A Compositional Situation Semantics for Attitude Reports*

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1 Introduction

There is agreement among a number of researchers that the attitudes should be analyzed in terms of structured objects which are fine-grained enough to prevent some of the troublesome inferences that arise from the classical possible worlds approach as represented by Montague (1971 [PTQ]). It seems to us that the approach developed in Barwise and Perry (1983,1985) is essentially similar in important respects to that developed within DRT[1] (Kamp, Asher, Zeevat) and also to that developed in the philosophical literature by Crimmins, Forbes, Richard. While, of course, there are differences in the various proposals (see, for example, the recent debate in *Linguistics and Philosophy* between Crimmins, Richard and Saul) there is something that all these approaches have in common: namely a concern with a structured analysis of mental states.

In this paper we shall (in section 2) recast Barwise and Perry's (1983, 1985) original ideas using the kind of situation theory developed in Barwise and Cooper(1991, 1993). In section 3 we address the issue of defining a compositional fragment for the attitudes on the basis of the fragment defined in appendix 4. In an extended version of this paper, we will illustrate the account in greater detail and discuss the predictions concerning the fine grain of belief reports and show how to deal with embedded beliefs and quantifier scoping.

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[1]For discussion see Cooper's paper in this volume.

2 Mental States

2.1 Preliminary assumptions

A number of people have presented a triadic theory of belief, that is, one that treats belief not as a relation between agents and propositions but as a relation between an agent and two arguments in place of the proposition. The variant we present here is a reconstruction and elaboration of a variant of the triadic view presented by Barwise and Perry (1983,1985).

Ignoring the time argument, the standard Fregean view of the attitudes is "dyadic", i.e. attitude relations are seen as a relation between agents and propositions:
$\alpha(a, p)$

The important part of the triadic theory we characterize here is the use of two arguments ty and f in place of a single propositional argument as in the standard Fregean theory of the attitudes. The idea is that the type ty classifies the internal state of the agent. It corresponds to what Barwise and Perry called a "frame of mind". It comes along with various roles which may be linked to the world external to the agent. As the assignment is only partial there may be certain roles in the internal state which are not linked to objects in the world. In the case where there is a complete assignment, however, the result of applying the ty to f gives us a proposition, the "content" of the mental state. The intuition is that this is the same proposition as would be given on the dyadic view. The relation is expressed below:
$\alpha(a, p)$
$\alpha(a, ty, f)$
$ty\ f = p$

Thus the object of belief on the dyadic view is what we would call the content, the result of merging the internal state with the way that internal state is associated with objects in the world.

We treat mental states as a particular subclass of situations. We present some axioms that might be included in a theory of mental states below. We define notions of *mental state*, *content*, *exportation* and, *rationality*, as well as allowing for the possibility that different attitudes might allow for different reasoning about mental states.

Mental state

1. A *mental state* is a situation ms such that a proposition of the following kind is true:

$$\boxed{\begin{array}{l} \boxed{ms} \\ \\ \alpha_1(a_1, ty_1, f_1, t_1) \\ \ldots \\ \alpha_n(a_n, ty_n, f_n, t_n) \end{array}}$$

where α_i are *internal* attitude relations corresponding to *believe, know, desire*, a_i are agents, ty_i are types (possibly zero-place, i.e. propositions), f_i are partial assignments appropriate to ty_i, and t_i are times.[2]

[2]The need for distinguishing between an *internal* attitude predicate and the attitude predicates used in attitude reports is discussed in section 3.

Content

2. Let $\exists^*\zeta$ be $(\zeta\ !\ \exists)$ if ζ is a type and ζ if ζ is a proposition. The α-*content* of a mental state, ms, in symbols $alpha$-content(ms) is

   $$\exists^*(ty_1\ f_1) \wedge \ldots \wedge \exists^*(ty_n\ f_n)$$

   where $ms \models \langle\!\langle \alpha, a_1, ty_1, f_1, t_1; 1\rangle\!\rangle$
   $\ldots$
   $ms \models \langle\!\langle \alpha, a_n, ty_n, f_n, t_n; 1\rangle\!\rangle$

   and there is no other infon σ with relation α such that $ms \models \sigma$

Exportation

3. If

   $$ms \models \alpha(a, \begin{array}{|l|}\hline \rho_1 \to X_1,\ \ldots,\ \ \rho_n \to X_n \\ \hline p(b) \\ \\ \hline \end{array}, f, t)$$

   then

   $$\exists r(ms \models \alpha(a, \begin{array}{|l|}\hline \rho \to X,\ \rho_1 \to X_1,\ \ldots,\ \ \rho_n \to X_n \\ \hline p(X) \\ \\ \hline \end{array},$$

   $$f \cup [\ \rho \to b],\ t))$$

Different logics for different attitudes

4. $ms \models \langle\!\langle \alpha, a, ty, f, t;\ 1\rangle\!\rangle$ and
   $ty \approx_\alpha ty'$
   implies
   $ms \models \langle\!\langle \alpha, a, ty', f, t;\ 1\rangle\!\rangle$

   For example, if a believes that the glass is half full we would probably want it to follow that a believes that the glass is half empty. However, if a is glad that the glass is half full it does not seem to follow that a is glad that the glass is half empty.

Rationality

5. If ms is rational then there is no infon $\sigma = \langle\!\langle \alpha, a, ty, f; 1\rangle\!\rangle$ such that $ms \models \sigma$ and ty is

   $$\begin{array}{|l||l|}\hline \multicolumn{2}{|c|}{\rho_1 \to X_1, \ldots, \rho_n \to X_n} \\ \hline \boxed{s} & \\ \sigma & \\ \overline{\sigma} & rest \\ \ldots & \\ \hline \end{array}, \quad \begin{array}{|l||l|}\hline \multicolumn{2}{|c|}{\rho_1 \to X_1, \ldots, \rho_n \to X_n} \\ \hline \begin{array}{|l|}\hline s \\ \hline \sigma \\ \hline \end{array} & \\ \begin{array}{|l|}\hline s \\ \hline \overline{\sigma} \\ \hline \end{array} & rest \\ \ldots & \\ \hline \end{array}, \quad \begin{array}{|l||l|}\hline \multicolumn{2}{|c|}{\rho_1 \to X_1, \ldots, \rho_n \to X_n} \\ \hline p & \\ \neg\, p & rest \\ \ldots & \\ \hline \end{array},$$

$$\begin{array}{|l||c|}\hline \multicolumn{2}{|c|}{\rho_1 \to X_1, \ldots, \rho_n \to X_n} \\ \hline X_i \neq X_i & \\ \ldots & \mathit{rest} \\ & \\ \hline \end{array}, \ldots.$$

2.2 Tackling the puzzles

Kripke (1979) contains the by now well worn puzzle about Pierre, who believes that London is ugly but Londres is beautiful. Kripke argues that on the basis of his behaviour as a French speaker we appear to conclude that Pierre believes the proposition that London is beautiful, while on the basis of his behaviour as an English speaker we conclude that he does not believe the proposition that London is beautiful. Kripke's Pierre has spawned a cottage industry of related puzzles (see below). If we make the distinction between internal and external aspects of the belief, this gives us a finer grain than just propositions. There can be several different *ty* and *f* such that the result of applying *ty* to *f* all yield the same proposition. Although various diagnoses have been made concerning such puzzles, we believe an important insight in this regard is Donnellan (1990), who argues that '[...] the puzzles are about what it is possible for someone to believe or disbelieve in a situation and not upon Kripke's principles about sentences which *express* beliefs or upon a principle about translation.' (Donellan 1990 p. 209). If this is correct, the current proposal is well placed to distinguish beliefs, since the technique employed, based on distinguishing between the restrictions of two given mental state types, is quite general and not restricted to linguistically based differentiation. (see e.g. Richard 1990).

We illustrate this by showing how to treat the Pierre puzzle in terms of mental states (using the situation theory and graphical notation developed in Barwise and Cooper, 1991, 1993).[3]

[3]Actually, this example is for a version of Pierre that concerns the issue of whether Nelson's Column is pretty or not, a version that is more plausibly treated as involving contradictory beliefs about a single situation than Kripke's original formulation.

Pierre

ms

believe(Pierre, $\rho_1 \to X,\ \rho_2 \to Y$

s

pretty(X)

r

see(Pierre,X, t')
in(X, Y, t')
travel-brochure(Y, t')
named(X,"Column de Nelson",t')

, $\begin{bmatrix}\rho_1 \to \text{Nelson's Column}\\ \rho_2 \to b\end{bmatrix}$, t)

believe(Pierre, $\rho_1 \to X,\ \rho_2 \to Y$

s

$\neg$ pretty(X)

r'

see(Pierre, X, t')
in(Pierre, Y, t')
named(X, "Nelson's Column",t')

, $\begin{bmatrix}\rho_1 \to \text{Nelson's Column}\\ \rho_2 \to \text{London}\end{bmatrix}$, t)

3 A compositional treatment

3.1 Bringing propositions back in

We have, then, two important tools for semantic analysis: propositions and mental states. However, as far as we are aware, there have been few if any attempts at incorporating mental states in a compositional semantics for a fragment that includes attitude reports. Indeed, Crimmins and Perry have expressed pessimism about the viability of such an attempt: 'Also closed is the prospect of a strictly compositional semantics for belief sentences. The semantic values of the subexpressions in a belief report, on our analysis, do not provide all the materials for the semantic value of the report itself.' (Crimmins and Perry, 1989 p. 24).

Here we attempt to dispell such pessimism, though, in fairness to Crimmins and Perry, the view of compositionality they appear to be taking is compositionality of *content* rather than *meaning*. In so doing, however, we argue for a move that veers back at least part way to Montague's original analysis (Montague 1973): in common with Montague, we analyze 'believe' and its ilk as a relation that involves *at the very least* an agent, a time, and a proposition. There exist many basic arguments that demonstrate that *propositions have their place*, one which was denied them in the Barwise and Perry (1983) analysis of 'believe' as a relation between an agent, a time, and a (structured) mental state.[4]

We review briefly some arguments for an analysis of belief in terms of propositions:

(1a) Jill believes that p; her belief is true/false.

(1b) Jill believes Mike's claim/theory; Hence, Jill believes that Mike's claim/theory is true.

(1c) Jill believes everything Mike says. Mike says that Bill is here. Hence, Jill believes that Bill was here.

(1a) illustrates that beliefs are entities of which truth/falsity can be predicated. (1b) is one illustration of a more general phenomenon: all NP complements of 'believe' denote entities of which truth/falsity can be predicated; predicating that such an entity is believed involves predicating that such an entity is believed to be true. The simplest explanation of what's going on in (1c) (though certainly not the only one available cf. Forbes, 1992.) is that whatever the cognitive argument of 'believe' is, it is identical to the complement of 'say' or 'assert', a highly plausible candidate for which is a proposition.

3.2 An option substituting Austinian propositions for Montague's propositions

To what extent should one actually part from a Montague style analysis? At the present time we believe this question is to some extent an open one. Certainly given their independent motivation it seems quite natural and necessary to substitute *Austinian* propositions for Montague style propositions, even when the latter are recreated within situation theory (see Cooper, 1993). Is this sufficient?

One might hope so, afterall whereas on most "neo-Russellian" accounts of propositions, there is just one proposition *that London is beautiful*, a situation semanticist armed with Austinian propositions can appeal to the existence of many such propositions, potentially as many such propositions as there are situations.

Unfortunately, such a hope seems to be frustrated because the situation in an Austinian proposition is the one which the proposition is about rather than the source or environment situation which represents something about how the agent comes to believe the proposition. Consider a case where Robin sees Anna go to school in the morning and believes later in the morning of a situation s at school that Anna is at school. However, later morning he is walking into work and sees a girl in the distance leaving the school. He does not realize that this girl is Anna but believes that the same situation s that supports Anna being at school supports the fact that this girl he sees is not at school. Clearly he believes that Anna is both at school and not at school. There is, however, no reason to require that he believes this of different situations.

The moral of this tale, it seems, is that Austinian propositions are not fine grained enough for the purposes at hand, namely distinguishing beliefs individuated by a rational agent. So we need to go a step further than merely replacing Montagovian propositions with Austinian ones.

[4]But Barwise and Perry 1985 do seem to recognize the need: see p. 64.

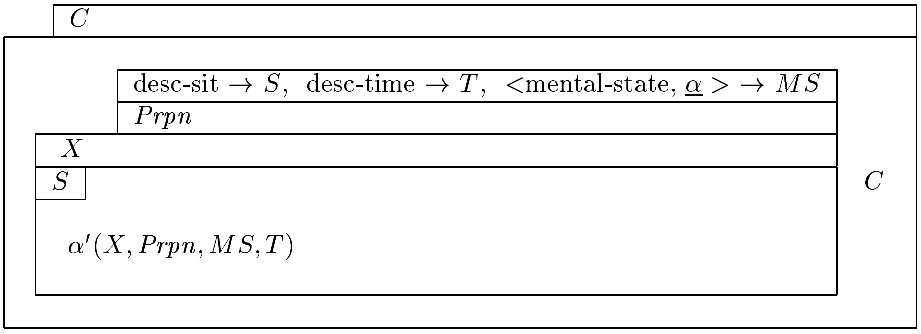
The moral would appear to involve recognizing that "the mental" also has its place. This place can be located, we shall suggest, in at least two distinct ways: either by recognizing that attitudes possess an additional (implicit) argument, filled by or quantifying over one of the reported agent's mental states, a situation that, intuitively, reflects the currently reported perspective; or, more radically, for better and worse, by enriching the theory of truth for propositions along lines hinted in Barwise (1989) when he talks of Holmesian. Both accounts interface onto the theory of mental states via constraints which relate beliefs in propositions to mental states.

We concentrate on developing the first of these two options.

4 Mental states as an unarticulated constituent

Our analysis is rooted in a situation semantic treatment of Montague's PTQ fragment.[5] We take the semantics of belief reports to express a relation between an agent a proposition and a mental state, i.e. a situation of the kind discussed in section 2. This is illustrated by our lexical entry for *believe*.

$[\![\underline{\alpha}]\!]$ where α is a V_{S}



The use of a propositional argument enables us to build up meanings for utterances in a standard compositional way since one can compositionally compute the meaning and potential content of the complement to *believe*.

Constraints need to be placed on the relationship between the mental state (here provided by the context) and the proposition whose belief is reported. The most obvious and conservative ones for positive and negative attributions are expressed by the following constraints used in our fragment.

Attitude verbs

$$s \models \langle\!\langle BELIEVE, a, p, ms, t; 1\rangle\!\rangle \rightarrow$$
$$\exists T, f(ms \models \langle\!\langle BELIEVE\#, a, T, f, t; 1\rangle\!\rangle \wedge \exists^* T f = p)$$

$$s \models \langle\!\langle BELIEVE, a, p, ms, t; 0\rangle\!\rangle \rightarrow$$
$$\neg\exists T, f(ms \models \langle\!\langle BELIEVE\#, a, T, f, t; 1\rangle\!\rangle \wedge \exists^* T f = p)$$

(If α is a type $\exists^*\alpha$ is $(\alpha \,!\, \exists)$. If α is a proposition $\exists^*\alpha$ is α.)

[5]For more details of this treatment see Cooper 1993.

The first constraint amounts to linking a positive belief attribution of proposition p relative to the mental situation ms with the existence of an *internal* belief state, classified by the relation BELIEVE#, such that applying its type component T and assignment component f yields p. The second constraint supplies the required analogue for negative belief attributions.

We would like to suggest (in line with Barwise and Perry, 1983) that the semantics only makes this requirement and that other considerations come into play in the pathological cases which require the meaning of the embedded sentence to be closer to the internal characterization of the mental state. An advantage of our theory of mental states is that the objects which we use to classify the internal aspects of mental states can be essentially similar to the objects which are used to characterize the meanings of sentences. This then enables such a theory to be made precise.

A A Fragment with the Attitudes

Notation

Parameter sorts

Parameters	**Sort**
S, MS	situation (mental state)
T	time
X, Y, X_i	individual
C, F	assignments (circumstances of an utterance)
$\mathcal{P}$	$([X] \rightarrow$ proposition$) \rightarrow$ proposition$)$ *i.e.* type of types of individuals, a noun-phrase "content"
M	$[C] \rightarrow$ proposition *i.e.* a type of assignments (circumstances), a meaning
$Prpn$	proposition *i.e.* a sentence content
P, Q	$[X] \rightarrow$ proposition *i.e.* type of individuals

Combination ("Linguistic application")

$\alpha\{\beta\} = \lambda[C](\alpha[C][\beta[C]])$

Uses

If α is a linguistic expression we use $\underline{\alpha}$ to represent a use or utterance of α.

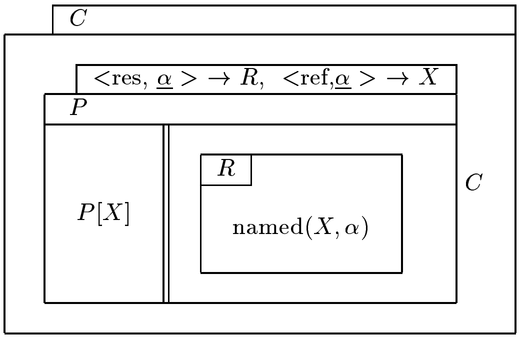
Assignments

$C/[\ r_1 \rightarrow a_1,\ldots,\ r_n \rightarrow a_n]$ is an assignment like C except it assigns a_i to r_i, for all i between 1 and n.

Lexicon

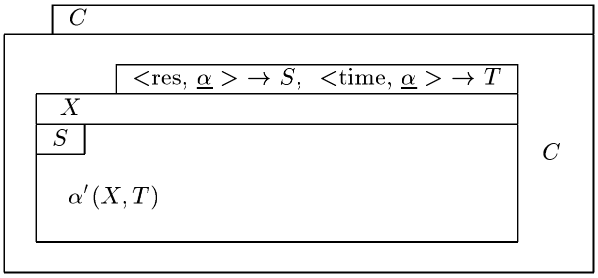
1. *proper names*

⟦$\underline{\alpha}$⟧ where α is a proper name



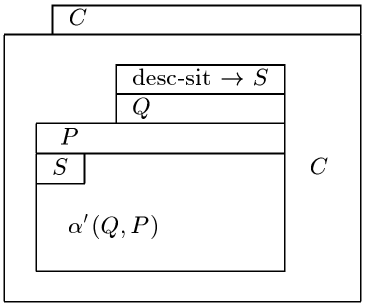
2. *common nouns*

⟦$\underline{\alpha}$⟧ where α is a common noun



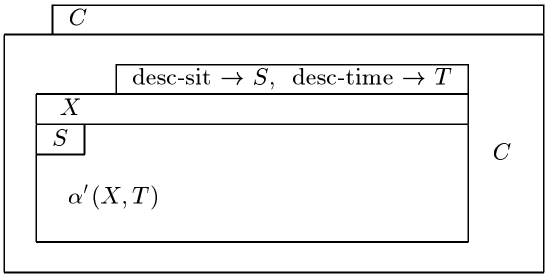
3. *determiners*

⟦$\underline{\alpha}$⟧ where α is a determiner



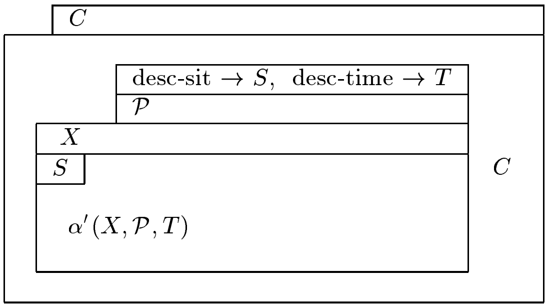
4. *intransitive verbs*

⟦$\underline{\alpha}$⟧ where α is an intransitive verb



5. *transitive verbs*

⟦$\underline{\alpha}$⟧ where α is an transitive verb



[[$\underline{\text{be}}$]]

$$\begin{array}{|c|}\hline C \\ \hline \mathcal{P} \\ \hline X \\ \hline \mathcal{P}\left[\begin{array}{|c|}\hline Y \\ \hline X = Y \\ \hline\end{array}\right] \\ \hline\end{array}$$

Where: $(X = Y)$ abbreviates $(X, Y \; ! \; =)$

6. *verbs taking sentential complements*

[[$\underline{\alpha}$]] where α is a $\mathrm{V_S}$

$$\begin{array}{|l|}\hline C \\ \hline \begin{array}{|l|}\hline \text{desc-sit} \to S,\ \text{desc-time} \to T,\ \langle\text{mental-state}, \underline{\alpha}\rangle \to MS \\ \hline Prpn \\ \hline X \\ \hline \boxed{S} \\ \alpha'(X, Prpn, MS, T) \\ \hline\end{array} \quad C \\ \hline\end{array}$$

7. *Items used in Infl*

[[$\underline{\text{n't}}$]]

$$\begin{array}{|c|}\hline C \\ \hline M \\ \hline \neg \ \boxed{M[C]} \\ \hline\end{array}$$

[[$\underline{\text{Pres}}$]]

$$\begin{array}{|c|}\hline C \\ \hline M \\ \hline M[C] \\ \hline\end{array}$$

8. *Variables (used in quantifying in constructions)*

[[$\underline{x_i}$]] where x_i is a variable $\qquad X_i$

Phrase structure

Non-branching rules are assumed to yield identical interpretations for their mother constituents as for their daughters unless explicitly mentioned otherwise.

1. *simple sentences*

   [[$\underline{[_\mathrm{S}\ \text{NP Infl}'\ \text{VP}]}$]] $\qquad \lambda[C]([\![\underline{\text{Infl}'}]\!][C][[\![\underline{\text{NP}}]\!]\{[\![\underline{\text{VP}}]\!]\}])$

2. *noun phrases with determiner*

   [[$\underline{[_\mathrm{NP}\ \text{Det N}']}$]] $\qquad [\![\underline{\text{Det}}]\!]\{[\![\underline{\text{N}'}]\!]\}$

3. *verb phrases with complements*

   [[$\underline{[_\mathrm{VP}\ \mathrm{V}_t\ \text{NP}]}$]] $\qquad [\![\underline{\mathrm{V}_t}]\!]\{[\![\underline{\text{NP}}]\!]\}$

   [[$\underline{[_\mathrm{VP}\ \mathrm{V_S}\ \mathrm{S}']}$]] $\qquad [\![\underline{\mathrm{V_S}}]\!]\{[\![\underline{\mathrm{S}'}]\!]\}$

4. *S′*

$[\![[_{S'}$ (that) Sent$]]\!]$

C	
$\begin{array}{\|c\|}\hline \text{<concern, }\underline{\text{Sent}}\text{>} \rightarrow S \\ \hline [\![\underline{\text{Sent}}]\!][C/[\text{ desc-sit} \rightarrow S]] \\ \hline \end{array}$	C

or

C	
$\exists S$	$[\![\underline{\text{Sent}}]\!][C/[\text{ desc-sit} \rightarrow S]]$

5. *Infl*
   $[\![[_{\text{Infl}}$ Tns $]]\!]$ — $[\![\underline{\text{Tns}}]\!]$

   $[\![[_{\text{Infl}'}$ Infl n't $]]\!]$ —

C
M
$[\![\underline{\text{n't}}]\!][C][[\![\underline{\text{Infl}}]\!]\{[M]\}$

6. *rules for quantifying in*

   $[\![[_S$ NP X_i Sent$]]\!]$ —

C
$[\![\underline{\text{NP}}]\!][C][\ \begin{array}{\|c\|}\hline X_i \\ \hline [\![\underline{\text{Sent}}]\!][C] \\ \hline \end{array}\ ]$

   $[\![[_{VP}$ NP X_i VP$]]\!]$ —

C
Y
$[\![\underline{\text{NP}}]\!][C][\ \begin{array}{\|c\|}\hline X_i \\ \hline [\![\underline{\text{VP}}]\!][\text{C}][\text{Y}] \\ \hline \end{array}\ ]$

   $[\![[_{N'}$ NP X_i N'$]]\!]$ —

C
Y
$[\![\underline{\text{NP}}]\!][C] \left[\begin{array}{\|c\|}\hline X_i \\ \hline [\![\underline{\text{N}'}]\!][C][Y] \\ \hline \end{array} \right]$

Constraints

Determiners

1. $\exists s(s \models \langle\!\langle \text{every}, \tau_1, \tau_2; 1\rangle\!\rangle)$ iff $\forall x\ x : \tau_1 \rightarrow x : \tau_2$
2. $\exists s(s \models \langle\!\langle \text{a}, \tau_1, \tau_2; 1\rangle\!\rangle)$ iff $\exists x\ x : \tau_1 \wedge x : \tau_2$
3. $\exists s(s \models \langle\!\langle \text{the}, \tau_1, \tau_2; 1\rangle\!\rangle)$ iff $\exists x(x : \tau_1 \wedge \forall y(y : \tau_1 \rightarrow y = x)) \wedge \forall x(x : \tau_1 \rightarrow x : \tau_2)$
   We assume that there are only actual situations to give the $\Leftarrow$ direction of these biconditionals more that just modal force.

Extensional verbs

4. $s \models \langle\langle \alpha', x, \mathcal{P}, t; 1\rangle\rangle$ iff
$$\mathcal{P}[\lambda[Y](s \mathbin{!} \langle\langle \alpha', x, Y, t; 1\rangle\rangle)] \text{ is true.}$$

Attitude verbs

5. $s \models\langle\langle \alpha', a, p, ms, t; 1\rangle\rangle \rightarrow$
$$\exists T, f(ms \models \langle\langle \alpha'\#, a, T, f, t; 1\rangle\rangle \wedge \exists^* Tf = p$$

$s \models\langle\langle \alpha', a, p, ms, t; -\rangle\rangle \rightarrow$
$$\neg\exists T, f(ms \models \langle\langle \alpha'\#, a, T, f, t; +\rangle\rangle \wedge \exists^* Tf = p)$$

(If α is a type $\exists^*\alpha$ is $(\alpha \mathbin{!} \exists)$. If α is a proposition $\exists^*\alpha$ is α.)

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