions
  2. the logical type of these propositions was not satisfactorily defined
  3. temporal operators, e.g., 'P' were not sufficient to differentiate between semantical differences in various tenses in English, as e.g., the Past Simple and the Present Perfect
     - *Nick was happy*.
     - *Nick has been happy*.

Transparent Intensional Logic

- *universes of discourses* are collections of individuals, and *intensional bases*, which are collections of attributes that individuals could obtain
- universe of discourse and intensional base form *epistemic framework* on which the language is built
- the distribution of attributes could change in time, hence the obtaining and losing of attributes creates different *histories*
- the possession of different attributes of objects creates different *possible worlds*

Transparent Intensional Logic

- TIL is a typed calculus, it constructs elaborate objects from the basic ones
- There are four basic types of objects in TIL:
  - the class of truth-values **‘o’**, which contains two elements – truth and falsehood
  - the universe of discourse **‘ι’**, which is the class that contains individuals
  - the logical space **‘ω’**, which is the class that contains possible worlds
  - the time-scale **‘τ’** that contains moments of time, as the moments could be represented by real numbers, ‘τ’ is a class of real numbers

Transparent Intensional Logic

- propositions are objects of type ‘(oτ)ω’
- the proposition:

  Nick is happy.
- represents the construction:

  $\lambda w \lambda t \cdot [H_{wt}] X$
- ‘X’ stands for ‘Nick’, ‘H’ for ‘happiness’ and the operators and variables are of the type: w/ω, t/τ, H/(((oι)τ)ω), X/ι.

specification of tenses in Tichý's TIL – Past Tense

- definition of the operator for the Past Simple 'P':
  - $P_t sc \Leftrightarrow_{df} (\imath i)\cdot(\exists t_l)[ct_l \wedge \cdot t_l < t] \wedge i = \cdot s\lambda t_l \cdot ct_1 \wedge \cdot t_1 < t$
- it corresponds with the truth conditions for the propositions in the Past Simple
- its type in TIL is $(o(o(o\tau))(o\tau))\tau$

specification of tenses in Tichý's TIL – Past Tense

- *Nick was happy on Christmas Eve 2021.*
  - $\lambda w\, \lambda t \cdot P_t[Onc_w\, \lambda w\, \lambda t\, H_{wt} X]\, \lambda t \cdot t = T^0$
- *Nick was happy throughout 2019.*
  - $\lambda w\, \lambda t \cdot P_t[Thr_w\, \lambda w\, \lambda t\, H_{wt} X]\, C^{2019}$
- *Nick was happy when Bill was sad.*
  - $\lambda w\, \lambda t \cdot P_t[Onc_w\, \lambda w\, \lambda t\, H_{wt} X]\, \lambda t_1 \cdot P_t[Onc_w\, \lambda w\, \lambda t\, S_{wt}\, Y]\{t_1\}$

specification of tenses in Tichý's TIL – Past Tense

- the definition of the operator 'Pf' for the Present Perfect is:
  - $Pf_t sc \Leftrightarrow_{df} (\imath i)\cdot(\exists t_l)[\lambda t_2 \cdot t_l < t_2 \leq t] \subset c \wedge i = \cdot s\lambda t_2 \cdot ct_2 \wedge \cdot t_2 \leq t.$
- it also corresponds with the truth conditions for the propositions in the Present Perfect
- the operator 'Pf' is of the same type as the operator 'P', i.e. (o(o(oτ))(oτ))τ

specification of tenses in Tichý's TIL – Past Tense

- *Nick was happy ever since 2022.*
  - $\lambda w \lambda t \cdot Pf_t[Thr_w\ \lambda w \lambda t\ H_{wt}X]\ \lambda t \cdot Aft_t C^{2022}$

- *Nick was not happy since Christmas Eve in 2021.*
  - $\lambda w \lambda t\ Pf_t\ [Thr_w\ \lambda w \lambda t\ \neg\ H_{wt}X]\ \lambda t \cdot Aft_t = T^0$

specification of tenses in Prior's Hybrid Temporal Logic

- Prior sparsely discussed specification of tenses in his work
- development of the system was not driven by Prior's aim to specify tenses
- introducing hybrid logic Prior concerns metaphysical issues
  - presentism
  - nominalism

specification of tenses in Prior's Hybrid Temporal Logic

A-series

- unary operators P, F, G, H
- variables *p, q, r,…* stand for propositions
- Pp – It was the case that *p*

B-series

- binary operator 'U'
- variables *a, b, c, …* stand for time instants (or possible worlds)
- Uab - the time instant *a* is earlier that the time instant *b*

specification of tenses in Prior's Hybrid Temporal Logic

- Prior linked the systems with a binary operator T that is defined as:
  - Uab $\Leftrightarrow_{df}$ TbPa
- Ta(p) – 'it is the case at the instant *a* that *p*'
- variables *a, b, c…* are understood as instant propositions, they represent a cojunct of propositions that is true in precisely one instant of time
  - counterpart of nominals in contemporary hybrid logic
- Prior derived them from Meredith's constant *n* for contingent truth

specification of tenses in Prior's Hybrid Temporal Logic

- Prior also replaced variables for instant propositions with operator 'Q'
  - $Qp \Leftrightarrow_{df} \Diamond p \wedge \forall q\, [\blacksquare(p \rightarrow q) \vee \blacksquare(p \rightarrow \neg q)]$
- the constant *n* corresponds Wp and is defined as:
  - $Wp \Leftrightarrow_{df} p \wedge Qp$
  - $Wp \Leftrightarrow_{df} p \wedge \forall q\, [q \rightarrow \blacksquare(p \rightarrow q)]$

specification of tenses in Prior's Hybrid Temporal Logic

- *Nick was happy on Christmas Eve 2021.*
  - $P(a \wedge p)$

- *Nick was happy throughout 2019.*
  - $P(a \wedge p) \wedge P(b \wedge \neg p) \wedge \forall c[(TaFc \wedge TcFb) \rightarrow (c \wedge p)]$

- *Nick was happy when Bill was sad.*
  - $P(a \wedge p) \wedge P(a \wedge q)$

specification of tenses in Prior's Hybrid Temporal Logic

- *Nick was happy ever since 2022.*
  - $P(a \wedge p) \rightarrow \forall b[TaFb \rightarrow (b \wedge p)]$

- *Nick was not happy since Christmas Eve in 2021.*
  - $P(a \wedge p) \wedge \forall b[TaFb \rightarrow (b \wedge \neg p)]$

comparison of Tichý and Prior's approach

Tichý

Nick was happy on Christmas Eve 2021.

$\lambda w\, \lambda t{\cdot}P_t[Onc_w\, \lambda w\, \lambda t\, H_{wt}X]\, \lambda t{\cdot}t = T^0$

Nick was happy throughout 2019.

$\lambda w\, \lambda t{\cdot}P_t[Thr_w\, \lambda w\, \lambda t\, H_{wt}X]C^{2019}$

Nick was happy ever since 2022.

$\lambda w\, \lambda t{\cdot}Pf_t[Thr_w\, \lambda w\, \lambda t\, D_{wt}X]\, \lambda t{\cdot}Aft_tC^{2022}$

Prior

Nick was happy on Christmas Eve 2021.

- $P(a \wedge p)$

Nick was happy throughout 2019.

- $P(a \wedge p) \wedge P(b \wedge \neg p) \wedge \forall c[(TaFc \wedge TcFb) \rightarrow (c \wedge p)]$

Nick was happy ever since 2022.

- $P(a \wedge p) \rightarrow \forall b[TaFb \rightarrow (b \wedge p)]$

comparison of Tichý and Prior's approach

Tichý

- Tichý's formalisation is more dependent on each natural language
- propositions do not have truth-value if they do not fulfil presuppositions

Prior

- Prior aimed to develop a system that would be suitable for formalisation, regardless of the natural language
- Prior's systems are influenced by his metaphysical views

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