Compositionality II: arguments and problems*

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Abstract

This is the second part of a two-part article on compositionality, i.e. the principle that the meaning of a complex expression is determined by the meanings of its parts and the way they are put together. In the first, Pagin and Westerståhl 2009, we provide a general historical background, a formal framework, definitions, and a survey of variants of compositionality. It will be referred to as Part I. Here we discuss arguments for and arguments against the claim that natural languages have a compositional semantics. We also discuss some problem cases, including belief reports, quotation, idioms, and ambiguity.

1 Arguments in favor of compositionality

1.1 Learnability

Perhaps the most common argument for compositionality is the argument from *learnability*:

> A natural language has infinitely many meaningful sentences. It is impossible for a human speaker to learn the meaning of each sentence one by one. Rather, it must be possible for a speaker to learn the entire language by learning the meaning of a finite number of expressions, and a finite number of construction forms. For this to be possible, the language must have a compositional semantics.

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This argument was to some extent anticipated already in Sanskrit philosophy of language.[1] A modern classical passage plausibly interpreted along these lines is due to Donald Davidson:

> It is conceded by most philosophers of language, and recently by some linguists, that a satisfactory theory of meaning must give an account of how the meanings of sentences depend upon the meanings of words. Unless such an account could be supplied for a particular language, it is argued, there would be no explaining the fact that we can learn the language: no explaining the fact that, on mastering a finite vocabulary and a finite set of rules, we are prepared to produce and understand any of a potential infinitude of sentences. I do not dispute these vague claims, in which I sense more than a kernel of truth. Instead I want to ask what it is for a theory to give an account of the kind adumbrated (Davidson 1967, 17).

Properly spelled out, the problem is not that of learning the meaning of infinitely many meaningful sentences (given that one has command of a syntax), for if I learn that they all mean that *snow is white*, I have already accomplished the task, without having to derive new meanings. Rather, the problem is that there are infinitely many propositions that are each expressed by some sentence in the language (with contextual parameters fixed), and hence infinitely many equivalence classes of synonymous sentences.[2]

Still, as an argument for compositionality, the learnability argument has two main weaknesses. First, the premise that there are infinitely (or even finitely) many sentences that have a determinate meaning although they have never been used by any speaker, is a very strong premise, in need of justification. To make this vivid, consider two competing hypotheses: At a given time t_0, according to the first hypothesis, the speaker or speakers employ a semantic function μ defined for infinitely many sentences, and according to the second, they employ an alternative function μ_0 which agrees with μ on all sentences that have in fact been used up to t_0 but is simply *undefined* for those that have not been used. On the alternative hypothesis, when using a new sentence s,

[1] During the first or second century BC Patañjali writes: '... Bṛhaspati addressed Indra during a thousand divine years going over the grammatical expressions by speaking each particular word, and still he did not attain the end. ... But then how are grammatical expressions understood? Some work containing general and particular rules has to be composed ...' Cf. Staal 1969, 501-02. Thanks to Brendan Gillon for the reference.

[2] In fact, that the number is infinite is not really crucial either. What matters is that there are more meanings to be learned than can be learned one at a time by a human being. Any large finite number suffices that requires a different mode of learning. This has been pointed out e.g. in Grandy 1990. The learnability argument is usually presented in the weaker form, since it is assumed that the number of meaningful sentences of natural languages is infinite anyway.

the speaker or the community *gives* some meaning to s, thereby extending μ_0 to μ_1, and so on. Phenomenologically, the new sentence *seemed* to the speakers to come already equipped with meaning, but that was just an illusion. On this alternative hypothesis, there is no infinite semantics to be learned. To argue that there is a learnability problem, we must first justify the premise that we employ an infinite semantic function.[3] This cannot be justified by induction, for we cannot infer from finding sentences meaningful that they were meaningful before we found them, and exactly that would have to be the induction base.

Of course, the alternative hypothesis may seem wildly implausible. But in order to argue that it is implausible, something other than the learnability argument would be required (cf. sections 1.5 and 1.6 below). Note that on both alternatives the speakers simply associate new sentences with (usually) new meanings, and that the difference only is that on the one alternative the sentences already have those meanings, while on the other they don't. That speakers tend to associate the *same* meanings with new sentences can in either case only be explained by appeal to the similarity of their cognitive mechanisms. It cannot be explained by the fact that what they associate with the new sentences are the *right* meanings, for there is as much intersubjective agreement if the speakers all associate the same wrong or undetermined meanings with those sentences.[4]

The second weakness is that even with the infinity premise in place, the conclusion of the argument would be that the semantics must be computable, but computability does not entail compositionality, as we saw in Part I, section 3.2.

1.2 Novelty

Closely related to the learnability argument is the argument from *novelty*: speakers are able to understand sentences they have never heard before, which is possible only if the language is compositional.

When the argument is interpreted so that, as in the learnability argument, we need to explain how speakers reliably *track* the semantics, i.e. assign to new sentences the meaning that they independently have, then the argument from novelty shares the two main weaknesses with the learnability argument.

[3] It is enough that the function gives meaning to sentences that have not been used, so that the speakers know the meaning of those sentence before actually using them.

[4] Note that that this objection against the learnability argument does appeal to any (wittgensteinian) problems with rule-following in general.

1.3 Productivity

According to the pure argument from *productivity*, we need an explanation of why we are able to *produce* infinitely many meaningful sentences, and compositionality offers the best explanation. Classically, productivity is appealed to by Noam Chomsky as an argument for generative grammar. One of the passages runs

> The most striking aspect of linguistic competence is what may call the 'creativity of language', that is, the speaker's ability to produce new sentences that are immediately understood by other speakers although they bear no physical resemblance to sentences that are 'familiar'. The fundamental importance of this creative aspect of normal language use has been recognized since the seventeenth century at least, and it was the core of Humboldtian general linguistics (Chomsky 1971, 74).

This passage does not appeal to pure productivity, since it makes an appeal to the understanding by other speakers (cf. Chomsky 1980, 76-78). The pure productivity aspect has been emphasized by Fodor (e.g. Fodor 1987, 147-48), i.e. that natural language can *express* an open-ended set of propositions.

However, the pure productivity argument is very weak. On the premise that a human speaker can think indefinitely many propositions, all that is needed is to assign those propositions to sentences. The assignment does not have to be systematic in any way, and all the syntax that is needed for the infinity itself is simple concatenation. Unless the assignment is to meet certain conditions, productivity requires nothing more than the combination of infinitely many propositions and infinitely many expressions.

1.4 Systematicity

A related argument by Fodor (1987, 147-50) is that of systematicity. It can be stated either as a property of speaker understanding or as an expressive property of a language. Fodor tends to favor the former (since he is ultimately concerned with the mental). In the simplest case, Fodor points out that if a speaker understands a sentence of the form tRu, she will also understand the corresponding sentence uRt, and argues that this is best explained by appeal to compositionality.

Formally, the argument is to be generalized to cover the understanding of any new sentence that is formed by recombination of constituents that occur and construction forms that are used in sentences already understood. Hence, in this form it reduces to one of three different arguments; either to the argument

from *novelty*, or to the *productivity* argument, or finally, to the argument from intersubjectivity (below), and only spells out a bit the already familiar idea of old parts in new combinations.

It might be taken to add an element, for it not only aims at explaining the understanding of new sentences that is in fact manifested, but also predicts what new sentences will be understood. However, Fodor himself points out the problem with this aspect, for if there is a sentence s formed by a recombination that we do *not* find meaningful, we will not take it as a limitation of the systematicity of our understanding, but as revealing that the sentence s is not in fact meaningful, and hence that there is nothing to understand. Hence, we cannot come to any other conclusion than that the systematicity of our understanding is maximal.

The systematicity argument can alternatively be understood as concerning natural language itself, namely as the argument that sentences formed by grammatical recombination are meaningful. It is debatable to what extent this really holds, and sentences (or so-called sentences) like Chomsky's *Colorless green ideas sleep furiously* have been used to argue that not all grammatical sentences are meaningful.

But even if we were to find meaningful all sentences that we find grammatical, this does not in itself show that compositionality, or any kind of systematic semantics, is needed for explaining it. If it is only a matter of assigning some meaning or other, without any further condition, it would be enough that we can think new thoughts and have a disposition to assign them to new sentences.

1.5 Induction on synonymy

We can observe that our synonymy intuitions conform to Subst($\equiv_\mu$). In case after case, we find the result of substitution synonymous with the original expression, if the new part is taken as synonymous with the old. This forms the basis of an *inductive generalization* that such substitutions are always meaning-preserving. In contrast to the argument from *novelty*, where the idea of tracking the semantics is central, this induction argument may concern our habits of *assigning* meaning to, or reading meaning into, new sentences: we tend to do it compositionally.

There is nothing wrong with this argument, as far as it goes, beyond what is in general problematic with induction. It should only be noted that the conclusion is weak. Typically, arguments for compositionality aim at the conclusion that there is a systematic pattern to the assignment of meaning to new sen-

tences, so that it is determined in advance what sentences so far unused mean, or will mean once they are used. This is not the case in the synonymy induction argument, for the conclusion is compatible with the possibility that the semantic function is not even defined for new sentences; speakers only tend to extend it (cf. the learnability argument above) to new functions in such a way that substitution conditions are always met. It is also compatible with the possibility that the semantic function, even if it *is* defined for unused sentences, is not computable, and or even finitely specifiable. So, although the argument may be empirically sound, it does not establish what arguments for compositionality usually aim at.

Furthermore, as we saw in Part I, section 3.1, if there are very few synonymy pairs, compositionality places very weak constraints on the meaning composition functions (in particular, if there are *no* synonymies, there are *no* constraints, and the semantics is trivially compositional).

1.6 Intersubjectivity and communication

The problems with the idea of tracking semantics when interpreting new sentences can be eliminated by bringing in intersubjective agreement in interpretation. For by our common sense standards of judging whether we understand sentences the same way or not, there is overwhelming evidence (e.g. from discussing broadcast news reports) that in an overwhelming proportion of cases, speakers of the same language interpret new sentences *similarly*. This convergence of interpretation, far above chance, does not presuppose that the sentences heard were meaningful before they were used. The phenomenon needs an explanation, and it is reasonable to suppose that the explanation involves the hypothesis that the meaning of the sentences are computable, so that it isn't left to guesswork or mere intuition to figure out what the new sentences mean.

The appeal to intersubjectivity disposes of an unjustified assumption about semantics in the learnability and novelty arguments, but two problems remain. First, when encountering new sentences, these are almost invariably produced by a speaker, and the speaker has intended to convey something by the sentence, but the speaker hasn't *interpreted* the sentence, but fitted it to the content of an antecedent thought. Secondly, we have an argument for computability, but not for compositionality.[5]

[5]If it is assumed that public language semantics has priority over thought content, then no argument from intersubjectivity can work. But then we need another argument, and another good argument is not easy to find. This issue is discussed with reference to Davidson's philosophy of in Pagin 1999.

The first observation indicates that it is at bottom the success rate of linguistic communication with new sentences that gives us a reason for believing that sentences are systematically mapped on meanings. This was the point of view in Frege's famous passage from the opening of 'Compound Thoughts':

> It is astonishing what language can do. With a few syllables it can express an incalculable number of thoughts, so that even a thought grasped by a terrestrial being for the very first time can be put into a form of words which will be understood by someone to whom the thought is entirely new. This would be impossible, were we not able to distinguish parts in the thoughts corresponding to the parts of a sentence, so that the structure of the sentence serves as the image of the structure of the thought. (Frege 1923, p. 55)

As Frege depicts it here, the speaker is first entertaining a new thought, or proposition, finds a sentence for conveying that proposition to a hearer, and by means of that sentence the hearer comes to entertain the same proposition as the speaker started out with. Frege appeals to semantic structure for explaining how this is possible. He claims that the proposition has a structure that mirrors the structure of the sentence (so that the semantic relation may be an isomorphism), and goes on to claim that without this structural correspondence, communicative success with new propositions would not be possible.[6]

It is natural to interpret Frege as expressing a view that entails that compositionality holds as a consequence of the isomorphism idea.[7] The reason Frege went beyond compositionality (or homomorphism, which does not require a one-one relation) seems to be an intuitive appeal to symmetry: the speaker moves from proposition to sentence, while the hearer moves from sentence to proposition. An isomorphism is a one-one relation, so that each relatum uniquely determines the other.

Because of synonymy, a sentence that expresses a proposition in a particular language is typically not uniquely determined within that language by the proposition expressed. Still, we might want the speaker to be able to *work out* what expression to use, rather searching around for suitable sentences by

[6] We would have an argument from intersubjectivity even if we only had the phenomenon of agreement among hearers in *interpretation*, without having to consider what *speakers* mean, and hence without having to consider communication strictly speaking. However, the empirical evidence we have almost invariably does come from communication.

[7] There is some work to do to spell out the isomorphism idea, partly because one has to take account of *occurrences*, both of concepts in other concepts, and of expressions in other expression, partly because there is synonymy on the language side as opposed to identity on the meaning side, and partly because we need a semantic relation for the entire *language*, not just one separate isomorphic relation for each sentence.

interpreting candidates one after the other. The inverse functional compositionality principle, InvFunct(μ), of section 3.4 in Part I, offers such a method. Inverse compositionality is also connected with the idea of structured meanings, or thoughts, while compositionality by itself isn't, and so in this respect Frege is vindicated.[8]

1.7 Complexity

As we have seen, the standard arguments only justify the principle the meaning is computable or recursive, and the principle that up to certain syntactic variation, an expression of a proposition is computable from that proposition.[9] Why should the semantics also be compositional, and possibly inversely compositional? One reason could be that compositional semantics, or at least certain simple forms of compositional semantics, is very *simple*, in the sense that a minimal number of processing steps are needed by the hearer for arriving at a full interpretation (or, for the speaker, a full expression).

That a semantic value is computable in principle does not entail that it is also practically *tractable*, i.e. can be computed by ordinary language users during the limited time they usually have. Normal oral communication proceeds on-line; hearers interpret sentence utterances pretty much while hearing them, and speakers express contents pretty much while thinking them. Computability in principle does not explain how this is possible. There must also be a bound on the complexity of the task.

Compositionality is not sufficient for low complexity (or even computability, cf. section 3.2 of Part I), but the stronger version which requires that meaning operations be *polynomial* is (cf. section 3.4 of Part I). If the semantic function is polynomial, as is the case in all standard examples of compositional semantics, the hearer can compute the meaning of a term by means of immediate interpretations of the elements of the term (occurrences of operators or atomic terms). No intermediate computation steps will be needed. Since there is a reason to think that polynomial meaning operations are desirable, there is a reason to think that compositionality is a desirable.[10]

[8] These ideas are developed in Pagin 2003*a*.

[9] This has recently been stressed also in Jönsson 2008. Compare also Pelletier's view in Pelletier 1994, where it is argued that it is enough if the semantics is *grounded* in a sense that is somewhat similar to *computable*.

[10] For a more detailed discussion, see Pagin 2009.

1.8 Summing up

Although many share the feeling that there is "more than a kernel of truth" (cf. section 1.1 of Part I) in the usual arguments for compositionality, some care is required to formulate and evaluate them. One must avoid question-begging presuppositions; for example, if a presupposition is that there is an infinity of propositions, the argument for *that* had better not be that standardly conceived natural or mental languages allow the generation of such an infinite set.

Properly understood, the arguments can be seen as inferences to the best explanation, which is a respectable but somewhat problematic methodology, partly because the best explanation need not be the right explanation, and partly because the best explanation may not yet have been found.

2 Arguments against compositionality

Arguments against compositionality of natural language can be divided into four main categories:

a) arguments that certain constructions are counterexamples and make the principle false,
b) arguments that compositionality is an empirically vacuous, or alternatively trivially correct, principle,
c) arguments that compositional semantics is not *needed* to account for actual linguistic communication,
d) arguments that actual linguistic communication is not *suited* for compositional semantics.

The first category, that of counterexamples, will be treated in a separate section dealing with a number of problem cases. Here we shall discuss arguments in the last three categories.

2.1 Vacuity and triviality arguments

Vacuity. Some claims about the vacuity of compositionality in the literature are based on mathematical arguments. For example, Zadrozny in Zadrozny 1994 shows that for every semantics μ there is a compositional semantics ν such that $\nu(t)(t) = \mu(t)$ for every expression t, and uses this fact to draw a conclusion of that kind. But note that the mathematical fact is itself trivial: let $\nu(t) = \mu$ for

each t and the result is immediate from (2) in section 3.1 above.[11]

Claims like these tend to have the form: for any semantics μ there is another semantics ν which is compositional and from which μ can be easily recovered. But this too is completely trivial as it stands: if we let $\nu(t) = \langle \mu(t), t \rangle$ then ν is 1-1, hence compositional by observation (3) in section 3.1, and μ is clearly recoverable from ν.

In general, it is not enough that the old semantics can be computed from the new compositional semantics: for the new semantics to have any interest it must *agree* with the old one in some suitable sense. As far as we know there are no mathematical results showing that such a compositional alternative can always be found (see Westerståhl 1998 for further discussion).

Triviality. Paul Horwich (e.g. in Horwich 1998, Horwich 2005) has argued that compositionality is not a substantial property of a semantics, but is *trivially* true. He exemplifies the view with the sentence *dogs barks*, and says (Horwich 1998, 156-57) that the meaning property

(1) x means DOGS BARK

consists in the so-called construction property

(2) x results from putting terms whose meanings are DOG and BARK, in that order, into a schema whose meaning is Ns V.

As far as it goes, the resulting semantics is compositional, and this is a trivial consequence of Horwich's conception of meaning properties. Horwich's view here is equivalent to Carnap's conception of synonymy as intensional isomorphism. Neither allows that that an expression with different structure or composed from parts with different meanings could be synonymous with an expression that means DOGS BARK. However, for supporting the conclusion that compositionality is trivial, these synonymy conditions must themselves hold trivially, and to the extent that this is is at least in part an empirical question, that is not the case.

2.2 Superfluity arguments

Mental processing. Stephen Schiffer (Schiffer 1987) has argued that compositional semantics, and public language semantics altogether, is superfluous in the account of linguistic communication. All that is needed is to account for how the hearer maps his mental representation of an uttered sentence on

[11] Other parts of Zadrozny's results use non-wellfounded sets and are less trivial.

a mental representation of meaning, and that is a matter of a syntactic transformation, i.e. a translation, rather than interpretation. In Schiffer's example (Schiffer 1987, 192-200), the hearer Harvey is to infer from his belief that

(3) Carmen uttered the sentence 'Some snow is white'.

the conclusion that

(4) Carmen said that some snow is white.

Schiffer argues that this can be achieved by means of transformations between sentences in Harvey's neural language M. M contains a counterpart α to (3), such that α gets tokened in Harvey's so-called belief box when he has the belief expressed by (3). By an inner mechanism the tokening of α leads to the tokening of β, which is Harvey's M counterpart to (4). For this to be possible for any sentence of the language in question, Harvey needs a translation mechanism that implements a recursive translation function f from sentence representations to meaning representations. Once such a mechanism is in place, we have all we need for the account, according to Schiffer.

The problem with the argument is that the translation function f by itself tells us nothing about communicative success. By itself it just correlates neural sentences of which we know nothing except for their internal correlation. We need another recursive function g that maps the uttered sentence *Some snow is white* on α, and a third recursive function h that maps β on the proposition *that some snow is white*, in order to have a complete account. But then the composed function $h(f(g(\ldots)))$ seems to be a recursive function that maps sentences on meanings.[12]

Pragmatic composition. According to François Recanati (2004), word meanings are put together in a process of *pragmatic* composition. That is, the hearer takes word meanings, syntax and contextual features as the his input, and forms the interpretation that best corresponds to them. As consequence, semantic compositionality is not needed for interpretation to take place.

A main motivation for Recanati's view is the ubiquity of those pragmatic operations that Recanati calls *modulations*,[13] and which intuitively contribute to "what is said", i.e. to communicated content before any conversational implicatures. To take an example from Recanati, in reply to an offer of something to eat, the speaker says

[12] For an extended discussion, see Pagin 2003*b*.

[13] These, under varying terms and conceptions, have been described e.g. by Dan Sperber and Deirdre Wilson (1992), Kent Bach (1994), Robyn Carston (2002) and by Recanati himself.

(5) I have had breakfast

thereby saying that she has had breakfast in the morning of *the day of utterance*, which involves a modulation of the more specific kind Recanati calls *free enrichment*, and implicating by means of what she says that she is not hungry. On Recanati's view, as naturally interpreted in Recanati 2004, communicated contents are always or virtually always pragmatically modulated. Moreover, modulations in general do not operate on a complete semantically derived proposition, but on the conceptual constituents.[14] Hence, it seems that what the semantics delivers does not feed into the pragmatics.

However, if meanings, i.e. the outputs of the semantic function, are *structured* entities, in the sense specified by (Rev) and InvFunct(μ) of section 3.4, then the last objection is met, for then semantics is able to deliver the arguments to the pragmatic operations, e.g. properties associated with VP:s. Moreover, the modulations that are in fact made appear to be controlled by a given semantic structure: as in (5), the modulated part is of the same category and occupies the same slot in the overall structure as the semantically given argument that it replaces. This provides a reason for thinking that modulations operate on a given (syntactically induced) semantic structure, rather than on pragmatically composed material.[15]

2.3 Unsuitability arguments

According to a view that has come to be called *radical contextualism*, truth evaluable content is radically underdetermined by semantics, i.e. by literal meaning. That is, no matter how much a sentence is elaborated, something needs to be added to its semantic content in order to get a proposition that can be evaluated as true or false. Since there will always be indefinitely many different ways of adding, the proposition expressed by means of the sentence will vary from context to context.[16] A characteristic example from Charles Travis (1985, 197) is the sentence

(6) Smith weighs 80 kg

[14] In (5) it is the property of *having breakfast* that is modulated into *having breakfast this day*, not the proposition as a whole or even the property of *having had breakfast*.

[15] This line of reasoning is elaborated in Pagin and Pelletier 2007. It should be noted that in later works Recanati has defended a view that is very close to the present one. See especially Recanati 2009.

[16] Well-known proponents of radical contextualism include John Searle (e.g. 1978), Charles Travis (e.g. 1985), and Sperber and Wilson (1992).

Although it sounds determinate enough at first blush, Travis points out that it can be taken as true or as false in various contexts, depending on what counts as important in those contexts. For example, it can be further interpreted as being true in case Smith weighs

(6a) 80 kg when stripped in the morning
(6b) 80 kg when dressed normally after lunch
(6c) 80 kg after being force fed 4 liters of water
(6d) 80 kg four hours after having ingested powerful diuretic
(6e) 80 kg after lunch adorned in heavy outer clothing

Although the importance of such examples is not to be denied, their significance for semantics is less clear. It is in the spirit of radical contextualism to minimize the contribution of semantics (literal meaning) for determining expressed content, and thereby the importance of compositionality. However, strictly speaking, the truth or falsity of the compositionality principle for natural language is orthogonal to the truth or falsity of radical contextualism. For whether the meaning of a sentence s is a proposition or not is irrelevant to the question whether that meaning is determined by the meaning of the constituents of s and their mode of composition. The meaning of s may be unimportant but still compositionally determined.

In an even more extreme version, the (semantic) meaning of sentence s in a context c is what the speaker uses s to express in c. In that case meaning itself varies from context to context, and there is no such thing as an invariant literal meaning. Not even the extreme version need be in conflict with compositionality (extended to context dependence), since the substitution properties may hold within each context by itself. Context shift failure, in the sense of section 3.7, may occur, if e.g. word meanings are invariant but the meanings of complex expressions vary between contexts.

It is a further question whether radical contextualism itself, in either version, is a plausible view. It appears that the examples of contextualism can be handled by other methods, e.g. by appeal to pragmatic modulations mentioned in section 2.2 (cf. Pagin and Pelletier 2007), which does allow propositions to be semantically expressed. Hence, the case for radical contextualism is not as strong as it may *prima facie* appear. On top, radical contextualism tends to make a mystery out of communicative success.

3 Problem cases

A number of natural language constructions present apparent problems for compositional semantics. In this concluding section we shall briefly discuss a few of them, and mention some others.

3.1 Belief sentences

Belief sentences offer difficulties for compositional semantics, both real and merely apparent. At first blush, the case for a counterexample against compositionality seems very strong. For in the pair

(7) a. John believes that Fred is a child doctor.
b. John believes that Fred is a pediatrician.

(7a) may be true and (7b) false, despite the fact that *child doctor* and *pediatrician* are synonymous. If truth value is taken to depend only on meaning and on extra-semantic facts, and the extra-semantic facts as well as the meanings of the parts and the modes of composition are the same between the sentences, then the meaning of the sentences must nonetheless be different, and hence compositionality fails. This conclusion has been drawn by Jeff Pelletier (1994).

What would be the reason for this difference in truth value? When cases such as these come up, the reason is usually that there is some kind of discrepancy in the understanding of the attributee (John) between synonyms. John may e.g. erroneously believe that *pediatrician* only denotes a special kind of child doctors, and so would be disposed to assent to 'Fred is child doctor' but dissent from 'Fred is a pediatrician'.[17] This is not a decisive reason, however, since it is what the words mean in the sentences, e.g. depending on what *the speaker* means, that is relevant, not what the *attributee* means by those words. The speaker contributes with words and their meanings, and the attributee contributes with his belief contents. If John's belief content matches the meaning of the embedded sentence *Fred is a pediatrician*, then (7b) is true as well, and the problem for compositionality is disposed of.

A problem still arises, however, if belief contents are more fine-grained than sentence meanings, and words in belief contexts are somehow tied to these finer differences in grain. For instance, as a number of authors have suggested,

[17] Cf. Benson Mates (1950) and Tyler Burge (1978). Mates took such cases as a reason to be skeptical about synonymy.

perhaps belief contents are propositions under modes of presentation.[18] It may then be that different but synonymous expressions are associated with different modes of presentation. In our example, John may believe a certain proposition under a mode of presentation associated with *child doctor* but not under any mode of presentation associated with *pediatrician*, and that accounts for the change in truth value.

One possible view is to say that the underlying form of a belief sentence such as (7a) is something like

(8) Bel(John, *the proposition that Fred is a child doctor*, M('Fred is a child doctor'))

where M(-) is a function from a sentence to a mode of presentation or a set of modes of presentation. In this form, the sentence *Fred is a pediatrician* occurs both used and mentioned (quoted), and in its used occurrence, *child doctor* may be replaced by *pediatrician* without change of truth value. Failure of substitutivity is explained the fact the surface form fuses a used and a mentioned occurrence. In the underlying form, if there is a problem for compositionality, it comes from the use of quotation.

Another possibility is to accept directly that belief sentences in some cases do violate standard compositionality, but not the generalized form of compositionality that is sensitive to linguistic context (cf. subsection 3.7 of Part I). One way of developing such a semantics can make use of the idea of *structured contents* to model how the believer represents a proposition to herself. The structured content can then be part of the semantic value of a sentence in contexts governed by attitude verbs. The result will be complex, and generalized compositional semantics can be more easily exemplified for quotation.

3.2 Quotation

Often quotation is set aside for special treatment as an exception to ordinary semantics, which is supposed to concern *used* occurrences of expressions rather than *mentioned* ones. Sometimes, this is regarded as cheating, and quotation is proposed as a clear counterexample to compositionality: *brother* and *male sibling* are synonymous, but *'brother'* and *'male sibling'* are not (i.e. the expressions that include the opening and closing quote). If enclosing an expression in quotes is a real syntactic operation on an argument (and not e.g. a demonstrative, as

[18] See e.g. Burdick 1982, Salmon 1986. Salmon, however, existentially quantifies over modes of presentations, which preserves substitutivity.

in some pragmatic theories), we have a counterexample.

Let us assume that quoting is a genuine syntactic operation. Then the syntactic rules include a total unary operator κ that applies to expressions to form expressions enclosed in quotes. That is, for any simple or complex expression e,

$$\kappa(e) = \text{`}e\text{'}$$

(i.e. the string leftquote$^\frown e^\frown$rightquote). The semantics of quoted expressions is given simply by

(Q) $\quad \mu'(\overline{\kappa}(t)) = V(t)$

for any meaningful term t. (Recall from section 2 of part I the string value function V, and the convention to use $\overline{\kappa}$ as a name for κ.) (Q) gives the semantic value of quote-terms: it is simply the string value of the argument to the quote operator. Then, since $t \equiv_{\mu'} u$ does not imply $V(t) = V(u)$, substitution of u for t in $\overline{\kappa}(t)$ may violate compositionality.

However, not much is required for transforming such a non-compositional semantics for quotation into one that is compositional in the generalized sense. To see how this can be done, start with a grammar $\mathbf{E} = (E, A, \Sigma)$ (for a fragment of English, say) and a compositional semantics μ for $\mathbf{E}$. First, extend $\mathbf{E}$ to a grammar containing the quotation operator κ. To describe this in detail one would need to know more about $\mathbf{E}$, but the idea is simple: we need to allow not only quote-strings of the form *'John', 'likes'*, *"Mary"*, etc., but also things like *John likes 'Mary'* (meaning that he likes the word), whereas we should disallow things like *John 'likes' Mary* (this is not an account of scare quotes) or *'John likes' Mary* as ungrammatical. This involves extending each function $\alpha \in \Sigma$ to a function α' in a way which accounts for such facts; the details should be fairly straightforward (for example, one could treat all quote-strings as NPs). Let E' be the closure of E under these operations and κ (that we take to be a total unary function on E'), and let $\Sigma' = \{\alpha' : \alpha \in \Sigma\} \cup \{\kappa\}$. Then we have a new grammar $\mathbf{E}' = (E', A, \Sigma')$ that incorporates quotation.

Next, extend μ to a semantics μ' for $\mathbf{E}'$ using (Q) above for κ. Since Funct(μ) holds, there corresponds to each $\alpha \in \Sigma$ a semantic operation r_α, and this is extended to an operation $r_{\alpha'}$, roughly by including the strings of E' among the objects of the universe, with certain properties and relations to other objects. This yields an extended universe $M' = M \cup E'$, where M is the result of closing the original universe *range*(μ) under the new semantic operations, and assumed

to be disjoint from the set E' of meanings of quote-terms.

As we already indicated, the straightforward semantics μ' is *not* compositional: even if Mary is the same person as Sue, *John likes 'Mary'* doesn't mean the same as *John likes 'Sue'*. However, allowing for *linguistic context dependence*, as in section 3.8 in Part I, we can obtain a semantics which is compositional in the generalized sense. As noted there, this can be done in two ways. One is to reformulate μ' so that it takes a *context type* as additional argument, where we have one default context type for ordinary use, and a distinct one for quotation, and similarly for the semantic operations. An equivalent way, chosen here, is to keep μ' as it is but add a second semantic function to handle quotation. This function is simply the string value function V, already defined, and now the semantics $S = \{\mu', V\}$ is compositional, i.e. Funct(S) holds.[19] The new semantics, in either formulation, will be very close to adapting Frege's view in Frege 1892 that quotation provides a context in which expressions refer to themselves.[20]

In somewhat more detail, we do the following. First, for an atomic term $a \in A$, we have:

(i) $\mu'(a) = \mu(a)$

(ii) $V(a) = a$

To satisfy Funct(S), we are required to define, for each $\alpha' \in \Sigma'$, suitable operations $r_{\alpha',\mu'}$ and $r_{\alpha',V}$. The latter is to satisfy

(iii) $V(\overline{\alpha'}(t_1, \ldots, t_n)) = r_{\alpha',V}(V(t_1), \ldots, V(t_n))$

and we already know that $V(\overline{\alpha'}(t_1, \ldots, t_n)) = \alpha'(V(t_1), \ldots, V(t_n))$, so $r_{\alpha',V}$ is simply the function α'. In particular, for $\alpha' = \kappa$ we have

(iv) $r_{\kappa,V}(V(t)) = \kappa(V(t)) =$ '$V(t)$'

[19] Think of μ' as the function applying in the initial state of the semantic machine S, where some operators trigger a transition to a different machine state. *Switcher* semantics in this sense has been employed e.g. in Glüer and Pagin 2006.

[20] Markus Werning Werning 2005 gives a compositional semantics by treating all apparent quotation of non-atomic strings as concatenation of names of atomic strings (letters, phonemes), and by treating those names as unstructured primitives. Thus, he does not have a quotation operator. Christopher Potts Potts 2007 gives a semantics for quotation with a quote function similar to κ, although he works with expression triples (roughly) like those in section 3.6 of Part I, and lets the quote function apply to such triples. But, in spite of his (at least implicit; cf. Potts 2007, pp. 406, 426) claim to the contrary, this semantics is *not compositional* (although it is recursive; cf. section 3.2 of Part I), for precisely the reasons exemplified here: if Mary is Sue, 'Mary' and 'Sue' are synonymous in Potts' semantics, but 'John likes 'Mary'' and 'John likes 'Sue'' are not. (More exactly, this holds for the corresponding triples.)

(leftquote$^\frown V(t)^\frown$rightquote). This will apply only in iterated quotation contexts, since V is not the designated function and only applies to term occurrences in the scope of κ.

As to $r_{\alpha',\mu'}$, we just identify it with $r_{\alpha'}$ on arguments in M' when $\alpha \in \Sigma$ (undefined otherwise). Finally, $r_{\kappa,\mu'}$ is the identity function. Hence,

(v) $\quad \mu'(\kappa(t)) = r_{\kappa,\mu'}(V(t)) = V(t)$

To see how the semantics S works, suppose the string *John likes Mary* is the value of the term $t_1 = \overline{\beta}(\overline{John}, \overline{\gamma}(like, \overline{Mary}))$ in the given grammar $\mathbf{E}$, and that its meaning $\mu(t_1)$ is $r_\beta(j, r_\gamma(\text{LIKE}, m))$. Then *John likes 'Mary'* will be the string value of the term $t_2 = \overline{\beta'}(\overline{John}, \overline{\gamma'}(\overline{like}, \overline{\kappa}(\overline{Mary})))$ in $\mathbf{E}'$, whose designated meaning is calculated as follows:

$$\begin{aligned}
\mu'(t_2) &= r_{\beta',\mu'}(\mu'(John), \mu'(\overline{\gamma'}(like, \overline{\kappa}(\overline{Mary})))) \\
&= r_{\beta',\mu'}(j, r_{\gamma',\mu'}(\mu'(\overline{like}), \mu'(\overline{\kappa}(\overline{Mary})))) \\
&= r_{\beta',\mu'}(j, r_{\gamma',\mu'}(\text{LIKE}, r_{\kappa,\mu'}(V(\overline{Mary})))) \\
&= r_{\beta',\mu'}(j, r_{\gamma',\mu'}(\text{LIKE}, V(\overline{Mary}))) \\
&= r_{\beta',\mu'}(j, r_{\gamma',\mu'}(\text{LIKE}, Mary)) \\
&= r_{\beta'}(j, r_{\gamma'}(\text{LIKE}, Mary))
\end{aligned}$$

This is just like the meaning of t_1, except that Mary (the woman) is replaced by *Mary* (the word). $V(t_2)$, on the other hand, is the string *John likes 'Mary'* as before.[21] The third line of the calculation above shows how the condition LC-Funct(S) is satisfied in this example, with the semantic function applying to the subterm distinct from the one applying to the term. In general, we have the following:

— S handles quotation correctly, i.e. its designated semantic function gives the intended meaning to sentences containing quotation. It extends μ in the sense that if t in $\mathbf{E}$ is meaningful, $\mu'(t) = \mu(t)$.

— LC-Funct(S) holds (as well as Funct(V), but Funct(μ') may fail).

So S is compositional in the generalized sense. That $t \equiv_\mu u$ holds does not license substitution of u for t in $\overline{\kappa}(t)$, since t there occurs in a quotation context,

[21] Note that if semantic functions are combined with assignment functions for giving values to free variables, and this is applied to V in particular, quantification into quotation contexts becomes straightforwardly available.

and we may have $V(t) \neq V(u)$.[22]

3.3 Idioms

Idioms are almost universally thought to constitute a problem for compositionality. Usually the thought here is of the following kind: The VP *kick the bucket* can also mean DIE, but the semantic operation corresponding to the standard syntax of, say, *fetch the bucket*, giving its meaning in terms of the meanings of its immediate constituents *fetch* and *the bucket*, cannot be applied to give the idiomatic meaning of *kick the bucket*.

This is no doubt a problem of some sort, but not necessarily for compositionality. First, that a particular semantic operation fails doesn't mean that no operation works, but just that would be required to violate compositionality. Second, we must take into account that *kick the bucket* is actually *ambiguous* between its literal and its idiomatic meaning, but compositionality presupposes non-ambiguous meaning bearers. Unless we take the ambiguity itself to be a problem for compositionality (about this, see the next subsection), we should first find a suitable way to disambiguate the phrase, and only then raise the issue of compositionality.

Such disambiguation may be achieved in various ways. We could treat the whole phrase as a lexical item (an atom), in view of the fact that its meaning has to be learnt separately. Or, given that it does seem to have syntactic structure, we could treat it as formed by a different rule than the usual one.[23] In neither case is it clear that compositionality would have a problem.

To see what idioms really have to do with compositionality, it is convenient to think of the following situation. Given a grammar and a compositional semantics for it, suppose we decide to give some already meaningful phrase a non-standard, idiomatic meaning. Can we then *extend* the given syntax (in particular, to disambiguate) and semantics in a natural way that preserves compositionality? Note that it is not just a matter of accounting for one particular phrase, but rather for all the phrases in which the idiom may occur. This requires an account

[22]Here we have only accounted for the quotation of *expressions*. As stressed by an anonymous referee, for a full account we need also to account for the quotation of arbitrary strings of letters (as in *'cena' is not a word in English*) as well as other re-identifiable shapes. This is not a problem in principle: we would need for each simple quotable type a term argument to the string value function V, and (at least) one concatenation function for forming complex terms. These terms belong to the language, but their V images in general do not (*'cena'* does but not *cena*).

[23]That rule would have the same effect as the ordinary rule, concatenating the transitive verb with the NP, but it would have a different name, so another semantic operation could correspond to it. If you think this is cheating, observe that if it were the same rule and the same components, we are back to the problem of ambiguity.

of how the syntactic rules apply to the idiom, and to its parts if it has structure, as well as a corresponding semantic account.

Interestingly, idioms differ as to syntactic behavior. While the idiomatic *kick the bucket* is fine in *John kicked the bucket yesterday*, or *Everyone kicks the bucket at some point*, it is not fine in

(9) The bucket was kicked by John yesterday.

(10) Andrew kicked the bucket a week ago, and two days later, Jane kicked it too.

In contrast, *pull strings* preserves its idiomatic meaning in passive form, and *strings* is available for anaphoric reference with the same meaning:

(11) Strings were pulled to secure Henry his position.

(12) Kim's family pulled some strings on her behalf, but they weren't enough to get her the job.

This suggests that these two idioms should be analyzed differently; indeed the latter kind is called "compositional" in Nunberg, Sag, and Wasow 1994 (from which (12) is taken), and is analyzed there using the ordinary syntactic and semantic rules for phrases of this form but introducing instead idiomatic meanings of its parts (*pull* and *string* in this case), whereas *kick the bucket* is called "non-compositional".

A semantics may take care of these two kinds in different ways, and nothing in principle prevents such a semantics from being compositional in our sense. Incorporating idioms in syntax and semantics is an interesting task. For example, in addition to explaining the facts noted above one has to prevent *kick the pail* from meaning DIE even if *bucket* and *pail* are synonymous (if one strives for compositionality, that is), and likewise to prevent the idiomatic versions of *pull* and *string* to combine illegitimately with other phrases. For an overview of the semantics of idioms, see Nunberg, Sag, and Wasow 1994. Westerståhl 2002 is an abstract discussion of various ways to incorporate idioms while preserving compositionality.

3.4 Ambiguity

Even though the usual formulation of compositionality requires non-ambiguous meaning bearers, the occurrence of ambiguity in language is usually *not* seen as a problem for compositionality. This is because *lexical ambiguity* seems eas-

ily dealt with by introducing different lexical items for different meanings of the same word (say, by indexing), whereas *structural ambiguity* corresponds to different derivation histories of the same surface string, and so if meaning is assigned to these histories (terms in the term algebra), as we have done here, the ambiguity disappears.

It is possible, however, to be dissatisfied with this analysis. More precisely, one may argue that even though there are clear cases of structural ambiguity in language, as in *Old men and women were released first from the occupied building*, in other cases the additional structure is just an *ad hoc* way to avoid ambiguity. In particular, *quantifier scope* ambiguities could be taken to be of this kind. For example, while semanticists since Montague have had no trouble inventing different underlying structures to account for the two readings of

(13) Every critic reviewed four films.

it may be argued that this sentence in fact has just one structural analysis, a simple constituent structure tree, and that meaning should be assigned to that one structure. A consequence is that meaning assignment is no longer functional, but relational, and hence compositionality either fails or is just not applicable. Pelletier (1999) draws precisely this conclusion.

Even if one agrees with such an account of the syntax of (13), abandoning compositionality is not the only option. One possibility is to give up the idea that the meaning of (13) is a proposition, i.e. something with a truth value (in the actual world), and opt instead for *underspecified meanings* of some kind. Such meanings can be uniquely, and perhaps compositionally, assigned to simple structures like constituent structure trees, and one can suppose that some further process of interpretation of particular utterances leads to one of the possible specifications, depending on various circumstantial facts. This is a form of context-dependence, and we saw in section 3.7 of Part I how similar phenomena can be dealt with compositionally. What was there called *standing meaning* is one kind of underspecified meaning, represented as a function from indices to 'ordinary' meanings. In the present case, where just a few meanings, all specifiable in advance, are available, one might try to use the *set* of those meanings instead. A similar but more sophisticated way of dealing with quantifier scope is so-called Cooper storage (see Cooper 1983). It should be noted, however, that while such strategies restore a functional meaning assignment, the compositionality of the resulting semantics is by no means automatic; it is an issue that has to be addressed anew.

If one dislikes the idea that ambiguity leads to underspecified meanings, an-

other option might be to accept that meaning assignment becomes relational and attempt instead to reformulate compositionality for such semantics. Although this line has hardly been tried in the literature, it may be an option worth exploring.[24]

3.5 Other problems

Other problems than those above, some with proposed solutions, include possessives (cf. Partee 1997; Peters and Westerståhl 2006; Westerståhl 2008), the context sensitive use of adjectives (cf. Lahav 1989; Szabó 2001; Reimer 2002), noun-noun compounds (cf. Weiskopf 2007), *unless*+quantifiers (cf. Higginbotham 1986; Pelletier 1994), *any* embeddings (cf. Hintikka 1984), donkey and cross-sentence anaphora (cf. Groenendijk and Stokhof 1991, Pagin and Westerståhl 1993), and indicative conditionals (e.g. Lewis 1976).

All in all, it seems that the issue of compositionality in natural language will remain live, important and controversial for a long time to come.

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[24] For some first attempts in this direction, see Westerståhl 2007. Yet another possible route to deal with ambiguity while preserving compositionality was hinted at in section 3.6; cf. footnote 24.

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