Worlds, events and perspectives

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1 The intensional facet of event semantics

The traditional Montagovian treatment of adjectival modification, which derives from early work by Montague (1973), Parsons (1970), and Kamp (1975), distinguishes between several classes of adjectives, namely, *intersective*, *subsective*, *privative*, and *plain non-subsective* adjectives (see Kamp & Partee 1995 for an exposition of the classification).

A paradigmatic example of an intersective adjective is *carnivorous*. By saying that the Tyrannosaurus rex is a carnivourous dinosaur, we state that it is both a dinosaur and a carnivore. Accordingly, if we take both nouns and adjectives to denote sets of entities, we have that

(1) $[\![\text{carnivourous dinosaur}]\!] = [\![\text{carnivorous}]\!] \cap [\![\text{dinosaur}]\!]$

More generally, an adjective ADJ is intersective, by definition, if there exists a set of entities $[\![\text{ADJ}]\!]$ such that for every noun N:

(2) $[\![\text{ADJ N}]\!] = [\![\text{ADJ}]\!] \cap [\![\text{N}]\!]$

In terms of type theory, we then assign the following semantic recipe to intersective adjectives:

(3) $\lambda n x.(\mathbf{adj}\, x) \wedge (n\, x)$

where **adj**, which is of type $\mathsf{e} \to \mathsf{t}$, denotes the characteristic function of the set *adj*.

As observed by Parsons (1970), such a treatment is not appropriate for an adjective such as *small* because it would lead to the wrong inference that a small elephant is a small animal. We must therefore conclude that the adjective *small* is not intersective. Nevertheless, one of the inferences that intersective adjectives allow remains valid, namely, for the example at hand, that a small elephant is an elephant. Adjectives with this property are said to be subsective. More precisely, an adjective ADJ is subsective, by definition, if for every noun N we have:

(4) $[\![\text{ADJ N}]\!] \subset [\![\text{N}]\!]$

In accordance with the type of term (3), *small* is then interpreted with a set modifier, i.e., an operator **small** of type $(\mathsf{e} \to \mathsf{t}) \to \mathsf{e} \to \mathsf{t}$ that transforms sets of individuals into other sets of individuals. Then, to account for the subsective nature of the adjective, we need a meaning postulate such as:

(5) $\forall n x.(\mathbf{small}\, n\, x) \to (n\, x)$

Interpreting adjectives as extensional set transformers does not allow for a proper treatment of the subsective adjectives of an intensional nature, such as *skillful*. If all and only cobblers are darts players, it does not follow that all and only skillful cobblers are skillful darts players.[1] However, if *skillful* is interpreted as a term of type $(\mathsf{e} \to \mathsf{t}) \to \mathsf{e} \to \mathsf{t}$ (say **skillful**), then in any first-order model in which the interpretations of *cobbler* and *darts player* (say **cobbler** and **player**) are coextensive (i.e., denote the same set), **skillful cobbler** and **skillful player** are also coextensive. Consequently, the following formula, which we do not expect to be true, is valid in every possible model:

[1] Kamp (1975) attributes this example to Lewis.

(6) $(\forall x.(\mathbf{cobbler}\,x) \leftrightarrow (\mathbf{player}\,x)) \rightarrow (\forall x.(\mathbf{skillful}\,\mathbf{cobbler}\,x) \leftrightarrow (\mathbf{skillfull}\,\mathbf{player}\,x))$

To avoid this kind of problems, Montague (1970) interprets adjectives as operators that transform set intensions into set intensions, i.e., operators of type $(\mathsf{e} \rightarrow \mathsf{s} \rightarrow \mathsf{t}) \rightarrow \mathsf{e} \rightarrow \mathsf{s} \rightarrow \mathsf{t}$, where s is the type of possible worlds. Using this typing, formula (6) is rewritten, mutatis mutandis, as formula (7), for which, as expected, counter-models exist.

(7) $(\forall x.(\mathbf{cobbler}\,x\,w) \leftrightarrow (\mathbf{player}\,x\,w)) \rightarrow (\forall x.(\mathbf{skillful}\,\mathbf{cobbler}\,x\,w) \leftrightarrow (\mathbf{skillfull}\,\mathbf{player}\,x\,w))$

$$\begin{aligned} \text{where }\ \mathbf{cobbler}, \mathbf{player} &: \mathsf{e} \rightarrow \mathsf{s} \rightarrow \mathsf{t} \\ \mathbf{skillful} &: (\mathsf{e} \rightarrow \mathsf{s} \rightarrow \mathsf{t}) \rightarrow \mathsf{e} \rightarrow \mathsf{s} \rightarrow \mathsf{t} \end{aligned}$$

What is said above about intensional adjectives also applies to intensional adverbs. For example, sentence (8) is not necessarily true (and so, should not be predicted as such).

(8) If everyone who sings dances, and vice versa, then all and only those who sing gracefully dance gracefully.

Accordingly, in Montague semantics, adverbs are semantically interpreted by terms of type $(\mathsf{e} \rightarrow \mathsf{s} \rightarrow \mathsf{t}) \rightarrow \mathsf{e} \rightarrow \mathsf{s} \rightarrow \mathsf{t}$, just like adjectives.[2] Sentence (8) is then interpreted by the following formula, similar to formula (7):

(9) $(\forall x.(\mathbf{sing}\,x\,w) \leftrightarrow (\mathbf{dance}\,x\,w)) \rightarrow (\forall x.(\mathbf{gracefully}\,\mathbf{sing}\,x\,w) \leftrightarrow (\mathbf{gracefully}\,\mathbf{dance}\,x\,w))$

Let us now explore how sentence (8) can be assigned a meaning in the framework of Davidson's event semantics.[3] Consider the proposition *everyone who sings dances (and vice versa)*. Using events, it can be paraphrased as follows: *for every person, say x, who is the agent of a singing event, there exists a dancing event of which x is the agent (and vice versa)*. Now, even if the set of agents of singing events is coextensive with the set of agents of dancing events, the fact that the singing events are distinct from the dancing events blocks the spurious inference that every agent of a graceful singing event is the agent of a graceful dancing event. More formally, in the framework of event semantics, the meaning of sentence (8) is captured by formula (10), which is satisfiable but not valid.

(10)
$$\begin{aligned} &(\forall x.(\exists e.(\mathbf{sing}\,e) \wedge (\mathbf{agent}\,e\,x)) \leftrightarrow (\exists e.(\mathbf{dance}\,e) \wedge (\mathbf{agent}\,e\,x))) \\ &\qquad \rightarrow (\forall x.(\exists e.(\mathbf{sing}\,e) \wedge (\mathbf{agent}\,e\,x) \wedge (\mathbf{graceful}\,e)) \\ &\qquad\qquad \leftrightarrow (\exists e.(\mathbf{dance}\,e) \wedge (\mathbf{agent}\,e\,x) \wedge (\mathbf{graceful}\,e))) \end{aligned}$$

Let us draw some conclusions from what we have discussed so far. We have seen that in order to avoid problems related to the accidental coextensivity of predicates, the Montagovian treatment of adjectival and adverbial modification is based on possible world semantics. But we have also seen that a similar effect can be achieved by appealing to event semantics and that, for instance, the meaning of sentence (8) can be modeled satisfyingly without any explicit reference to intensions or possible worlds. This shows that event semantics has some "intensional flavor", which motivates the question that we address in this paper: is there any form of correspondence between possible worlds and events, and if so, what might it be?

[2] This type is indeed the semantic type of adverbs used in (Montague 1970). In (Montague 1973), however, the semantic type assigned to adverbs is a bit more complex, namely, $(\mathsf{s} \rightarrow (\mathsf{s} \rightarrow \mathsf{e}) \rightarrow \mathsf{t}) \rightarrow (\mathsf{s} \rightarrow \mathsf{e}) \rightarrow \mathsf{t}$. We stick to the simplest version, which is sufficient for the purpose of this paper.

[3] Instead of Davidson's original proposal (Davidson 1967), we use the so-called neo-Davidsonian approach (Parsons 1990). This technical choice, however, is not crucial for our purpose.

2 Possible worlds as sets of events

The wording *possible worlds* suggests the existence of alternative realities corresponding to what the (actual) world could have been. This intuition certainly prevailed at the time of the early developments of alethic modal logic. Nowadays, however, depending on the fields to which modal logics are applied, the expression *possible world* can refer to formal objects of a very different nature, such as the values contained in the memory cells of a computer system in a given state, a reality compatible with the beliefs of a cognitive agent, an abstract notion of context, or even something as concrete as the hand of a card player.

In a framework where sentences are interpreted in terms of events (or rather, using Bach's terminology (1986), *eventualities*), it seems that a possible world can be sensibly modeled as a set of events — the set of events that occur in this world.[4] To investigate the consequences of this hypothesis, let us consider a simple sentence such as *Olga sings*. In standard possible world semantics, this sentence is interpreted as the set of possible worlds in which Olga sings. Now, in an event-based setting in which possible worlds are sets of events, *Olga sings* is naturally interpreted as the set of sets of events that contain a singing event by Olga:

(11) $[\![\text{Olga sings}]\!] = \{w \mid \exists e \in w.\, (\mathbf{sing}\, e) \wedge (\mathbf{agent}\, e\, \mathbf{olga})\}$

In type theory, sets are represented by their characteristic functions. Thus, if we take v to be the type of events, the type $\mathsf{v} \to \mathsf{t}$ is the type of sets of events. Hence, we posit $\mathsf{s} = \mathsf{v} \to \mathsf{t}$. Then, the analysis in (11) is expressed in type-theoretic parlance as follows (where $w\, e$ expresses that e is a member of w):

(12) $[\![\text{Olga sings}]\!] = \lambda w.\, \exists e.\, (\mathbf{sing}\, e) \wedge (\mathbf{agent}\, e\, \mathbf{olga}) \wedge (w\, e)$

Most interestingly, interpretation (12) matches exactly the analysis of Champollion (2011, 2015), who, in order to solve independent issues related to compositionality in event semantics, interprets verb phrases as generalized quantifiers over events.

Now, to be consistent in our approach, we must interpret a copula sentences like *Olga is a singer* in a way parallel to (12). This leads us to propose the following interpretation:

(13) $[\![\text{Olga is a singer}]\!] = \lambda w.\, \exists e.\, (\mathbf{singer}\, e) \wedge (e \succ \mathbf{olga}) \wedge (w\, e)$

Here, one should not think of e as an event in the literal sense, but rather as a *perspective* (on some individual), and the binary relation $\succ$ between perspectives and individuals is such that $e \succ x$ is true just in case the perspective e is on the individual x. Perspectives are a sort of event(ualitie)s, a perspective is always on some individual and distinct perspectives may be on the same individual — the same person, for instance, may be alternatively seen as a friend, as a neighbor and as a philosopher, corresponding to three perspectives with properties of their own. The analysis in (13) can then be paraphrased as follows: *there exists a singer perspective that is a perspective on Olga*. This analysis is similar to Larson's (1998), who speaks of the *hidden event parameter* of nominals — one crucial difference is the interpretation of this eventuality and, in relation, the fact that our perspectives are introduced by a standard existential quantifier rather than the generic quantifier (Chierchia 1995) used by Larson (1998).

3 Paralleling adverbial and adnominal modification

As illustrated by the analysis in (13), considering possible worlds to be sets of events leads us to introduce event-like arguments at the nominal level. In principle, this should allow event-based

[4] Champollion (2015: p. 40) expresses a similar idea: "Intuitively, one might think of the world as the set of all events that exist."

semantic analyses to be transferred from the verbal domain to the nominal domain. This is what we now investigate.

We have seen that in event semantics the sentence *Olga sings gracefully* is analyzed as follows:

(14) $[\![\text{Olga sings gracefully}]\!] = \lambda w. \exists e. (\mathbf{sing}\, e) \wedge (\mathbf{agent}\, e\, \mathbf{olga}) \wedge (\mathbf{graceful}\, e) \wedge (w\, e)$

By analogy, elaborating on (13), we interpret the sentence *Olga is a skillful singer* as follows:

(15) $[\![\text{Olga is a skillful singer}]\!] = \lambda w. \exists e. (\mathbf{singer}\, e) \wedge (e \succ \mathbf{olga}) \wedge (\mathbf{skillful}\, e) \wedge (w\, e)$

Notice that, in the above interpretation, the predicate **skillful** takes a perspective e as an argument, not the individual **olga**. Consequently, if Olga is both a dancer and a skillful singer, our semantic interpretation does not allow one to draw the false conclusion that Olga is a skillful dancer. In addition, we do not need any meaning postulate to account for the subsectivity of the adjective *skillful*. For instance, we analyze *if Olga is a skillful singer, she is a singer* as (16), which is correctly predicted to be a tautology (it denotes the set of all possible worlds).

(16) $\lambda w. (\exists e. (\mathbf{singer}\, e) \wedge (e \succ \mathbf{olga}) \wedge (\mathbf{skillful}\, e) \wedge (w\, e)) \rightarrow (\exists e. (\mathbf{singer}\, e) \wedge (e \succ \mathbf{olga}) \wedge (w\, e))$

Let us now see how the analysis in (15) can be obtained compositionally. In Montague semantics, common nouns are interpreted as intensions of sets of individuals, i.e., terms of type $\mathsf{e} \rightarrow \mathsf{s} \rightarrow \mathsf{t}$. Therefore, by identifying possible worlds with sets of events, we interpret common nouns as terms of type $\mathsf{e} \rightarrow (\mathsf{v} \rightarrow \mathsf{t}) \rightarrow \mathsf{t}$. These typing considerations suggest to interpret a common noun like *singer* by the following term:

(17) $\lambda x w. \exists e. (\mathbf{singer}\, e) \wedge (e \succ x) \wedge (w\, e)$

As for the the adjective *skillful*, it must be interpreted as a term of type $(\mathsf{e} \rightarrow \mathsf{s} \rightarrow \mathsf{t}) \rightarrow \mathsf{e} \rightarrow \mathsf{s} \rightarrow \mathsf{t}$, which leads to the following interpretation:

(18) $\lambda n x w. n\, x\, (\lambda e. (\mathbf{skillful}\, e) \wedge (w\, e))$

Then, applying (18) to (17) results in a λ-term that β-reduces to term (19):

(19) $\lambda x w. \exists e. (\mathbf{singer}\, e) \wedge (e \succ x) \wedge (\mathbf{skillful}\, e) \wedge (w\, e)$

An interesting feature of this interpretation of common nouns, as illustrated in (17), is that it has access to the perspective variable e but also to the underlying individual x. This allows intersective adjectives to be accommodated straightforwardly. For instance, the common noun phrase *Italian singer* can be interpreted as (20a) by using (20b) as the interpretation of the intersective adjective *Italian*.

(20) a. $\lambda x w. (\mathbf{italian}\, x) \wedge (\exists e. (\mathbf{singer}\, e) \wedge (e \succ x) \wedge (w\, e))$
b. $\lambda n x w. (\mathbf{italian}\, x) \wedge (n\, x\, w)$

The above treatment of the subsective and intersective adjectives can be used to give an account of the ambiguity of sentence (21), which either states that Olga is a person who dances beautifully (subsective interpretation) or states that Olga is a person who is beautiful and who is a dancer (intersective interpretation); we see this ambiguity as a lexical ambiguity between two versions of *beautiful*.

(21) Olga is a beautiful dancer.

Extending the concept of event from the verbal to the nominal domain result in a new treatment of adjectives that is obtained by importing and adapting solutions that have been devised for adverbs. Modal adverbs are known to be modifiers of sentences rather than verb phrases. For example, the sentence *John allegedly stole the money* can be interpreted as follows using a modal connective, say **allegedly**, which in our setting must be of type $((\mathsf{v} \to \mathsf{t}) \to \mathsf{t}) \to (\mathsf{v} \to \mathsf{t}) \to \mathsf{t}$:

(22) $\mathbf{allegedly}\,(\lambda w.\, \exists e.\, (\mathbf{stole}\, e) \wedge (\mathbf{agent}\, e\, \mathbf{john}) \wedge (\mathbf{theme}\, e\, \mathbf{money}) \wedge (w\, e))$

This suggests the following interpretation to the noun phrase *alleged thief*:

(23) $\lambda x.\, \mathbf{allegedly}\,(\lambda w.\, \exists e.\, (\mathbf{thief}\, e) \wedge (e \succ x) \wedge (w\, e))$

We end this section by providing a grammatical fragment that gives a compositional account of the kind of examples we have discussed.

$$
\begin{array}{rcll}
[\![\text{Olga}]\!] & = & \lambda p.\, p\, \mathbf{olga} & : \textsc{np} \\
[\![\text{singer}]\!] & = & \lambda x w.\, \exists e.\, (\mathbf{singer}\, e) \wedge (e \succ x) \wedge (w\, e) & : \textsc{n} \\
[\![\text{dancer}]\!] & = & \lambda x w.\, \exists e.\, (\mathbf{dancer}\, e) \wedge (e \succ x) \wedge (w\, e) & : \textsc{n} \\
[\![\text{Italian}]\!] & = & \lambda n x w.\, (\mathbf{italian}\, x) \wedge (n\, x\, w) & : \textsc{n} \to \textsc{n} \\
[\![\text{skillful}]\!] & = & \lambda n x w.\, n\, x\, (\lambda e.\, (\mathbf{skillful}\, e) \wedge (w\, e)) & : \textsc{n} \to \textsc{n} \\
[\![\text{beautiful}_{\text{int}}]\!] & = & \lambda n x w.\, (\mathbf{beautiful}\, x) \wedge (n\, x\, w) & : \textsc{n} \to \textsc{n} \\
[\![\text{beautiful}_{\text{sub}}]\!] & = & \lambda n x w.\, n\, x\, (\lambda e.\, (\mathbf{beautiful}\, e) \wedge (w\, e)) & : \textsc{n} \to \textsc{n} \\
[\![\text{alleged}]\!] & = & \lambda n x.\, \mathbf{allegedly}\, (n\, x) & : \textsc{n} \to \textsc{n} \\
[\![\text{a}]\!] & = & \lambda p q w.\, \exists x.\, (p\, x\, w) \wedge (q\, x\, w) & : \textsc{n} \to \textsc{np} \\
[\![\text{every}]\!] & = & \lambda p q w.\, \forall x.\, (p\, x\, w) \to (q\, x\, w) & : \textsc{n} \to \textsc{np} \\
[\![\text{is}]\!] & = & \lambda a s.\, s\, (\lambda x.\, a\, (\lambda y w.\, x = y)) & : \textsc{np} \to \textsc{np} \to \textsc{s}
\end{array}
$$

where $\mathsf{p} = (\mathsf{v} \to \mathsf{t}) \to \mathsf{t}$, $\textsc{np} = (\mathsf{e} \to \mathsf{p}) \to \mathsf{p}$, $\textsc{n} = (\mathsf{e} \to \mathsf{p})$, and $\textsc{s} = \mathsf{p}$.

4 Conclusions

The conceptualization of possible worlds as sets of events led us, on the one hand, to recover Champollion's (2015) quantificational theory of events and, on the other hand, to extend the notion of event by providing nominals with event-like parameters, which we have called *perspectives on individuals*. This allowed us to propose new treatments of adjectives, inspired by the treatment of adverbs provided by Davidson's event semantics.

The use of perspectives may prove to be a useful tool to discuss the existence and identity of individuals. In our framework, it is natural to consider that an individual x exists at world w iff w contains a perspective on w. Furthermore, while the fragment given here analyses *Olga is Fred* as a proposition equivalent to $\lambda w.\, \mathbf{olga} = \mathbf{fred}$, which, in any given model, is either a tautology or a contradiction, a variant of the analysis of proper names based on a primitive set of perspectives (rather than a primitive individual) could predict this sentence to be only contingently true or false — an interesting feature for the analysis of attitude reports (e.g., *Lois does not know that Clark Kent is Superman*).

The work we have presented in this paper is a work in progress, and several points remain to be clarified. Many of the intuitions on which we rely have already been discussed in one form or another in the literature. In particular, concepts similar to our notion of perspective exist, most notably the *qua objects* of Fine (1982). In another vein, seeing possible worlds as sets of events opens the door to a notion of partial (or incomplete) worlds, which is reminiscent of Barwise & Perry's 1983 situation semantics. Further research will be needed to unravel the links between these theories and our approach.

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