Modularity and compositionality: the case of temporal modifiers

1. Introduction One says that a semantics is compositional when it allows the meaning of a complex expression to be computed from the meaning of its constituents. One also says that a system is modular if it is made of relatively independent components. In the case of a semantic system, say a Montague grammar, we will say that it is modular if the ontology on which it is based (including notions such as *truth, entities, events, possible worlds, time intervals, state of knowledge, state of believe, ...*) is obtained by combining relatively independent simple ontologies. The question we want to investigate in this paper is then the following. Given an *atemporal* Montague grammar, on the one hand, and a temporal ontology, on the other hand, is it possible to combine them into a new grammar such that it would: (i) conservatively extend the original grammar, and (ii) allow temporal modifiers to be accommodated. This question is not as easy as it might seem at first sight. Temporal modifiers, indeed, may be cascaded, which interacts in a non-trivial way with quantification and binding. This is illustrated by sentence (1), taken from [6].

(1) *Mary kissed John during every meeting one Monday.*

Temporal modifiers also interact with tense and aspect, but we do not have enough space in this abstract to discuss this second point.

2. The temporal ontology In order to present a generic solution to our problem, we must impose as few requirements as possible on the temporal ontology. We therefore only require the existence of a partial order $(\mathbb{I}, \subset)$. The elements of $\mathbb{I}$ are thought of as time intervals, and the binary relation $\subset$ as time interval inclusion. In order to accomodate temporal preposition such as *before, after*, or *until*, one may require some additional structure on $\mathbb{I}$. This is explained in the full paper. Typically, $\mathbb{I}$ may be the set of closed intervals obtained from a linearly ordered set, as it is the case in standard interval temporal logic [5].

3. The temporalization procedure The first step is to provide our original grammar with a temporal dimension. To this end, we add a new type, i, to our object language. This type will be semantically interpreted as $\mathbb{I}$. We then take tt, as defined in (2), to be type of the propositions, and we applied a systematic *temporalization procedure* akin to the intentionalization procedure defined in [4].

(2) $\mathsf{tt} \stackrel{\triangle}{=} \mathsf{i} \rightarrow \mathsf{t}$

This allows temporal connectives to be added to our object logic. Typically, we defined the *during* modality as follows.

(3) $\langle \textsc{d} \rangle \phi \stackrel{\triangle}{=} \lambda i.\, \exists j.\, (j \subset i) \wedge (\phi\, j)$

We may then systematically transform our Montagovian lexicon in order to take time into account. This results in lexical entries akin to (4), where $\overline{\mathbf{student}}$ is the image of the original relational symbol $\mathbf{student}$ under the temporalization procedure.

(4) $\textsc{student} := \lambda x.\, \langle \textsc{d} \rangle (\overline{\mathbf{student}}\, x) : \mathsf{e} \rightarrow \mathsf{tt}$

4. Translating the generalized quantifiers The system we have obtained so far allows one to deal with first-order quantification (existential and universal). However, we are seeking a solution that would apply uniformly to every generalized quantifier (including quantifiers that are not first-order definable, or quantifiers that ar not monotonic in their first argument, such as *most*). To this end we use a notion of *continuation* [1], and define a second systematic transformation based on the definitions that follow.

(5) a. $\mathsf{T} \stackrel{\triangle}{=} \mathtt{t} \to \mathtt{t}$

b. $[\phi] \stackrel{\triangle}{=} \lambda k.\, \langle \mathrm{D} \rangle (\phi \mathbin{\overline{\wedge}} k)$

c. $\phi_1\,;\phi_2 \stackrel{\triangle}{=} \lambda a.\, \phi_1\,(\phi_2\, a)$

This allows to define the following appropriate transformation for the generalized quantifiers.

(6) $[Q] \stackrel{\triangle}{=} \lambda abk.\, Q\,(\lambda x.\, a\, x\,(\lambda i.\, \top))\,(\lambda x.\, (a\, x\,; b\, x)\, k)$

Finally, by composing our two transformations, we obtain a semantic lexicon akin to the following one.

(7) a. JOHN $:= \lambda p.\, p\, \mathbf{j} : (\mathsf{e} \to \mathsf{T}) \to \mathsf{T}$

b. MARY $:= \lambda p.\, p\, \mathbf{m} : (\mathsf{e} \to \mathsf{T}) \to \mathsf{T}$

c. KISSED $:= \lambda so.\, s\,(\lambda x.\, o\,(\lambda y.\, [\overline{\mathbf{kissed}}\, x\, y])) : ((\mathsf{e} \to \mathsf{T}) \to \mathsf{T}) \to ((\mathsf{e} \to \mathsf{T}) \to \mathsf{T}) \to \mathsf{T}$

d. MONDAY $:= \lambda x.\, [\overline{\mathbf{monday}}\, x] : \mathsf{e} \to \mathsf{T}$

e. MEETING $:= \lambda x.\, [\overline{\mathbf{meeting}}\, x] : \mathsf{e} \to \mathsf{T}$

f. EVERY $:= [\overline{\mathbf{every}}] : (\mathsf{e} \to \mathsf{T}) \to (\mathsf{e} \to \mathsf{T}) \to \mathsf{T}$

g. SOME $:= [\overline{\mathbf{some}}] : (\mathsf{e} \to \mathsf{T}) \to (\mathsf{e} \to \mathsf{T}) \to \mathsf{T}$

h. DURING $:= \lambda ab.\, a\,(\lambda x.\, b) : ((\mathsf{e} \to \mathsf{T}) \to \mathsf{T}) \to \mathsf{T} \to \mathsf{T}$

6. Conclusion To conclude, we compare our proposal with several solutions that have been proposed in the literature (among others [2, 3, 6]). Interestingly enough, our work explains the rationale behind these solutions, and allows some possible defects to be pointed out. It also shows that some implicit ontological choices made by the authors of these solutions are sometimes central. This is the case, for instance, with the notion of an event in [6].

References

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