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Structured Propositions in a Generative Grammar

The Montagovian tradition in formal semantics combines two basic tenets to explain a wide variety of linguistic phenomena.

INTENSIONAL SEMANTICS: The compositional semantic value of a sentence is an intension, a function from points of evaluation into truth-values. A sentence is true if it is true at some privileged point of evaluation.

FUNCTIONAL COMPOSITIONALITY: The compositional semantic value of each basic expression is an entity in a basic category or a function defined in terms of these basic categories, characterized in the typed λ -calculus. The semantic value of a whole is the result of applying the function which is the semantic value of one component to the semantic value of the other component.¹

The first tenet explains the truth conditional properties of sentences and their entailment relations. The second tenet explains how the meanings of larger expressions depend on the meanings of their components. Montague's combination of these two tenets led to 'the emergence of semantics as a new discipline within linguistic theory' (Stanley 2008, p. 414).

Although widely accepted in formal semantics, intensional semantics has received a mixed reaction in philosophy.² Specifically, if points of evaluation are possible worlds, then necessarily equivalent sentences have the same compositional semantic values. This troubles philosophers who believe that the semantic values of sentences must be more fine-grained. They charge that intensional semantics falters on propositional attitude ascriptions. A propositional attitude ascription contains a subject term and a psychological verb such as 'believes' followed by a complement clause of the form \ulcorner that ϕ \urcorner . Sentences in the complement clauses of attitude ascriptions seem to contribute something richer than an intension. For instance, an adequate semantics must allow for the possibility that sentences (1) and (2) have different truth-values, since one may believe of a human being that she flies without believing that she has any parents.

¹I take the term from (Cresswell 2002). As shall become clear, this is a 'leading idea' in Montague Semantics (Heim and Kratzer 1998, p. 13), though semanticists depart from this core model of semantic composition in various ways.

²See (Partee 2008c, p. 9).

- (1) Terry believes that Sam flies.
- (2) Terry believes that Sam flies and Sam's father existed.

Yet, the existence of a human being necessitates the existence of her material origins. So the sentences in the complement clauses of (1) and (2)—‘Sam flies’ and ‘Sam flies and Sam's father existed’—have the same intension. As a result, they make the same contribution to (1) and (2), and these attitude ascriptions themselves have the same truth-value at every point of evaluation.

A standard diagnosis concludes from these substitutivity failures that the compositional semantic values of sentences must do justice to our underlying theory of the objects of attitudes that they express. I focus on one model due to Moore (1899) and Russell (1903/1996): the object of an attitude is a structured entity, a *structured proposition*, made of objects and properties. The proposition that Sam flies is composed of Sam and the property of flying. The proposition that Sam flies and Sam's father existed contains additional constituents. On a rival model due to (an interpretation of) Frege, a proposition is composed not of individuals and properties but of *representations*.³

If propositions are the compositional semantic values of sentences (in context — a qualification I normally suppress), then semantics should describe how the proposition expressed by a sentence depends on the compositional semantic values of its constituents and their arrangement. Standard structured proposition-*alists* see that, in the ideal case, the constituents of a structured proposition correspond to the constituents of a sentence that expresses it.⁴ Thus, ‘Sam flies’ expresses a structured proposition with Sam and the property of flying as constituents. Typical proponents of structured propositions infer—wrongly as I shall argue—that the compositional semantic value of an expression is always the propositional constituent, if any, corresponding to it: that the semantic value of the name ‘Sam’ is the woman herself and the semantic value of the predicate ‘flies’ is the property of flying. Almost all recent proponents of structured propositions in the tradition of Russell and Moore—including Nathan Salmon (1986), Scott Soames (1987), and Jeff King (2007)—propose semantic theories along these lines.

Such semantic theories depart not only from intensional semantics, but also from functional compositionality, which Heim and Kratzer call *Frege's Conjecture*.

[T]here will be many small and some not-so-small departures from the semantic analyses that Frege actually defended. But his treatment of semantic composition as functional application

³The most explicit statement is (Frege 1963, p. 1). This interpretation is defended in (Dummett 1981, pp. 152-7) and challenged in (Geach 1976). See (Klement 2002, chapter 3).

⁴Russell (1905b, p. 155): ‘We may say broadly that *a* is a constituent of *p* if *a* is mentioned in stating *p*.’

(*Frege's Conjecture*), will remain a leading idea throughout. (Heim and Kratzer 1998, p. 13)

The idea that the *core cases* of semantic composition should be modeled as type-driven functional application reflects the success of this treatment in formal semantics. Rejecting this tenet of the Montagovian program threatens the hope that intensional semantics generally can be developed ‘in the spirit of Frege’ and that the successes of formal semantics should be ‘adaptable to new foundations’ including the study of hyperintensional contexts such as belief (Heim and Kratzer 1998, pp. 309, 311). If we abandon *both* intensional semantics *and* functional compositionality, what is left of the Montagovian program?⁵

Standard proponents of structured propositions offer little to replace this ‘leading idea’. Indeed, according to King and Stanley (2005, p. 134), standard advocates of structured propositions—including King himself—say that ‘no significant composition of semantic contents of the elements of a sentence occurs in the mapping from sentence to proposition.’ As they say about another view, trivializing semantic composition threatens to result in ‘trivializing semantics’ (*ibid*, p. 123).⁶ Indeed, taken at face value, the rhetoric of many current advocates of structured propositions implies structured propositions are outright incompatible with functional compositionality. King (2007, p. 113) holds that functional compositionality ‘is the main issue’ dividing proponents of structured and unstructured propositions. Others simply define structured propositions as wholes composed of the semantic values of the components of sentences used to express them.⁷

This paper argues that functional compositionality is compatible with the thesis that the semantic value of a sentence in context is a structured proposition. To do so, I develop a theory on which the compositional semantic value of an expression need not be a propositional constituent, but may be a function which yields a structured proposition as its value. This type of theory is hinted at by Dummett (1981, p. 294) in a Fregean context.⁸ It has been developed in greater detail by Elbourne (2011, pp. 104-7) who gives a functionally compositional semantics for atomic sentences containing names and transitive verbs.⁹ The semantic theory I develop here agrees with that of Elbourne on atomic sentences. But as Elbourne says, there is “much

⁵Armstrong and Stanley (2011, p. 211, footnote 7) note that David Kaplan, the most prominent recent structured propositionalist, develops an intensional system in (Kaplan 1989). Similarly, proponents of structured meanings within the formal semantics tradition usually deny that these play a role in belief ascriptions or hold that their role is an exception to the general rule of functional application. Lewis (1970) adopts the first route and Cresswell (1985; 2002), the second.

⁶They do suggest that there is non-trivial composition in determining the truth-value of a proposition from its constituents. But it is unclear to me to what extent this should be thought of as *semantic* composition.

⁷See (Soames 2010a, p. 112), (Hanks 2011, p. 11ff), and (Keller and Keller 2013, p. 1).

⁸According to Dummett, the *referent* of a predicate in a propositional attitude ascription is a function which takes the sense of a name and outputs a *structured* sense of a sentence.

⁹Pagin and Pelletier (2007) very abstractly sketch a similar approach for deriving structured meanings. Another precedent can be found in the tradition originating from Kamp’s (1981) *Discourse Representation Theory*, which posits structured entities as the semantic values of discourses. An interesting semantic tradition developed to make this theory functionally compositional, resulting in (Van der Sandt 1992), (Asher 1993), and (Muskens 1996).

more to English than names and simple transitive verbs” (p. 109) and it is not transparent how to extend this story to more complex constructions. In addition to bringing the semantic issues into contact with philosophical worries about integrating structured propositions with functional compositionality, this paper extends the story for incorporating structured propositions into a functionally compositional semantics which deals with more complex constructions, including quantifiers, names analyzed as determiner phrases, complex demonstratives, and the currently controversial case of variable binders.

Functional compositionality offers three main advantages to the advocate of structured propositions. First, your workaday semanticist can rest easy, knowing that her results won’t be overturned when she incorporates hyperintensional phenomena into her theory. Structured propositionists can conservatively extend the insights of formal semantics. Indeed, unlike standard advocates of structured propositions who offer semantic theories for the regimented language of first-order logic, I offer a direct interpretation of sentences of a fragment of English. Second, the model of semantic composition as type-driven functional application offers genuine advantages for Montague semantics. The model constrains the range of possible semantic theories thereby providing discipline and empirical traction. The approach developed here can replicate this power. Third, the proponent of structured propositions should acknowledge that some sentential constituents do not correspond to propositional constituents. I argue that the best way to make sense of these failures of correspondence is to construe a proposition as the output of a function corresponding to one sentential constituent for an argument corresponding to another sentential constituent. So, this paper rehabilitates the traditional idea that the structure of a proposition can differ from the structure of a sentence expressing it.

In §1, I briefly discuss some motivations for believing in structured propositions. In §2, I sketch the standard propositionalist semantics. In §3, I discuss the virtues of functional compositionality. In §4, I provide a functionally compositional semantics for propositions. In §5, I discuss some benefits of typing for proponents of structured propositions. In §6, I discuss the benefits of thinking of a proposition as the *output* of the function expressed by one sentential constituent to the argument expressed by another rather than as a whole composed of the semantic values of these sentential constituents. In §7, I examine how my approach deals with one problem case for semantic theories based on functional application, variable binding.

1 Structured Propositions

The examples (1) and (2) illustrated that necessarily equivalent sentences do not substitute *salva veritate* in attitude ascriptions. The specific example relied on potentially controversial theses about the necessity

of origins. But, mathematically and logically equivalent sentences also do not in general substitute *salva veritate* into attitude ascriptions. (3) and (4) may have different truth-values despite having mathematically equivalent complement clauses. Similarly, (5) and (6) may have different truth-values despite having logically equivalent complement clauses.

- (3) Sam believes that $2+2=4$.
- (4) Sam believes that the Fourier transform of a Gaussian is a Gaussian.
- (5) Sam believes that Jane runs.
- (6) Sam believes that everyone either runs or is not identical to Jane.

The proponent of structured propositions can hold that the sentences embedded in the complement clauses express different structured propositions. So, she can resist the conclusion that these belief ascriptions are synonymous. She is thereby better able to account for belief.¹⁰

1.1 Fine-Grained Attitudes without Structure

Other views *do* allow for these substitutivity failures. Proponents of *unstructured* propositions have suggested the following strategies.

Metaphysically Simple Propositions: The objects of attitudes are fine-grained, simple objects with no internal structure.

Fine-grained intensional semantics: The objects of attitudes are functions from points of evaluation into truth-values, but the points of evaluation may differentiate between necessarily or even logically equivalent sentences.

Church (1951), Bealer (1982), and Schiffer (2003) posit simple, but fine-grained meanings. The situation semantics of Kratzer (1989) and of Barwise and Perry (1999) result in a form of fine-grained intensionalism.¹¹

Unfortunately, these approaches don't rest on an underlying view of the nature of the objects of belief. They seem guided only by judgments concerning the truth-values of attitude ascriptions. And any such theory is unstable. Speakers are willing to make very fine-grained distinctions in attributing attitudes. In sufficiently enriched contexts, speakers will deny that even synonymous sentences are substitutable *salva*

¹⁰Soames (1987) offers a related argument against intensional semantics from the premise that names are directly referential.

¹¹Ripley (2012, p. 111) defends an even more fine-grained intensionalism, holding that there are points of evaluation differentiating any two syntactically distinct sentences.

veritate in attitude ascriptions.¹² Yet, it is undesirable to say that *every* difference between two sentences gives rise to a difference between the beliefs they express in context. Moreover, if the objects of belief are fine-grained enough to capture every difference in speaker judgments about belief ascriptions, then the semantic values of sentences will need to be even more fine-grained. On different occasions, the same belief ascription may not appear to have the same truth conditions. Speakers who know that Pierre has encountered a man, Paderewski, expertly playing the piano will often endorse the sentence ‘Pierre believes that Paderewski has musical talent’. But when presented with the fact that Pierre has met the same man, Paderewski, acting as a politician with no obvious musical ability, speakers often endorse the sentence ‘Pierre does not believe that Paderewski has musical talent’ (Kripke 1979). The same sentence occurs in the complement clause of these two attitude ascriptions. An account based exclusively on the distribution of speaker judgments about attitude ascriptions will lead to the problematic result that two uses of a single sentence never express the same proposition.

1.2 The Nature of Representation

A successful theory of the objects of attitudes must make sense of the practice of ascribing attitudes in general. But it must also provide a serviceable model of the objects of attitudes, including their individuation conditions. This latter task may involve rejecting some pretheoretically acceptable belief ascriptions.

Proponents of *structured propositions* purport to achieve both goals. Moore and Russell introduced structured propositions by considering the nature of representation. Consideration of different aspects of representation motivated two different theories of structured propositions for these early propositionalists. One aspect concerns *what is represented* in a propositional attitude. The other aspect concerns *how we represent*. Contemporary views reflect each motivation, so I briefly outline them.

WHAT IS REPRESENTED: In believing that Sam flies, one is related to the complex state of the world that Sam flies, involving Sam and the property of flying. In believing that Sam loves Terry, one is likewise related to the state of the world that Sam loves Terry, involving Sam, Terry, and the relation of loving. According to this view, structured propositions just are the states of the world that we believe to obtain. Russell and Moore called such states of the world *propositions*.¹³

HOW WE REPRESENT: Russell (1906a, 1913/1992) came to adopt an alternative view according to which

¹²See (Mates 1952).

¹³Russell (1904, pp. 75-6) held that a fact—such as the fact that Sam loves Terry—is just a true structured proposition. In characterizing his view from (Moore 1899), Moore (1953, 284-5) describes the worldly fact that lions exist as ‘the possession by the *proposition* “that lions exist” of one simple property’, namely truth. Even Frege (1918, p. 342) claims that a fact is a true thought. Recently, Richard (2014, p. 3) has defended a similar position.

an agent represents the individuals her attitude is about *directly*.¹⁴ In believing that Sam flies, one stands in a relation to Sam and the property of flying and *attributes* this property to Sam. To believe that Sam loves Terry, one must attribute the loving relation to Sam and Terry in that order. There need not be any single entity believed to obtain. Rather, the attitude state itself is a complex involving the various objects and properties it is about. A structured proposition is analyzed in terms of or identified with an attitude state. Recently, Soames (2010b), Moltmann (2003), and Hanks (2011) have defended views of this sort. King (1995; 2007) defends a related view according to which agents stand in a relation mediated by a linguistic item to the various objects and properties the belief is about.

Both the complex state of the world that Sam flies and the mental act ascribing flying to Sam somehow involve Sam and flying. The mode of combination of individuals into either a complex state of the world or an attitude raises deep metaphysical questions.¹⁵ But what is important for my purposes is that this structure can be formally characterized. Proponents of structured propositions commonly represent this structure using set theoretic n -tuples.¹⁶ The proposition that Sam flies predicates flying of Sam. This may be represented as $\langle \textit{Flying}, \langle \textit{Sam} \rangle \rangle$. Similarly, the proposition that Sam loves Terry can be represented as: $\langle \textit{Loving}, \langle \textit{Sam}, \textit{Terry} \rangle \rangle$. These set theoretic representations should not be taken too seriously. They are only devices for displaying the constituency structure of propositions.

2 The Standard Propositional Semantics

If structured propositions are the compositional semantic values of sentences expressing them (in context), then a semantic theory for a language L must map each sentence S of L (in context c) to a structured proposition p . If the language is learnable, then this mapping should be recursively specifiable.

Of course, one might ask after the truth conditions of the sentences of L .¹⁷ The proponent of structured propositions specifies these in terms of the truth conditions of the propositions they express. Thus, the truth conditions of a sentence are specified in a two-stage process: a semantic theory and a metaphysics of truth.

Semantic Theory: Each sentence S is mapped to structured proposition p via a recursively specifiable procedure.

Metaphysics of Truth: Propositions are assigned truth conditions by a T-sentence of the form: the proposition that p is true if and only if ϕ .

¹⁴Moore (1953) rejects his previous view of belief but doesn't quite endorse a replacement.

¹⁵See Keller (2014) for some specific proposals and criticisms.

¹⁶See, for instance, Salmon (1986, Appendix A) and Soames (1987). Note, $n \geq 1$, so $\langle \textit{Sam} \rangle$ counts as a 1-tuple.

¹⁷'Semantics with no treatment of truth conditions is not semantics' (Lewis 1970, p. 18).

I will outline a standard semantics incorporating structured propositions, of the sort in Salmon (1986, Appendix A) and Soames (1987). This semantics assigns propositional constituents as the semantic values of simple expressions. It specifies the proposition expressed by a sentence in terms of the propositional constituents expressed by its constituent vocabulary and the mode of combination of this vocabulary. Some advocates of structured propositions such as King (1995, pp. 527-8; 2007, pp. 218-222) disagree about details of this semantics. But they agree on the central point that semantic composition paradigmatically involves some sort of ‘combination’ or ‘pairing’ rather than functional application. It is this common principle I reject.

I then examine the metaphysics of truth. If propositions are worldly states of affairs, one may think of the metaphysics of truth as specifying the conditions under which the state of affairs *is the case*. If propositions are attitude states, then the metaphysics of truth specifies when this attitude state *corresponds to a fact*. The truth-value of a proposition is determined by whether its constituents are arranged in the right way. The proposition that Sam flies is true just in case Sam *instantiates* the property of flying. Similarly, the proposition that Sam loves Terry is true just in case Sam stands in the loving relation to Terry.¹⁸

2.1 The Semantic Theory

Standard proponents of structured propositions offer a semantics for the regimented languages such as the language of first-order logic with a belief operator ‘ BEL_α ’.¹⁹ They rarely describe how to extend this semantics to natural language. The standard propositionalist semantics says that a simple atomic sentence formed by combining an n -ary predicate such as L^2 (for ‘loves’) with n constants such as s and t (for ‘Sam’ and ‘Terry’) expresses the proposition that predicates the relation expressed by the predicate ($\llbracket L^2 \rrbracket$) of the sequence of individuals denoted by the names. Thus, $\llbracket L^2 st \rrbracket = \langle \llbracket L^2 \rrbracket, \langle \llbracket s \rrbracket, \llbracket t \rrbracket \rangle \rangle$.

Propositional connectives such as ‘and’ (&) and ‘not’ (\neg) are modeled as expressing properties of and relations between propositions such as negation (*NEG*) and conjunction (*CONJ*). Such a model introduces potentially uncomfortable *logical objects* into our ontology.²⁰ But many are willing to live with this discomfort. Since my concern is semantics, I will not dwell on the issue.

¹⁸I say that the second stage is *metaphysics* and not *semantics* because it is sometimes said that semantic theories appealing to structured propositions are merely *translational*. A translational semantic theory defers the genuine semantics by translating sentences of a target language into another language, a *semantic markerese* (Lewis 1970, pp. 18-9). However, one cannot infer from the fact that a semantic theory assigns semantic values to sentences that are distinct from truth-values that the semantic theory is *translational*. Just as the proponent of structured propositions must specify the conditions under which a given structured proposition is true, the proponent of intensional semantics must specify that a sentence is true if it is true at the privileged point of evaluation. See also (Blanchette 2012, chapter 6).

¹⁹This includes Salmon (1986, Appendix A), Soames (1987), and King (2007, pp. 218-222).

²⁰Russell (1905a, p. 479) says that in thought we have acquaintance with ‘objects of a more abstract logical character’.

The treatment of quantification further complicates the story. Standard structured propositionalists follow Russell’s idea that a quantifier such as ‘some x ’ or ‘every x ’ predicates something of a propositional function, an entity which maps individuals to propositions.²¹ These propositional functions are expressed by complex predicates. A complex predicate can be formed by prefixing an open sentence ϕ with the expression ‘is such that’ (in English) or by a circumflexed variable $\hat{\alpha}$ in the formalism.²² In order to explain the semantic value of a complex predicate $\hat{\alpha}\phi$ in terms of the semantic value of ϕ , the semantics relativizes the semantic value of an expression to an assignment of values to variables. The complex predicate denotes a function from individuals to propositions. In particular, $\hat{\alpha}\phi$ denotes the function that takes an individual o as argument and returns as its value the proposition expressed by ϕ with the variable α assigned to o . Soames (2008) and Salmon (2010, p. 465) hold that a quantified sentence attributes the property of being instantiated or being universally instantiated to a propositional function.

Assuming a standard syntax, the basic semantics—drawn from Salmon (1986, Appendix A) and Soames (2003, pp. 102-6)—is as follows.

SEMANTICS:

Basic Vocabulary:

Variables: $\llbracket x_i \rrbracket^\sigma = \sigma_i$

Constants: If α is a constant, $\llbracket \alpha \rrbracket^\sigma = I(\alpha)$

Predicates:

Basic: Where π is a basic predicate, $I(\pi)$ is a property and $\llbracket \pi \rrbracket^\sigma = I(\pi)$

Complex: If ϕ is a sentence and α a variable, then $\llbracket \hat{\alpha}\phi \rrbracket^\sigma = \lambda o \llbracket \phi \rrbracket^{\sigma[\alpha/o]}$

Sentences:

Atomic: Where π is an n -ary basic and $\alpha_1, \dots, \alpha_n$ are terms:

$$\llbracket \pi\alpha_1 \dots \alpha_n \rrbracket^\sigma = \langle I(\pi), \langle \llbracket \alpha_1 \rrbracket^\sigma, \dots, \llbracket \alpha_n \rrbracket^\sigma \rangle \rangle$$

Molecular: Where ϕ and ψ are formulae, π is a complex predicate, and β a term:

$$\llbracket \phi \wedge \psi \rrbracket^\sigma = \langle CONJ, \langle \llbracket \phi \rrbracket^\sigma, \llbracket \psi \rrbracket^\sigma \rangle \rangle$$

$$\llbracket \neg\phi \rrbracket^\sigma = \langle NEG, \langle \llbracket \phi \rrbracket^\sigma \rangle \rangle$$

²¹(Russell 1905a, p. 480).

²²(Russell 1903/1996, §§80-1).

$$\begin{aligned} \llbracket \forall \pi \rrbracket^\sigma &= \langle ALL, \langle \llbracket \pi \rrbracket^\sigma \rangle \rangle \\ \llbracket \exists \pi \rrbracket^\sigma &= \langle SOME, \langle \llbracket \pi \rrbracket^\sigma \rangle \rangle \\ \llbracket BEL_\beta \phi \rrbracket^\sigma &= \langle I(BEL), \langle \llbracket \beta \rrbracket^\sigma, \llbracket \phi \rrbracket^\sigma \rangle \rangle \end{aligned}$$

Complex Predication:²³ If ϕ is a sentence, α is a variable, and β is a term, then $\llbracket \hat{\alpha}\phi(\beta) \rrbracket^\sigma = \llbracket \hat{\alpha}\phi \rrbracket^\sigma(\llbracket \beta \rrbracket^\sigma)$

The axioms above deliver the result that even logically equivalent sentences do not substitute *salva veritate* in belief ascriptions. The sentences ‘Sam flies’ and ‘Sam flies and Sam’s father existed’ (or, rather, their regimentations into the language of first-order logic) express different propositions. As a result, embedding them under ‘Terry believes that’ (BEL_{Terry}) yields sentences that do not express the same proposition. Thus, (1) ‘Terry believes that Sam flies’ and (2) ‘Terry believes that both Sam flies and Sam’s father existed’ do not express the same proposition on this semantics. Given the assignment of truth conditions in the next section, one of these sentences may be true while the other is false.

2.2 The Metaphysics of Truth

Every sentence of the language of first-order logic has been assigned a proposition as its compositional semantic value. The next step is to assign a truth-value to every proposition. The basic condition is that a proposition attributing a relation R to a sequence of n objects is true just in case the sequence of objects instantiate the relation.

Relation: The proposition $\langle R, \langle a_1, \dots, a_n \rangle \rangle$, combining an n -ary relation, R , with a sequence of n objects, $\langle a_1, \dots, a_n \rangle$ is true just in case a_1, \dots, a_n (in that order) instantiate R .

The semantics invokes specific properties and relations such as *NEG*, *CONJ*, *ALL*, and *SOME*. These call for special axioms.

CONJ: p and q instantiate *CONJ* if and only if p is true and q is true.

NEG: p instantiates *NEG* if and only if p is not true.

²³This paper follows Kripke’s (2005, p. 1025, footnote 45) Russell-inspired simple semantics, according to which a complex predication $\hat{\alpha}\phi(\beta)$ expresses the same proposition as its reduction $\phi[\alpha/\beta]$. Salmon (1986, Appendix A; 2010) and Soames (1987) disagree, arguing that a complex predication $\hat{\alpha}\phi(\beta)$ expresses a proposition composed of the propositional function expressed by $\hat{\alpha}\phi$ and the referent of β . Their position can be formalized as follows.

Complex Predication (Salmon/Soames): If ϕ is a sentence, α is a variable, and β is a term, then $\llbracket \hat{\alpha}\phi(\beta) \rrbracket^\sigma = \langle \llbracket \hat{\alpha}\phi \rrbracket^\sigma, \langle \llbracket \beta \rrbracket^\sigma \rangle \rangle$.

I follow Kripke’s regimentation, because it simplifies my presentation when I offer a type-driven compositional semantics for natural language.

ALL: f instantiates *ALL* if and only if for all a , $f(a)$ is a true proposition.

SOME: f instantiates *SOME* if and only if for some a , $f(a)$ is a true proposition.

Combining the semantics assigning propositions to sentences with the metaphysical theses assigning propositions to their truth-values, one can recursively specify the truth conditions of each sentence of the language.

3 Functional Compositionality

The standard propositionalist semantics has many virtues. It is *recursively specified* in that it assigns semantic features to the primitive expressions and semantic rules for the features of complex expressions in terms of the features of their components. Moreover, substituting an expression for a synonym in a complex expression always yields a new complex that is synonymous with the original.²⁴ Call this last feature the *substitutivity principle*, following Szabó (2000). These features jointly suggest a picture on which the meaning of a complex expression is determined by the meanings of its basic expressions and their arrangement. That is, these features hint at a *compositional* semantic theory, where compositionality is an aspiration and regulative norm of semantic theorizing.²⁵

Unfortunately, many semantic theories that are far less constrained share the virtues of the propositionalist semantics. Recursive specification is a rather modest goal. As Szabó (2000) argues, so is the substitutivity principle. It is trivially satisfied, for instance, by any theory that contains no synonyms. An interesting notion of compositionality must be paired with requirements on the semantic values of the expressions at the lexical base. (See e.g. Dever 1999: §6.) But even this is not enough. Szabó (2000, p. 485) also notes that a semantic theory switching the meaning of two atomic sentences (say ‘Sam flies’ and ‘Jane runs’) satisfies the substitutional principle so long as part-wise synonymous sentences are also suitably switched.²⁶ In particular, we could have two semantic theories—represented by $\llbracket \cdot \rrbracket_1$ and $\llbracket \cdot \rrbracket_2$ —which assign the same semantic values to the words, but different assignments to the sentences as follows.

Names: $\llbracket \text{Sam} \rrbracket_1 = \llbracket \text{Sam} \rrbracket_2$ and $\llbracket \text{Jane} \rrbracket_1 = \llbracket \text{Jane} \rrbracket_2$

Predicates: $\llbracket \text{flies} \rrbracket_1 = \llbracket \text{flies} \rrbracket_2$ and $\llbracket \text{runs} \rrbracket_1 = \llbracket \text{runs} \rrbracket_2$

Sentences: $\llbracket \text{Sam flies} \rrbracket_1 = \llbracket \text{Jane runs} \rrbracket_2$ and $\llbracket \text{Jane runs} \rrbracket_1 = \llbracket \text{Sam flies} \rrbracket_2$

²⁴I put aside complications having to do with variable binding until §7.

²⁵Issues of compositionality in formal semantics are discussed in Montague (1974b), Partee (2008a), Janssen (1997), Dever (1999), and Pagin and Westeråhl (2010a,b).

²⁶Szabó (2000, p. 491) describes even wilder semantic theories that are compatible with the substitution principle.

That is, even holding fixed the interpretation of the lexical base (‘Sam’, ‘flies’, ‘Jane’, and ‘runs’), the substitution principle fails to constrain the semantic values of the complex expressions.

In light of this sort of trivialization argument, Dever (2006, §26.1.1) infers that compositionality must be formulated more restrictively so that only certain compositional rules are permitted. Consider a complex expression E_1E_2 . Dever’s idea is that the semantic value of this expression, $\llbracket E_1E_2 \rrbracket$, must be determined as a function f from a restricted range of possible functions on the semantic values of E_1 and E_2 . That is, $\llbracket E_1E_2 \rrbracket = f(\llbracket E_1 \rrbracket, \llbracket E_2 \rrbracket)$, and f is one of a small class of functions.

Dever suggests that the Montagovian tradition in particular is characterized by the assumption that functional application is the *only* semantic composition rule: the semantic value of a whole is always the result of applying the semantic value of one constituent expression to the semantic value of the other component, so long as it is of the right type. That is: $\llbracket E_1E_2 \rrbracket = \llbracket E_1 \rrbracket(\llbracket E_2 \rrbracket)$. This would rule out the difference in the semantic theories considered above, because if $\llbracket \text{Sam} \rrbracket_1 = \llbracket \text{Sam} \rrbracket_2$ and $\llbracket \text{flies} \rrbracket_1 = \llbracket \text{flies} \rrbracket_2$, then $\llbracket \text{Sam flies} \rrbracket_1 = \llbracket \text{flies} \rrbracket_1(\llbracket \text{Sam} \rrbracket_1) = \llbracket \text{flies} \rrbracket_2(\llbracket \text{Sam} \rrbracket_2) = \llbracket \text{Sam flies} \rrbracket_2$.

A precise formulation requires a bit of type theory. Let the types be e which includes individuals and t which includes truth-values. The compositional semantic value of each basic expression is an entity in a basic category or a function defined in terms of these basic categories, characterized in the typed λ -calculus. The type which contains functions from type a to b is (a, b) . Following Heim and Kratzer, to indicate that an entity x is of type α , I write $x \in D_\alpha$.²⁷

Entities of the various types are then assigned as the compositional semantic values of the basic expressions of the language. Functional compositionality can then be formulated as follows, where σ is a sequence.²⁸

Functional Composition: If α is a node with branches β and γ and the saturated compositional semantic value of β , $\llbracket \beta \rrbracket^\sigma$, is in the domain of the saturated compositional semantic value of γ , $\llbracket \gamma \rrbracket^\sigma$, then the saturated compositional semantic value of α , $\llbracket \alpha \rrbracket^\sigma$, is the result of applying $\llbracket \gamma \rrbracket^\sigma$ to $\llbracket \beta \rrbracket^\sigma$, or $\llbracket \alpha \rrbracket^\sigma = \llbracket \gamma \rrbracket^\sigma(\llbracket \beta \rrbracket^\sigma)$.²⁹

Dever is right that the *paradigm* of functional compositionality is at the heart of many traditional works in the Montagovian tradition. For instance, in one of the founding works, Lewis (1970, p. 30) argued that Carnapian intensional semantics compares unfavorably to a broadly Montagovian one because Carnap’s semantics required ‘a miscellany of semantic projection rules rather than the uniform function-and-argument rule.’ Under a semantics whose only (or most dominant) composition rule is functional application, the

²⁷ D_α can be thought of as the domain of entities of type α . But if one wants to refrain from assuming that entities must be included in domains, one could simply read $x \in D_\alpha$ as saying that x is of type α .

²⁸Following (Heim and Kratzer 1998, rule (5), p. 49).

²⁹See, for instance, the rule for branching nodes in (Heim and Kratzer 1998, p. 95).

semantic values assigned to the expressions at the lexical base imposes much more stringent requirements on the interpretation of complex expressions, thus responding to the trivialization worry.

This is *not* to say that semanticists in the Montagovian tradition never depart from type-driven functional application. Indeed, I examine one rather prominent departure in §7. But still, functional compositionality is a ‘leading idea’ in formal semantics originating from Montague (Heim and Kratzer 1998, p. 13). I take it to be the *core* model of semantic composition.³⁰ Exceptions to the general principle are treated as theoretical costs payable in additional explanatory strength. Formal semanticists who reject Montague’s analysis often concede that positing special rules accounting for specific constructions is a theoretical cost. They argue, however, that the rules they posit are the most powerful generalizations available with the fewest exceptions. Thus, the default preference for a uniform type assignment to every expression proves a tool for theory choice in formal semantics.

The advantage of minimizing the departures from functional compositionality is that fixing the semantic value for one type of expression puts tighter constraints on the semantic values of other types of expression. Dever (2012: 69) says: ‘Because a formal semantic theory seeks a close alignment between syntactic structure of expressions and the calculation of semantic values of those expressions, it becomes possible for evidence that bears directly on syntactic theories to bear indirectly on semantic theories, and improve methodological tools for confirming or disconfirming those theories.’ Dever uses the example of verb phrases. Once a semantic type has been assigned to noun phrases and to sentences, there are tight constraints on the available meanings for verb phrases. Jacobson (1996, p. 90) agrees. She says: ‘The particular combinatorics used by the semantics at any point is a mirror of the syntactic combinatorics; given the syntax one can “read off” the semantics.’³¹ Thus, empirical evidence arising from syntax has immediate consequences for semantic values in light of the general constraints imposed by functional compositionality. These arguments are less persuasive if the semantics allows more departures from functional compositionality.

The standard structured propositionalists rarely address this strength of the Montagovian program. For them, the substitution principle is virtually guaranteed by the background mathematics of composition: if two complex expressions are composed of expressions with distinct semantic values or are arranged differently, then the wholes themselves have the distinct semantic values. Thus, there are sufficiently many sentence meanings to distinguish almost any construction. There is almost no risk of a violation of the substitutivity principle. Horwich says that given this type of composition rule:

³⁰See (Dowty et al. 1981, p. 92 rule (2) and p. 181 rule (4)) and (Heim and Kratzer 1998, rule (5), p. 49), and (Montague 1974a, p. 258 rule (4)).

³¹Jacobson illustrates this point using Montague’s (1974a) assimilation of the meaning of proper names to the meanings of determiner phrases.

compositionality imposes no constraint on how the meaning properties of the primitives are constituted. (Horwich 1997, p. 509)

King and Stanley (2005, pp. 129 and 134) argue that this type of trivial composition rule threatens to trivialize semantics.³² Thus, the vast majority of constructions invoke a trivial composition rule in the semantics above. It is hard to see how their model of compositionality can generate the same sort of theoretical traction as the Montagovian model.

4 Functional Compositionality with Structured Propositions

Specific semantic theories in the Montagovian tradition fall short of the ideal of total functional compositionality. But, functional compositionality provides discipline to semantic theory. Abandoning both functional compositionality and intensional semantics threatens to overturn the fruitful results of this program.

For this reason, structured propositionalists should accept type-driven functional application as their primary semantic composition rule. Current semantic frameworks incorporating structured propositions should be treated on analogy with the early intensional semantics of Carnap which assigned every expression to an intension (function from worlds to extensions). Lewis replaced these Carnapian intensions with compositional intensions (functions from the meanings of other expressions into sentence meanings). I propose something similar. The proponents of structured propositions were right to think that, in the ideal case, an expression corresponds to a propositional constituent. But that doesn't mean that the propositional constituent is the expression's compositional semantic value. The compositional semantic value of, say, an intransitive verb is a function from the compositional semantic value of a noun phrase into the compositional semantic value of a sentence. Other expressions can be treated similarly. In this section, I outline a semantics within this framework first for the language of first-order logic and then for natural language. This semantics shares the typing constraints with Montague semantics.

Before proceeding, I need to address two issues. First, some philosophers write as if it is essential to structured propositions that they are composed of the semantic values of the constituents of sentences expressing them. Yet, the tradition of structured propositions began by considering the objects of thought and judgment, and not the meanings of sentences. The early structured propositionalists frequently denied that these propositions mirrored the structure of sentences that express them.³³ This denial became most

³²See also (Johnson 2015, §4a).

³³(Moore 1900, pp. 120-1) suggests 'mind is identical to mind' expresses the proposition that mind is a subject. For discussion of Russell, see (Makin 2000, chapter 3 §§3-7), (Macbride 2012), and (Pickel 2013). This goes against Hylton (1990) who says that language is *transparent* prior to Russell's theory of descriptions.

self-conscious in (Russell 1905a). Given this history, it is implausible to simply define structured propositionalism in this way. Moreover, just as Carnapian intensions can sometimes be reconstructed from Lewis's compositional intensions, the propositional constituent corresponding to an expression is, in many cases, extractable from its compositional semantic value.

The second issue is more technical. The basic semantic types in Montague semantics are individuals e and truth-values t . The latter are the semantic values of sentences (relative to parameters). The present semantics has propositions as the semantic values of sentences. These are of a different semantic type, p for proposition.³⁴

4.1 The language of first-order logic

The idea is to identify the compositional semantic value of a functional expression with a function from a relevant argument type onto a proposition. This suggests the following semantic clauses for the vocabulary of the language of first-order logic.

Terms:

Variables: $\llbracket x_i \rrbracket^\sigma = \sigma_i$

Constants: If α is a constant, $\llbracket \alpha \rrbracket^\sigma = I(\alpha)$

Predicates:

Basic: If π is a basic n -ary predicate, $\llbracket \pi \rrbracket^\sigma = \lambda o_1, \dots, o_n \in D \langle I(\pi), \langle o_1, \dots, o_n \rangle \rangle$

Complex Predicates: If ϕ is a sentence and α is a variable, then $\llbracket \hat{\alpha}\phi \rrbracket^\sigma = \lambda o \in D \llbracket \phi \rrbracket^{\sigma[\alpha/o]}$

Connectives:

$\llbracket \wedge \rrbracket = \lambda q, r \in D_p \langle CONJ, \langle q, r \rangle \rangle$

$\llbracket \neg \rrbracket = \lambda q \in D_p \langle NEG, \langle q \rangle \rangle$

$\llbracket BEL \rrbracket = \lambda o \in D_e \lambda q \in D_p \langle I(BEL), \langle o, q \rangle \rangle$

$\llbracket \forall \rrbracket = \lambda g \in D_{(e,p)} \langle ALL, \langle g \rangle \rangle$

$\llbracket \exists \rrbracket = \lambda g \in D_{(e,p)} \langle SOME, \langle g \rangle \rangle$

³⁴A third issue: Cresswell (2002) argues against structured propositionalism taking functional compositionality as a premise. King (2007, pp. 111-120) follows him in finding these two positions to be incompatible. But Cresswell's (2002, p. 649) argument requires an additional controversial premise: 'that negation is an operator which does no more than reverse truth values.'

One slight complication (to be removed when I advance to natural language) is that not every complex expression of this language is formed by the merging of two constituent nodes. So, the semantic composition rules must be construction specific. But in every case (except for complex predicates, discussed in §7), the semantic composition rules mandate applying the semantic value of the dominant functional connective to the semantic values of its arguments as follows.³⁵

Sentences:

Atomic: Where π is an n -ary basic or complex predicate and $\alpha_1, \dots, \alpha_n$ are terms:

$$\llbracket \pi \alpha_1 \dots \alpha_n \rrbracket^\sigma = \llbracket \pi \rrbracket^\sigma (\llbracket \alpha_1 \rrbracket^\sigma, \dots, \llbracket \alpha_n \rrbracket^\sigma)$$

Molecular: Where ϕ and ψ are formulae, π is a complex predicate, and β is a term,

$$\llbracket \phi \wedge \psi \rrbracket^\sigma = \llbracket \wedge \rrbracket (\llbracket \phi \rrbracket^\sigma, \llbracket \psi \rrbracket^\sigma)$$

$$\llbracket \neg \phi \rrbracket^\sigma = \llbracket \neg \rrbracket (\llbracket \phi \rrbracket^\sigma)$$

$$\llbracket BEL_\beta \phi \rrbracket^\sigma = \llbracket BEL \rrbracket^\sigma (\llbracket \beta \rrbracket^\sigma, \llbracket \phi \rrbracket^\sigma)$$

$$\llbracket \forall \pi \rrbracket^\sigma = \llbracket \forall \rrbracket (\llbracket \pi \rrbracket^\sigma)$$

$$\llbracket \exists \pi \rrbracket^\sigma = \llbracket \exists \rrbracket (\llbracket \pi \rrbracket^\sigma)$$

The semantics for first-order languages already reveals how typing constraints can be imposed on a propositionalist semantics. It thus takes a step towards bringing semantic theories incorporating structured propositions into line with developments in natural language semantics.

4.2 Natural language

Extending this basic framework to a fragment of natural language issues in a semantics very similar to the standard Montagovian semantics. Provisionally, I treat names as denoting basic entities of type e . Common nouns and intransitive verbs denote one-place propositional functions. Transitive verbs (my treatment of which mirrors Elbourne 2011, pp. 104-7) denote two-place propositional functions. Going beyond the simple constructions, determiners may be treated as schönfinkelized functions from pairs of propositional functions to propositions. The semantic axioms for some basic lexical items of each kind may be stated as follows.

Proper Names (PN)

³⁵To simplify the presentation, I write $f(a, b)$ for $(f(a))(b)$ when a is of type α , b is of type β , and f is of type $(\alpha, (\beta, \gamma))$. The simplification will be dispensed with when we deal with the semantics for natural language in which all syntactic branching will be treated as binary.

$$\llbracket \text{Sam} \rrbracket^\sigma = \text{Sam}$$

$$\llbracket \text{Terry} \rrbracket^\sigma = \text{Terry}$$

Nouns (N):

$$\llbracket \text{Engineer} \rrbracket^\sigma = \lambda o \in D_e \langle \text{Engineer}, \langle o \rangle \rangle$$

Intransitive Verbs (IV):

$$\llbracket \text{fly} \rrbracket^\sigma = \lambda o \in D_e \langle \text{Flying}, \langle o \rangle \rangle$$

$$\llbracket \text{sit} \rrbracket^\sigma = \lambda o \in D_e \langle \text{Sitting}, \langle o \rangle \rangle$$

Transitive Verbs (TV):

$$\llbracket \text{love} \rrbracket^\sigma = \lambda o, o' \in D_e \langle \text{Loving}, \langle o', o \rangle \rangle$$

Quantifiers:³⁶

$$\llbracket \text{Every} \rrbracket^\sigma = \lambda g, g' \in D_{(e,p)} \langle \text{ALL}, \lambda x_i (\langle \rightarrow, \langle g(x_i), g'(x_i) \rangle \rangle) \rangle$$

$$\llbracket \text{A} \rrbracket^\sigma = \lambda g, g' \in D_{(e,p)} \langle \text{SOME}, \lambda x_i (\langle \text{CONJ}, \langle g(x_i), g'(x_i) \rangle \rangle) \rangle$$

Attitude:³⁷

$$\llbracket \text{Believes} \rrbracket^\sigma = \lambda q \in D_p \lambda o \in D_e \langle \text{BEL}, \langle o, p \rangle \rangle$$

The determiners ‘a’ and ‘every’ make use of the same underlying propositional structure as is offered by the standard semantics. Hence, the truth conditions for a proposition expressed by a sentence of the language above can be evaluated as before.

Other determiners such as ‘most’ will require more complex propositional structure: binary relations between propositional functions. The lexical entry for ‘most’ might then be as follows:

$$\llbracket \text{Most} \rrbracket^\sigma = \lambda g, g' \in D_{(e,p)} \langle \text{MOST}, \langle g, g' \rangle \rangle$$

³⁶Let ‘ \rightarrow ’ be the material conditional.

³⁷Because natural language branching is binary, it is natural to regard the natural language expression ‘believes’ as first forming a verb phrase with the ‘that’-clause of a belief ascription which is then merged with the subject term. This reverses the order of application from the language of first-order logic with the usual syntax.

The relation *MOST* requires an additional axiom to specify the truth conditions of propositions that contain it. This axiom might take the form: the relation *MOST* holds between propositional functions g and g' when the cardinality of $\{x|g(x) \text{ is true}\} \cap \{x|g'(x) \text{ is true}\}$ is greater than the cardinality of $\{x|g(x) \text{ is true}\} - \{x|g'(x) \text{ is true}\}$.³⁸

Semantic evaluation proceeds as follows. Non-branching nodes on a syntactic tree inherit their semantic values from their immediate constituents.³⁹ The semantic value of a branching node is the result of applying the function denoted by one constituent to the semantic value denoted by the other. More formally:

Functional Composition: $\left[\left[\begin{array}{c} \alpha \\ \beta \quad \gamma \end{array} \right] \right]^\sigma = \llbracket \beta \rrbracket^\sigma (\llbracket \gamma \rrbracket^\sigma)$, if $\llbracket \gamma \rrbracket^\sigma$ is in the domain of $\llbracket \beta \rrbracket^\sigma$.

Given this semantics, the proponent of structured propositions has re-created the type-driven functional application rule deployed in Montague semantics. The generality, unity, empirical traction, and explanatory power of can be carried over unaffected.

Here are some derivations to illustrate that semantic composition works exactly as in Montague semantics. Consider the derivation of the structured proposition expressed by a simple sentence such as ‘Sam flies’.

$$\left[\left[\begin{array}{c} \text{Sam flies} \\ \text{NP} \quad \text{VP} \\ \text{Sam} \quad \text{flies} \end{array} \right] \right]^\sigma = \llbracket \text{flies} \rrbracket^\sigma (\llbracket \text{Sam} \rrbracket^\sigma) = \lambda o \langle \text{Flying}, \langle o \rangle \rangle (\text{Sam}) = \langle \text{Flying}, \langle \text{Sam} \rangle \rangle$$

The derivation proceeds by applying the semantic value of ‘flies’ to the semantic value of ‘Sam’ to yield the same result as the standard propositionalist semantics. But this derivation employs only one non-trivial semantic composition rule.

Determiners work as in Montague semantics. A determiner first combines with a noun such as ‘engineer’ to form a determiner phrase such as ‘every engineer’ as follows.

$$\left[\left[\begin{array}{c} \text{every engineer} \\ \text{D} \quad \text{N} \\ \text{every} \quad \text{engineer} \end{array} \right] \right]^\sigma = \llbracket \text{every} \rrbracket^\sigma (\llbracket \text{engineer} \rrbracket^\sigma)$$

³⁸(Heim and Kratzer 1998, §5.5.2). Standard structured propositionalists must appeal to similar resources when they leave the realm of first-order logic. See (Soames 2010a: §1.22).

³⁹See (Heim and Kratzer 1998, p. 16).

$$\begin{aligned}
&= \lambda g, g' \in D_{(e,p)} \langle ALL, \langle \lambda x_i (\langle \rightarrow, \langle g(x_i), g'(x_i) \rangle) \rangle \rangle (\lambda o \in D_e \langle \text{Engineer}, \langle o \rangle \rangle) \rangle \\
&= \lambda g' \in D_{(e,p)} \langle ALL, \langle \lambda x_i (\langle \rightarrow, \langle \lambda o \langle \text{Engineer}, \langle o \rangle \rangle (x_i), g'(x_i) \rangle) \rangle \rangle \rangle \\
&= \lambda g' \in D_{(e,p)} \langle ALL, \langle \lambda x_i (\langle \rightarrow, \langle \langle \text{Engineer}, \langle x_i \rangle \rangle, g'(x_i) \rangle) \rangle \rangle \rangle
\end{aligned}$$

It can then be attached to a predicate as follows.

$$\begin{array}{c}
\left[\begin{array}{c}
\text{Every engineer sits} \\
\swarrow \quad \searrow \\
\text{DP} \quad \text{VP} \\
\swarrow \quad \searrow \quad | \\
\text{D} \quad \text{N} \quad \text{sits} \\
| \quad | \\
\text{every} \quad \text{engineer}
\end{array} \right]^\sigma = \llbracket \text{every engineer} \rrbracket^\sigma (\llbracket \text{sits} \rrbracket^\sigma) \\
= \langle ALL, \langle \lambda x_i (\langle \rightarrow, \langle \langle \text{Engineer}, \langle x_i \rangle \rangle, \langle \text{Sitting}, \langle x_i \rangle \rangle) \rangle \rangle \rangle.^{40}
\end{array}$$

It should be clear that the structure of the derivations resemble those in Montague semantics for this fragment of English almost exactly.

Moving finally to ‘believes’, the present view takes a belief ascription to express a proposition relating a subject to the structured proposition expressed by the sentence in the complement clause, as in the standard propositionalist semantics. In natural language, a belief ascription such as ‘Terry believes that Sam flies’ contains the complementizer ‘that’ combined with a sentence ‘Sam flies’. I suppose $\llbracket \text{that Sam flies} \rrbracket^\sigma = \llbracket \text{Sam flies} \rrbracket^\sigma$.⁴¹ Given this, the proposition expressed by ‘Terry believes that Sam flies’ can be derived as follows.

$$\begin{array}{c}
\left[\begin{array}{c}
\text{Terry believes that Sam flies} \\
\swarrow \quad \searrow \\
\text{PN} \quad \text{VP} \\
| \quad \swarrow \quad \searrow \\
\text{Terry} \quad \text{TV} \quad \text{CP} \\
\quad | \quad | \\
\quad \text{believes} \quad \text{that Sam flies}
\end{array} \right]^\sigma \\
= \llbracket \text{believes} \rrbracket^\sigma (\llbracket \text{that Sam flies} \rrbracket^\sigma) (\llbracket \text{Terry} \rrbracket^\sigma)
\end{array}$$

⁴⁰The intermediate steps are:

$$\begin{aligned}
&= \lambda g' \in D_{(e,p)} \langle ALL, \langle \lambda x_i (\langle \rightarrow, \langle \langle \text{Engineer}, \langle x_i \rangle \rangle, g'(x_i) \rangle) \rangle \rangle (\lambda o \langle \text{Sitting}, \langle o \rangle \rangle) \rangle \\
&= \langle ALL, \langle \lambda x_i (\langle \rightarrow, \langle \langle \text{Engineer}, \langle x_i \rangle \rangle, \lambda o \langle \text{Sitting}, \langle o \rangle \rangle (x_i) \rangle) \rangle \rangle \rangle.
\end{aligned}$$

⁴¹This follows the treatment of ‘*that_o*’ in (Cresswell 1985, p. 102). More specifically, I suppose that the lexical entry for the complementizer ‘that’ is: $\llbracket \text{that} \rrbracket^\sigma = \lambda p . p$.

$$\begin{aligned}
&= \lambda o \in D_e \langle BEL, \langle o, \llbracket \text{that Sam flies} \rrbracket^\sigma \rangle \rangle (\llbracket \text{Terry} \rrbracket^\sigma) \\
&= \langle BEL, \langle \text{Terry}, \langle \text{Flying}, \langle \text{Sam} \rangle \rangle \rangle \rangle
\end{aligned}$$

Given that a belief ascription expresses a proposition relating a subject to the structured proposition expressed by the sentence embedded in the ‘that’-clause, one should not expect sentences that express different structured propositions to substitute *salva veritate* in attitude constructions.

5 Consequences of Typing

This strategy shows that structured propositionals may reap the benefits of type-driven functional application as a single semantic composition rule. I will now explore some benefits of incorporating typing into a structured propositionalist framework. Specifically, the semantics allows proponents of structured propositions to better model predication and to engage with the methodology of standard semantics.

5.1 Schiffer on Predication

Schiffer (2003, pp. 29-31) charges that proponents of structured propositions cannot understand predication, the attribution of a predicate term to a subject term. Specifically, if a simple predication such as ‘Sam flies’ denotes a structured proposition $\langle \text{Flying}, \langle \text{Sam} \rangle \rangle$ in ‘Terry believes that Sam flies’, then the the predicate ‘flies’ has no other role than to name the property of flying. As a result, Schiffer charges that the predicate should be an admissible position to quantify into so that ‘there is something such that Terry believes Sam it’ is a true sentence of English. But obviously, it is not a true sentence of English. So, Schiffer concludes that structured propositions are not the semantic values of sentences.⁴² On the functionally compositional semantics above, the predicate ‘flies’ does not denote the property of flying, but rather the function which takes an individual and attributes this property to them: $\lambda o \in D_e \langle \text{Flying}, \langle o \rangle \rangle$. This function does not appear as a constituent in the structured proposition expressed by ‘Sam flies’. So it simply does have a different function from the name ‘Sam’, if the latter is construed as an ordinary referential singular term designating a propositional constituent.

⁴²Schiffer’s argument is more complicated to this. It invokes the premise that ‘that’-clauses are referring expressions. King (2007, pp. 103-106) has responded to this aspect of Schiffer’s argument.

5.2 Assimilating Names to Determiner Phrases

This assumption—that proper names such as ‘Sam’ and ‘Terry’ denote entities of the simplest type, e —was provisional. Montague’s (1974a) own semantics assimilates proper names to determiner phrases such as ‘an engineer’ or ‘every engineer’. In particular, proper names and determiner phrases can be coordinated in constructions such as ‘Terry and an engineer fly’. Assuming that coordinated expressions must be of the same semantic type, Montague concludes that proper names, like determiner phrases, are of type $((e, t), t)$. They take predicate meanings as arguments and output truth-values.

Many structured propositionalists assume that if the Montagovian semantics is correct, then sentences that contain proper names express propositions composed of generalized quantifier meanings rather than the individuals referred to by the names. Thus, Armstrong and Stanley (2011, p. 213) argue that ‘if “[Sam]” is a generalized quantifier, then occurrences of “[Sam is an engineer]” do not express [structured] singular propositions.’ In particular, ‘Sam is an engineer’ does not express a proposition containing the woman, Sam, as a constituent. Rather, Armstrong and Stanley say the relevant proposition contains the generalized quantifier meaning, which is the denotation of the proper name ‘Sam’.

Names in Montagovian Semantics: $\llbracket \text{Sam} \rrbracket = \lambda f \in D_{(e,t)} f(\text{Sam})$

Armstrong and Stanley take this to undermine a motivation for structured propositions since it breaks the link between the objects a sentence is about and the constituents of the proposition it expresses.⁴³

Even Montague’s opponents within formal semantics concede that proper names *sometimes* denote generalized quantifiers. On these views, names generally denote individuals of type e . But in some constructions such as ‘Sam and every engineer’, the name ‘Sam’ shifts to a denotation of a higher type (Partee 2002, p. 376). Thus, the worry is not parochial to Montague’s particular implementation of the typing constraints, but leaves structured propositionalism in tension with any view that takes these typing constraints seriously.

However, this objection presupposes the naïve propositionalist semantics according to which the proposition expressed by a sentence contains the semantic values of the expressions making up the sentence. This consequence does not obtain on the functional semantics given above. This semantics can wholly accommodate Montague’s assimilation of names to determiner phrases without giving up the idea that a proposition expressed by a sentence containing a proper name contains an individual as a constituent.

⁴³Even in his recent criticism of Armstrong and Stanley, King (2015, p. 546) concedes that if Montague is right about proper names, then ‘the Russellian proposition expressed by “John is a philosopher” will contain the function expressed by “John” and the property expressed by the predicate.’ Relatedly, Soames (2010a: p. 71) discusses similar worries which lead him to reject Montague’s analysis of names and concludes that Montague’s ‘strict isomorphism between syntax and semantic[s] motivating the analysis won’t bear the weight placed on it.’

The reason is that generalized quantifiers in the semantic framework above are functions taking predicate meanings as arguments and outputting propositions. A predicate meaning is a function from individuals into propositions. Thus, a proper name will be of type $((e,p),p)$ in the relevant contexts. So, a name can be modeled as a generalized quantifier just as in Montague’s semantics.

Names in Propositionalist Semantics: $\llbracket \text{Sam} \rrbracket = \lambda f \in D_{(e,p)} f(\text{Sam})$

The sentence ‘Sam flies’ is the result of applying the semantic value of ‘Sam’ to the semantic value of ‘flies’, where $\llbracket \text{fly} \rrbracket = \lambda o \in D_e \langle \text{Flying}, \langle o \rangle \rangle$. Putting this together we get the result that:

$$\llbracket \text{Sam flies} \rrbracket^\sigma = \llbracket \text{Sam} \rrbracket^\sigma (\llbracket \text{fly} \rrbracket^\sigma) = \langle \text{Flying}, \langle \text{Sam} \rangle \rangle$$

Thus, the proposition expressed by ‘Sam flies’ is the proposition that contains Sam and flying as constituents, even if the name ‘Sam’ acts as a generalized quantifier.

From the perspective of the present semantics, Montague’s arguments for assimilating proper names to determiner phrases concern how proper names determine the propositions expressed by sentences that contain them. In other terms, these arguments concern the *compositional semantic values* of proper names. Like determiner phrases, proper names take predicate meanings as arguments and output propositions. Armstrong and Stanley attempt to extract a lesson about the *constituents of the proposition* expressed by a sentence containing a proper name from this fact about how a proper name plays a role in *determining* the proposition. This paper has aimed to show that the compositional semantic value of an expression may differ from the constituent, if any, to which the expression corresponds in the proposition expressed by a sentence that contains it.

6 Sentential and Propositional Complexity

Moore and Russell thought that in an ideal or fully analyzed language, every expression corresponds to a constituent of the proposition expressed by a sentence that contains it. Many contemporary structured propositionalists assume that this holds for natural language.⁴⁴ Yet, the present account raises the possibility that some expressions correspond to *no* constituents of structured propositions expressed by sentences that contain them. The possibility came to special salience in Russell (1905a), where Russell argued that determiner

⁴⁴The exceptions—shared by the theories of Salmon and Soames—are quantified sentences which contain only a propositional function and a higher-level attribute. This features is the subject of an objection by King (1995, pp. 527-8). Unfortunately, King’s own theory of the propositions expressed by quantified sentences does not seem to be in good working order. See (Yli-Vakkuri 2013, p. 255).

(‘denoting’) phrases including definite descriptions do not correspond to constituents of the propositions expressed by sentences that contain them. Russell later called such expressions *incomplete symbols*.⁴⁵ He emphasized that the structure of the sentence could differ significantly from the structure of the proposition it expresses. The principle of a tight correspondence between sentential and propositional structure become more of an ideal case rather than the norm.

According to the present semantics, determiner phrases of natural language lack any precise correlates in the structured propositions expressed by sentences that contain them.⁴⁶ In this respect, they are incomplete symbols. However, they do have meaning or content on their own in the sense that they designate second-level propositional functions which take first-level propositional functions as arguments and output a structured proposition. Salmon (2005: p. 288) argues that this is consistent with Russell’s view.

It is perfectly consistent with Russell’s views to posit a separate semantic value of a designating expression that determines for any given context whether the expression has a content, and if so what that content is.

In other words, an incomplete symbol may express a function which, for any context, determines a proposition so long as that proposition contains no constituents corresponding to the incomplete symbol.⁴⁷

I now argue that allowing for the possibility that a structured proposition differs in structure from sentences which express it carries two significant advantages. One advantage is that it helps make sense of the possibility that different natural language sentences express the same proposition. The other advantage is that it provides a semantic account of complex singular terms such as complex demonstratives.

6.1 Fineness of Grain

Collins (2007) contends that natural language syntax posits more complexity than can reasonably be ascribed to propositions, focussing on two sorts of consideration.⁴⁸ First, sentences of a natural language with different syntactic structures sometimes express the same proposition. He considers active as opposed to passive sentences: ‘Sam loves Terry’ as opposed to ‘Terry is loved by Sam’. These sentences differ in syntactic constituents and arrangements but they seem to say the same thing. Similarly, two sentences in different

⁴⁵(Russell 1906b, p. 170) and (Whitehead and Russell 1910/1957).

⁴⁶A sentence such as ‘Most *F*s are *G*s’ containing a determiner phrase such as ‘most *F*s’ expresses a proposition that contains a generalized quantifier, construed as relations between propositional functions. The sentence expresses a proposition of the form $\langle MOST, \langle f, g \rangle \rangle$. Importantly, there is no constituent of this proposition corresponding to the determiner phrase ‘most *F*s’.

⁴⁷See (Pickel 2013).

⁴⁸See also (Martí and Zeman 2010).

natural languages may seemingly say the same thing. For instance, the sentence ‘Sam calls Terry’ of English and ‘Sam llama a Terry’ of Spanish seem to express the same proposition despite the presence of a personal ‘a’ in the latter. As Collins (2014, p. 145) summarizes:

[O]ne precisely wants propositions to be things that are coarser than the sentences that may be their vehicles, for we can surely express the same attitude with varied linguistic means, both within and across different languages

Positing a trivial concatenation rule such as pairing issues in an unreasonably tight connection between syntax and semantics, preventing sentences with even marginally different semantic structures from expressing the same proposition. As Lewis (1970: p. 32) says of his own view: we ‘thereby cut meanings too finely.’

The argument need not rely on intuitive notions of same saying or believing. It is widely acknowledged that at least some lexical items ‘make no semantic contribution to the structures in which they occur’ (Heim and Kratzer 1998, §4.1). These lexical items include the copula, the indefinite article in ‘Sam is an engineer’, and various prepositions. Thus, Heim and Kratzer (1998, §4.1) suggest that it is a theoretical desideratum that $[[\text{is an engineer}]] = [[\text{engineer}]]$. If this is right, then the compositional semantic value of a complex expression is insensitive to some of its syntactic features. If the semantic composition rule merely pairs the semantic values of constituent expressions, then these identities will not hold.

Heim and Kratzer suggest two strategies for such expressions. Either, the expressions are treated as identity functions so that the copula, ‘is’, takes a predicate meaning as argument and outputs that same predicate meaning, or the constituent expressions are treated as ‘invisible’ to semantic processing. Either way, these constructions pose a *prima facie* problem for a philosopher such as King, who holds that every syntactic difference corresponds to a difference in the structured propositions expressed.⁴⁹ On the present proposal, we may adopt either strategy. The verb ‘is’ (in the relevant use) might express the identity function on monadic propositional functions. Or, it might be invisible to semantic processing.

King (2013b, p. 3, footnote 7) seemingly softens his tone in response to Collins’s criticism.

[Collins’s] arguments against my view assume that I am committed to the claim that syntax provides exactly the right kind and amount of structure for propositional structure. However, I am not committed to this claim. Rather, [...] syntax provides enough structure (and perhaps much more than is needed) for propositional structure.

⁴⁹(King 2013a, p. 764).

Still it is unclear how this is possible on King’s model according to which semantic composition is trivial, exactly recapitulating syntactic structure. But, a functionally compositional semantics allows for the possibility that there is syntactic structure not re-capitulated in the structure of the proposition.⁵⁰

6.2 Complex Singular Terms

Treating the semantic value of a complex expression as the output of a function applied to the semantic values of its constituent expressions rather than as a whole composed of these semantic values can also resolve puzzles concerning complex singular terms. Certain complex expressions such as complex demonstratives (‘that engineer’) are held to be directly referential, contributing only their referents as constituents of propositions containing them. A sentence such as ‘that engineer flies’ expresses the singular proposition composed of the salient engineer and the property of flying. If Sam is the salient engineer, then ‘that engineer flies’ expresses the proposition $\langle Flying, \langle Sam \rangle \rangle$. As Braun (2012, §5.2) describes the view, ‘the common noun phrase does help determine the referent, but [...] its content does not appear as a constituent of the content of the complex demonstrative’. If we apply the typical semantics for structured propositions, the semantic value of ‘that engineer’ should be the result of pairing the semantic value of ‘that’ with the semantic value of ‘engineer’. But this is the wrong result. So, the proponent of the standard semantics would have to appeal to an *ad hoc* composition rule to deliver this sort of semantics for complex demonstratives. But a functionally compositional semantics can deliver the semantics in a straightforward, systematic way. The expression ‘that engineer’ in context c denotes the salient engineer in c if ‘that’ takes a predicate meaning and a context as arguments and outputs the most salient individual that satisfies the predicate meaning in the context.⁵¹

7 Variable Binding

Above, I conceded that semanticists in the Montagovian tradition take opportunistic departures from functional composition. These departures are costs to the semantic theory that the semanticist is ‘forced’ into (Heim and Kratzer 1998, p. 66). Most departures—including predicate modification and type shifting—retain the basic type theoretic superstructure.⁵² The semantic values of expressions fall into either basic types or functional types. The semantic value of a complex expression is characterized in terms of the ap-

⁵⁰King (2013a) takes a harder line, contemplating the possibility that sentences in languages with different structures never express the same proposition.

⁵¹Similar remarks apply to worries about the operator ‘dthat’ from (Kaplan 1989), as expressed by Salmon (2002, p. 512) and (Soames 2010a, p. 99). A related strategy also can deal with issues concerning the semantics for numerals. See discussion in (Keller and Keller 2013) and (Neale 2008 p. 2, footnote 3).

⁵²See the discussion of predicate modification in (Heim and Kratzer 1998, §§4.3.1-4.3.3).

plication of a small number of semantic composition rules applied to the semantic values of its constituents, depending on their types. Because functional types play a central role in determining which semantic composition rules apply in a given case, functional application can still be viewed as a ‘core case’ of semantic composition.

However, the treatment of variable binding looks especially problematic as has been noted by (Rabern 2013) and (Yli-Vakkuri 2013). Prominent Montagovians such as Heim and Kratzer (1998, pp. 96 and 114) formulate a syncategorematic semantic composition rule for their variable binding operators. The semantic value of a complex predicate $\widehat{x}\phi$ at a parameter is not a function of the semantic value of the embedded formula ϕ at that parameter, because the semantic value of ϕ at a parameter will be a truth-value. That is, one cannot infer $\llbracket \widehat{x}\phi \rrbracket^\sigma = \llbracket \widehat{x}\psi \rrbracket^\sigma$ from $\llbracket \phi \rrbracket^\sigma = \top = \llbracket \psi \rrbracket^\sigma$. So we seemingly have not only a failure of functional compositionality, but a failure of even weaker notions of compositionality. In particular, the meaning of a complex *at an assignment* is not a function of the semantic values of its parts *at that same assignment*. If the compositional semantic value of an expression is its semantic value at an assignment, then compositionality outright fails. The proposal developed so far shares this defect.

Soames (2010a: pp. 64-5, footnote 9) calls this failure an ‘ironic caveat worth noting at the outset’, charging that the Montagovian ambition of developing semantics within a type theory fails even for the simple case of variable binding.⁵³ Heim and Kratzer (1998, p. 107) themselves suggest of their rule for variable-binding that they ‘eventually want to abolish [syncategorematic] rules of this kind’ (98). If the Montagovian tenet of functional composition cannot even handle first-order logic, then why should this model be adopted by proponents of structured propositions?

Fortunately, Janssen (1997, §2.4) shows that functional compositionality can be restored by careful type assignments.⁵⁴ The strategy is to relativize the semantic values of basic expressions to assignments, a semantic type which I label s . The semantic value of a predicate is a function taking a term meaning and yielding a function from assignments into propositions. For instance:

Variables: $\llbracket x_i \rrbracket = \lambda\sigma \in D_s \sigma_i$

Predicates: If π is a basic n -ary predicate, $\llbracket \pi \rrbracket = \lambda v_1, \dots, v_n \in D_{(s,e)} \lambda\sigma \in D_s \langle I(\pi), \langle v_1(\sigma), \dots, v_n(\sigma) \rangle \rangle$

As a result, the compositional semantic value of a sentence is not a proposition, but a function from assignments from propositions. The objects of belief and assertion are propositions, but the semantic value of a

⁵³Hodges (2013: §2.1) reports that Tarski himself said that variable binding is not compositional in a conversation reported by Barbara Partee.

⁵⁴See discussion in (Rabern 2013, 395-397).

sentence determines a proposition only relative to an assignment. So a concrete speech situation must supply an assignment in order to extract what a sentence asserts from its compositional semantic value. This raises the question: where do the assignments come from?

On my preferred theory, assignments are elements of contexts. Variables function like the pronouns: ‘I’, ‘you’, ‘he’, ‘she’, and so on. A variable assignment—as a part of context—assigns referents for these pronouns.⁵⁵ So my position distinguishes the compositional semantic value of a sentence from the proposition that the sentence expresses in a context.⁵⁶ The compositional semantic value of a sentence is a character, a function from contexts to propositions, rather than content, the value of these functions in a particular context.⁵⁷ A concrete speech situation determines a context which sets the values for the variables, thereby determining the proposition asserted in that situation. Variable binding operators shift these assignments. A proposition is the semantic value of a sentence relative to a context.⁵⁸

Although the view distinguishes a sentence’s compositional semantic value from the proposition expressed in a context, these two still retain a tight connection. The proposition expressed by a sentence is the semantic value of the sentence in a context. Relatedly, propositions, like individuals, are root types. They are not merely one among many ways of generalizing on the semantic value of a sentence. So propositions retain their centrality to semantic theory.⁵⁹

The divergence between the compositional semantic value of a sentence and the proposition it expresses is not some incidental feature of the view. The semantic value of a predicate is *not* a constituent of the proposition expressed in a context by a sentence that contains it. More generally, the compositional semantic value of an expression need not be a constituent of the proposition expressed in a context by a sentence that contains it. So it should not be surprising if the compositional semantic value of a whole sentence fails to be a (trivial) constituent of the proposition that the sentence expresses in a context.⁶⁰

⁵⁵See (Heim 1982), (Cumming 2008), (Rabern 2013, 395-397), and (Pickel 2015).

⁵⁶In the terminology of (Dummett 1981), this view distinguishes assertoric content and ingredient sense. This issue is prominently discussed in (Lewis 1980) and (Stanley 1997).

⁵⁷Thus, I reject the Naïve View that contents are compositional in favor of the view that characters are. See (Yli-Vakkuri 2013, pp. 238 and 266).

⁵⁸Alternatively, following Tarski’s (1936/1956) procedure for producing an absolute truth-value, one might say that a sentence S expresses proposition p just in case for any sequence σ , $\llbracket S \rrbracket^\sigma = p$. On this interpretation, an open sentence will not express a proposition.

⁵⁹This seems to be King’s (2003) primary worry about similar proposals.

⁶⁰Thanks to an anonymous referee from *Mind* for putting the matter this way.

8 Conclusion

This paper aimed to show that structured propositionalists can endorse the thesis that semantic composition is type-driven functional application, allowing them to make sense of standard debates in formal semantics. I also argued that the approach resolves independent difficulties with structured propositions. But, the semantic framework and range of cases discussed in this paper is still limited. The Montagovian tradition handles a much wider range of constructions in English and other languages. It remains to be seen how far a semantic orientation of the kind I am proposing can be extended while replicating the elegance of the standard intensional approach.

I hope to have cleared up various *semantic* issues concerning structured propositions but I have largely ignored metaphysics. A great deal of recent research has aimed to develop a theoretically satisfying account of propositional constituency. One particular theme in this research has been an investigation into the components of the proposition expressed by a quantified sentences. It has been emphasized in the literature about the history of analytic philosophy that Russell was never wholly satisfied with the theory that a quantified proposition is composed of propositional function and a property attributed to this function.⁶¹ Recent proponents of structured propositions such as King (1995, 527-8) and Soames (2010b, pp. 122-9) have likewise questioned this analysis of the constituents of the structured propositions. The results of this paper can contribute to this project by separating semantic issues from the metaphysical problems.⁶²

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⁶¹See, for instance, (Hylton 1990, pp. 208-223), (Landini 1998), and (Klement 2010).

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