Compositionality

Part 2: Criticisms and variants

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A simple linguistic example

The following example is from Higginbotham (2007). Consider deontic

(1) Mary may not leave. (Contrast: Mary may not know John.)

According to H., the VP has the form [may [not leave]], and not leave denotes the complement of *leave*, and may indicates permission.

So a compositional analysis gives the meaning that Mary is permitted not to leave. That's not what (1) means. It means that Mary is forbidden to leave.

What to do? Several things are possible, e.g.

(A) Say (1) is ambiguous; the VP also has the analysis [[may not] leave]. Cf.

(2) Mary will not leave.

Does (2) describe something Mary will do, or something she will not do?

(B) Or say the LF is [not [may leave]], and try to explain the difference wrt

(3) Mary must not leave.

in terms of so-called polarity items.

(C) More elaborate semantics of deontic modals.

A slightly more complicated example (sketch)

This is also due to Higginbotham, (1986). Consider

(4) Every person will eat steak unless he eats lobster.
(5) No person will eat steak unless he eats lobster.

Assume unless here is a Boolean connective. Then it seems that in (4) it means OR but in in (5) it means AND NOT.

So, Higginbotham says, there is no fixed meaning of unless from which the meanings of (4) and (5) is determined compositionally.

A semantic solution (Pelletier, 1994): unless in itself has an underspecified meaning ('some binary connective'). It gets specified, compositionally, higher up in the tree in two ways, depending on whether the relevant NP has a 'negativity feature', as no person does, or not, as every person.

A syntactic solution (Pelletier, 1994): These features are syntactic; there is an (invisible) [+neg] or [-neg] feature, which the syntax uses to derive

(6) Every person will eat steak unless[-neg] he eats lobster.
(7) No person will eat steak unless[+neg] he eats lobster.

So unless is ambiguous (but in a systematic way).

Idioms: A problem?

It is frequently stated that they are a problem.

But often what is meant is just that the usual meaning composition rules, when applied to, say, μ(*kick*) and μ(*the bucket*), don't give the idiomatic meaning of *kick the bucket* (i.e. 'to die').

This is obvious, but has little to do with compositionality.

A more precise usage is from Nunberg, Sag and Wasow (1994), where *kick the bucket* is called non-compositional, whereas e.g. *pull strings* is compositional: composed from idiomatic meanings of *pull* and *string*. This is reflected in contrasts such as:

(8) John kicked the bucket two days ago.
(9) ?The bucket was kicked by John two days ago
(10) ?John kicked the bucket two days ago, but Lucy didn't kick it

(11) Strings were pulled to secure Henry his position
(12) Mary pulled some strings on Bill's behalf, but they didn't get him the job

Idioms, cont.

There are all kinds of interesting issues in the syntax and semantics of idioms, many of which can be formulated within the abstract framework we are using. For example:

- Do idioms have structure, or are some idioms atoms?
- Do some idioms have syntactic but not semantic structure, whereas others have both?
- Do answers to these questions explain the contrasting behavior with respect to passivization and anaphora?

Other typical issues:

- If *bucket* $\equiv_\mu$ *pail*, how can we prevent (the idiomatic) *kick the bucket* $\equiv_\mu$ *kick the pail*, while maintaining compositionality?
- If *pull* has an idiomatic meaning in *pull strings*, how can we prevent that meaning to be used in e.g. *pull the rope*?

Compositional extension problems for idioms

These issues also relate to compositionality, more precisely to compositional extension problems:

Suppose a complex expression in a given compositional language *L* acquires the status of an idiom, with a new meaning (paraphrasable in *L* or not) and new ways of combining with other expressions.

Can the given grammar and semantics be extended in a way which preserves compositionality and generates the expected meaningful expressions with the expected meanings (and is perhaps unique up to equivalence with these properties)?

Different kinds of extensions may be required for different kinds of idioms, but usually these extension problems have positive solutions (cf. W-hl 2002).

In conclusion: Compositionality is not a problem specifically for idioms.

An example from logic: branching quantification

Some logics use branching quantification, in particular the Henkin quantifier:

$$\begin{matrix} \forall x & \exists y \\ \forall z & \exists w \end{matrix} \; R(x, y, z, w)$$

Here y depends on x but not on z, and w depends on z but not on x.

The meaning can be explained by means of Skolem functions:

$$\exists f \, \exists g \, \forall x \, \forall z \, R(x, f(x), z, g(z))$$

This is different from the first-order

$$\forall x \, \exists y \, \forall z \, \exists z \, R(x, y, z, w),$$

which corresponds to

$$\exists f \, \exists g \, \forall x \, \forall z \, R(x, f(x), z, g(x, z))$$

Do Henkin quantifiers have a Tarski style (compositional) truth definition?

Barwise (1979) claimed that they don't. (He also argued that branching occurs in English.)

IF logic

Jaako Hintikka and Gabriel Sandu (1989 and later) proposed Independence-Friendly (IF) logic to express independence with a new syntax. For example, the Henkin sentence can be written

$$\forall x \, \exists y \, \forall z \, \exists w/x \, R(x, y, z, w)$$

$\exists w/x$ indicates that w is independent of x.

IF logic (or FO logic with Henkin quantifiers) is much stronger than FO logic: it is expressively equivalent to existential second-order logic. E.g.

$$\forall x \, \exists y \, \forall z \, \exists w/x \, ((Ax \rightarrow By) \wedge (x = z \leftrightarrow y = w))$$

expresses that there is a 1-1 function from A to B. So

$$\exists u[Au \wedge \forall x \, \exists y \, \forall z \, \exists w/x \, ((Ax \rightarrow Ay \wedge y \neq u) \wedge (x = z \leftrightarrow y = w))]$$

expresses that there is a 1-1 function from A to $A - \{u\}$, i.e. that A is infinite, which cannot be expressed in FO logic.

Hintikka and Sandu gave a game-theoretic semantics for IF logic.

One of Hintikka's main claims was that IF logic does not have a compositional semantics.

The compositionality of IF logic

However, Hodges (1997) gave a compositional semantics for IF logic.

It is 'Tarski style', but instead of interpreting formulas as sets of assignments, as Tarski in effect did for FO logic, his interpreted them as sets of sets of assignments. (So-called trumps, or teams.)

Cameron and Hodges (2001) showed that no semantics for IF logic in terms of sets of assignments is compositional.

Hodges (2001) also proved an abstract result showing that a Tarski style semantics must exist. We will look at the (very simple) argument later.

Hodges' work inspired Jouko Väänänen's Dependence Logic (2007), which has a standard FO syntax but a new atomic formula

$=(x_1, \ldots, x_n, y)$

saying that y depends (only) on $x_1, \ldots, x_n$.

The study of logics which explicitly express (in)dependence is a current very active research area.

The point is: Search for compositional semantics, in the face of apparent counter-examples, can lead to exciting new developments in semantics!

Composition as function application

For Frege, the main—perhaps the only—composition operation, is syntax as well as for meaning, was function application, which he called 'saturation'.

Nothing in compositionality itself requires this, but it has become a goal in many syntax-semantics interfaces. Heim and Kratzer (1998) call it Frege's Conjecture.

For example, a transitive verb stands for a binary relation, but since it combines first with the object, we can take it to have type $\langle e, et \rangle$. Thus:

(13) Mary [knows John]
$know(m, j)$ (predicate logic account)
$(know(j))(m)$ (functional account)

So predicates are functions from individuals to truth values, and binary relations are functions from individuals to predicates.

The second analysis follows the constituent structure of (13), and Frege's Conjecture holds.

But can it be maintained for more complex sentences?

Frege's Conjecture

Consider first:

(14) [Some student] [knows John]

Montague's great innovation was to let NPs like some student denote (generalized) quantifiers, i.e. sets of subsets of the universe (and thus of type $\langle et, t\rangle$ in simple type theory, or type $\langle 1\rangle$ in GQ theory).

So the function Q denoted by some student can be applied to the denotation (set) of knows John.

Moreover, some denotes a type $\langle et, \langle et, t\rangle\rangle$ (or type $\langle 1, 1\rangle$) quantifier, which, applied to student, yields the quantifier Q.

Frege's Conjecture is upheld throughout.

But there are more complicated cases: see Pauline Jacobson's course!

The general strategy is: Try to maintain the idea that semantic composition is function application by systematically lifting semantic values (denotations) to higher types.

Type lifting

A famous lift is from individuals to (type $\langle et, t\rangle$) quantifiers: j is lifted to the quantifier (often called a Montagovian individual) containing exactly the sets (over a given universe) containing j:

j is lifted to $\{B : j \in B\}$ (set notation)
j is lifted to $\lambda X.X(j)$ (lambda notation)

This allows

(15) Mary knows John.
(16) Some student knows John.

to be analyzed in the same way. And it easily handles coordination:

(17) [Mary or Sue] knows John.
(18) [Mary or some student] knows John.

Boolean operations on quantifiers are easily defined, but they cannot be defined on individuals.

Lifting rules can be treated as ordinary grammar rules.

But of course these rules themselves do not correspond to anything like function application.

Type lifting, cont.

But every account, it seems, will need rules that do not correspond to function application.

For example, an account in terms of logical form (LF) may analyze (19) as something like (20):

(19) Some student knows John.
(20) [some student: x] [x knows John]

Then you need special rules (which have nothing to do with function application) to obtain (20).

To deal with transitive verbs, as in

(21) Some student knows every teacher.

one needs more complex type lifting operations, but elegant proposals exist; see P. Jacobson's course.

She shows that in numerous cases, there are solutions involving only function application and type lifting for semantic composition. Such (directly compositional) accounts fit directly into the syntactic algebra framework for grammars.

Triviality, final words

We have seen that attempts to find compositional semantics lead to new developments, improving the syntax and/or the semantic values (meanings).

(Many more examples could be given.)

This is in itself an argument for compositionality.

It could be that for every purported counter-example to compositionality there is an improved syntax/semantics which is compositional.

Or it could be that some linguistic phenomena resist a compositional account.

Even so, there seem to be large compositional fragments of languages.

And in this case, it would certainly not be a trivial property!

It could still be that on the ultimately best account of how language works, compositionality plays no significant explanatory role.

But we are not there yet.

In the meantime, it would seem ill advised to ignore the quest for compositionality.