Binding, Compositionality, and Semantic Values[*]

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0. Introduction: the plan

Assume that propositions—things that are or determine functions from possible worlds to truth-values—are the objects of the attitudes, the possessors of modal properties like being possible or necessary, the things we assert by uttering sentences in contexts, and perhaps more. Suppose we have a compositional semantics that assigns semantic values relative to contexts to the well-formed expressions of a natural language.[1] What is the relation between the proposition expressed by a sentence in a context and the semantic value assigned to the sentence in that context? Surely the simplest view, and so the one we should prefer other things being equal, is that the relation is *identity*: the proposition expressed by a sentence in a context *just is* the semantic value of that sentence in that context. We'll call this *the classical picture*. Lewis [1980] claimed that the proper semantics for certain expressions precluded identifying the compositional semantic values of sentences relative to contexts with propositions as the classical picture does.

[1] Some people think that a semantics may not assign semantic values to some well-formed expressions, (this is mentioned in Westerståhl [2012] and Pagin and Westerståhl [2010a]). But we'll ignore that here since this issue is orthogonal to those we are concerned with.

King [2003, 2007] and Glanzberg [2011] argued that Lewis' argument ultimately fails and that the classical picture can be upheld. Call this exchange *the old debate*. It is worth noting that the dialectic of the old debate was that reasons need to be given for abandoning the classical picture. Absent such reasons, we should retain it, as it is the simpler alternative.

Recently, a number of philosophers have revived the Lewis-style argument for the claim that propositions cannot be identified with sentential semantic values in contexts. They too have argued that the proper semantics for certain expressions precludes this identification.[2] In the present work, we want to consider one instance of a new Lewis-style argument we find particularly interesting, in Rabern [2013], and respond to it. Call this *the new debate*. We begin by reviewing the old debate since we think the morals that should be drawn from that debate are essentially the same ones that should be drawn from the new debate.

Along the way, we'll touch on a number of additional issues that we think have independent interest. Chief among them will be issues about the nature of semantic composition and the way syntactic environments can affect what semantic values are composed and how they are composed. Our response to Rabern [2013] and defense of the classical picture will involve invoking multiple modes of semantic composition and allowing for type-adjusting of semantic values to take place in composition.

We wish to be explicit at the outset regarding the nature of our defense of the classical picture. It depends on making claims about what syntax is actually like and

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[2] For instance, Ninan [2010, 2012], Rabern [2012], Weber [2012], Yalcin [2011, 2014], and Yli-Vakkuri [2013] (though Ninan mainly argues that it is important to recognize the *possibility* that propositions are not compositional semantic values in contexts)

about how semantic composition in fact works. Hence, there is nothing "conceptual"

about our defense of the classical picture. Language could have evolved in such a way

that propositions could not be identified with sentential semantic values in context. We

just claim it didn't. Thus, our defense of the classical picture is empirical.[3]

I. The classical picture

We begin with what the classical picture says about propositions. They are the objects of

the attitudes. They are the things we assert in uttering sentences in contexts. They are

the bearers of truth and falsity, as well as modal properties like being possible or

necessary. They are the semantic values of sentences taken in contexts.[4] Here we focus

on this last property of propositions. We assume that semantic values (relative to various

parameters) are compositionally assigned to sentences. In defending the classical picture,

we then argue that these are propositions; or perhaps better, we resist arguments that they

are not. In the end, we think these come to the same thing, since, as mentioned above, we

think the classical picture is the one we should adopt unless we are for some reason

unable to. We return to this point below.

One assumption we will make throughout is that truth-conditional contents are

good candidates to be propositions. This is, perhaps, a simplification. Many, including

one of the authors,[5] hold that propositions are structured entities, individuating content

more finely than truth-conditions can. But it is commonly assumed that however fine-

grained propositions are, they determine truth conditions. This is a variant of what

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[3] This is also true of the defense of the classical picture in King [2003, 2007] and Glanzberg [2011]. To our surprise, some people seem not to have appreciated this.

[4] To clarify a little further, by 'semantic value in context', we intend the meaning assigned to an expression in a context by the correct semantic theory. The question then arises whether this theory is compositional and in what sense it is compositional. We discuss this extensively as we go forward.

[5] King [2007].

Cresswell [1982] calls the 'most certain principle', that the content you express, plus the facts in the world, determines a truth-value.[6] As we will see below, the main challenge to the classical picture is one where compositional semantic values for sentences are not truth-conditional at all. Hence, the simplifying assumption that propositions are truth conditions is a helpful way to focus on the issue at hand.

II. Lewis' [1980] challenge to the classical picture

Assume that sentences are (compositionally) assigned semantic values relative to a *context*. Sentential semantic values (relative to a context) are then evaluated for truth at *indices*. This is a version of what Lewis [1980] calls the *variable but simple semantic value* approach to semantics. The semantic values of sentences are *variable* in the sense that they differ from context to context for at least some sentences. They are *simple* in that they are or determine functions from merely indices to truth-values. (Lewis also considers what he calls the *constant but complicated semantic value* approach on which sentential semantic values are functions from context/index pairs to truth values, but we need not consider that here.) On the classical picture, these sentential semantic values assigned relative to context just are propositions. As we mentioned, for present purposes, we will assume, as Lewis [1980] does, that propositions are functions from worlds to truth-values. Accordingly, on the classical picture, indices are nothing but possible worlds.[7]

Lewis' [1980] argument that propositions cannot be identified with sentential semantic values relative to context is deceptively simple. Lewis points out that there is

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[6] Cresswell [1982, p. 69] writes, "If we have two sentences A and B, and A is true and B is false, then A and B do not mean the same."

[7] Of course, there are complications in Lewis' work relating to *de se* attitudes (Lewis [1979]), but these are not relevant to our discussion or that of Lewis [1980].

what he calls "shiftiness" in natural language: sometimes the truth-value of a complex sentence at a context and index depends on the truth-value of a sentence that is part of it at the context and the result of *shifting* the index. In particular, Lewis thought that there were various *index shifting sentence operators* that embed sentences to form more complex sentences. He thought there were location operators, tense operators, modal operators and standard of precision operators:

1.   a. Location: Somewhere [the sun is shining]
         b. Tense: There have been dogs= It has been that [there are dogs]
         c. Modal: Aunts must be women=It must be that [aunts are women]
         d. Standard of precision: Strictly speaking [France is not hexagonal]

As indicated, Lewis thought these operators work by *shifting the indices* at which the semantic values (relative to context) of the sentences they embed are evaluated. For instance, (suppressing contextual sensitivity) 'Past [S]' evaluated at (index) t tells us to see whether the semantic value of 'S' is true at a time prior to t. For these operators to be non-vacuous, sentential semantic values (relative to contexts) must be able to vary in truth-value across shifted indices. But, Lewis claimed, since we see that we have operators that shift time, location, standard of precision and world features of indices, sentential semantic values (relative to contexts) must be capable of varying in truth-value across times, locations, and standards of precision as well as worlds. That is, sentential semantic values (relative to contexts) must be *functions from times, locations, standards of precision and worlds to truth-values*. Hence, indices must be taken to be 4-tuples of times, locations, standards of precision, and worlds (at least). But *propositions* are functions from *worlds* to truth-values. So, Lewis concludes, sentential compositional semantic values assigned relative to contexts aren't propositions.

Because it will be important for later, we should add that Lewis [1980] took propositions to be the objects of the attitudes and the things we assert.[8] So even Lewis [1980] wants to associate propositions with sentences in contexts. He points out that his semantics does this since his assignment of semantic values, together with a context, *determines* the proposition expressed by a sentence in the context, even if it isn't identical to that proposition. The idea is that on the variable but simple semantic value approach we are considering (as well as the constant but complicated approach that we are ignoring) we end up with a definition of *sentence* S *is true at context* c *and index* i.[9] Recall that an index is a quadruple $<t,l,s,w>$, where t is a time, l is a location, s is a standard of precision and w is a world. From the relation S *is true at* c *and* $<t,l,s,w>$ that we defined from our compositional semantic values in context, define the proposition expressed by S at c as follows: $\{w: S \text{ is true at } c \text{ and } <t_c,l_c,s_c,w>\}$, where $t_c, l_c,$ and s_c are the time, location and standard of precision of the context c, respectively. Hence, Lewis [1980] has a way of *deriving* the proposition expressed by S at c from c and the compositional semantic value he assigns to S at c. It is in this sense that compositional semantic values determine propositions.

But the degree to which these kinds of semantic values really *determine* propositions is quite limited. The proposition we derived above from the compositional semantic value of S at c is what Lewis calls the *horizontal propositional content of* S *at* c. But Lewis [1980] thinks that S also has a *diagonal propositional content at* c (following

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[8] See p. 37 where he approvingly quotes Stalnaker saying that propositions are the objects of illocutionary acts. He also talks there of the propositional contents of sentences relative to contexts.

[9] Suppose we assign sentences relative to contexts functions from indices to truth-values in the way the variable but simple semantic value approach requires. Then (define) S *is true at context* c *and index* i iff $V^c_S(i)=1$, where V^c_S is the variable but simple semantic value assigned to S at c.

Stalnaker [1978]) that is also derivable from the compositional semantic value of S at c, together with the context c itself. As we saw above, from the compositional semantic values assigned to sentences at contexts, we can define *sentence* S *is true at context* c *and index* i. In much the same manner as we derived the horizontal propositional content, we can use this to derive the diagonal propositional content of S at c. First, consider a context c and consider the set W ={w: for all the speaker of c knows, she is in w}. For any w ε W, there will be some context c_w that is indistinguishable to the speaker from the context c she is actually in. The diagonal propositional content of S at c= {w: w ε W and S is true at c_w and i_{cw}}, where i_{cw} is the index whose features are drawn from c_w.[10] So on Lewis' [1980] view, both the horizontal and diagonal propositional contents of S at c, though not identical with the compositional semantic value of S at c, are derivable from it together with c. Thus, the compositional semantic value fails to determine a unique proposition.

III. Response to Lewis' challenge

We shall now sketch the response to Lewis [1980] in King [2003, 2007]. We'll mainly focus on the case of tense, but King's response in the cases of location and standards of precision is similar. What forces us to put times in indices, and so forces us to allow sentential semantic values (relative to context) to vary in truth-value over times in the way that propositions don't, is the claim that tenses are index shifting operators. But then

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[10] It depends a little on just how contexts are individuated, but there might be several contexts determined by w that are indistinguishable by the speaker from the context she is in. We would have this, for instance, if the speaker utters S on several occasions in w which she cannot distinguish. If this is possible, it will suffice to existentially generalize, and take as our diagonal content to be {w: w ε W and for some context c_w, S is true at c_w and i_{cw}}. Of course, there are other options; why not universally generalizing, for instance? That simply underscores the failure of compositional semantic values to really determine propositions.

if tenses *aren't* index shifting operators, we don't have to have times in our indices. This would *allow us* (not force us) to have sentential semantic values (relative to contexts) that don't vary in truth-value over time. As noted above, King [2003, 2007] simply assumed (with Lewis [1980]) that there were independent reasons for thinking that the objects of attitudes and the things we assert in uttering sentences in contexts—propositions—don't vary in truth-value over time. If neither locatives nor standard of precision expressions are index shifting operators either, we could likewise get locations and standards of precision out of our indices leaving only worlds and allowing us to have sentential semantic values (relative to contexts) that are functions from worlds to truth-values. That is, we could *identify* sentential semantic values (relative to contexts) with propositions and retain the classical picture.

As noted in both King [2003, 2007] and Glanzberg [2011], a lot of work since the 1970s on tense suggests that the operator/tense logic approach to tense is not the best semantic approach. We are not saying there is a knockdown argument here since complex operators have great expressive power. For instance, Cresswell [1990] showed that by using indexed operators one can achieve the expressive power of object language quantification over times. Nonetheless, we are saying there appears to be lots of data that looks more easily/elegantly explained by a theory on which we have object language quantification over and reference to times. Let's take a quick run through some of that data.

First, as noted by Partee [1973], tense exhibits variable-like behavior. In particular the triad of uses exhibited by variables—deictic, anaphoric, and bound—are exhibited by tenses:

2.   a. Deictic uses (tense seems to pick out a *particular* past time/time

interval):

I didn't turn the stove off

b. Anaphoric uses (second tense seems to pick up value from first):

Sheila had a party last Friday and Sam got drunk

c. Bound uses (past on *left* bound by *Whenever*):

Whenever John came in, Sue left.

Operator treatments of tense don't seem to shed any light on this behavior at all.

Second, there is so-called sequence of tense and related data (e.g. Abusch [1997],

Comrie [1985]):

3. We heard that Sue was pregnant.

(3) has two readings. On the first, the time of the alleged pregnancy is *before* the time of

the hearing. On the second, the time of the alleged pregnancy *is* the time of the hearing.

(3) does not have a reading on which the time of hearing is *before* the time of the alleged

pregnancy (and the time of the alleged pregnancy is before the present). However, in

addition to having the first two readings had by (3), relative clause constructions possess

this third reading that is missing in (3):

4. We saw the man (yesterday) who was crying (just now).

These cases look hard to understand on an operator view as noted by Enc [1987] since

sometimes the tenses are interpreted independently (the third reading of 4) and sometimes

they collapse (the second reading of 3 and 4).

Finally, there is the "tense in DP" phenomenon (Enc [1986], Musan [1995]):

5. Every fugitive is now in jail.

Here on the natural reading there is a past reading for *fugitive* and a present for the matrix tense. Since this isn't even sentential, this is a serious problem for sentential operator approaches to tense.

So the thought is that instead of an operator approach to tense, we put temporal variables and quantifiers into the object language. This looks better on the issues we just reviewed. First, it would seem to allow for pronoun-like phenomena. Second, independent manipulation of different variables seems like it could help with embedded tense problems. Third, it allows for temporal interpretation on non-matrix predicates. We'll leave things in this vague state concerning the details of a theory of tense, but will come back to this later.[11]

Let's summarize the main points of King [2003, 2007] and Glanzberg's [2011] response to the argument of Lewis [1980]. If tenses are implemented by variables and devices that manipulate them, Lewis' argument loses its force. We aren't forced to have times in indices for alleged tense operators to shift. Hence we are not *forced* to have sentential semantic values that vary in truth-value over times. Hence (on the score of times), we can allow propositions to be identified with sentential compositional semantic values relative to context. As promised, the rejoinder to Lewis is not on "conceptual" grounds but on empirical grounds. We can make perfectly good sense of tense operators and we understand formal languages that employ them. It just looks like *in fact* natural language doesn't work like that. So we don't think that tense and composition in fact

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[11] The important result is that the object language has temporal variables, and some way of manipulating them. The linguistics literature offers a few options for how that might be implemented, including quantification over times, and presuppositional constraints on the values of variables. See Abusch [1994], Enc [1987], Heim [1984], Kratzer [1998], Kusumoto [2005], and Oghiara [1996], among others. When we need to illustrate, we will opt for a treatment using quantifiers over times, as it is simple and familiar, but this is for purposes of illustration only, and any of the other options are consistent with our main point.

work in such a way as to give an argument against the classical picture. And as we said above, if there is no strong argument against the classical picture, we should adopt it.

Before moving on, we wish to make a few asides. The first aside is to emphasize something we suggested at the outset about why the point we just made—if there is no strong argument against the classical picture, we should adopt it—is correct. A theory that identifies compositional semantic values in contexts with propositions expressed by sentences at those contexts is all-other-things-being-equal simpler than a theory that *derives* propositions from compositional semantic values relative to contexts as does Lewis [1980]. For theories on which propositions are derived from compositional semantic values raise questions about the *nature* of the derivation. Is the derivation governed by a rule (for someone like Bach [1994], in general the answer is no; for Lewis [1980], each of the horizontal and diagonal contents is derivable by a rule)? Why or why not think so? If it is, what is the rule? If there is a rule, is the rule semantic or pragmatic (Lewis doesn't say so far as we can tell)? If the rule is semantic, is it part of our biologically endowed language faculty? If it is, might the rule be a parameter that is set differently in different languages? In answering these questions, the theorist who derives propositions from compositional semantic values is compelled to provide additional theory.[12] These questions simply don't arise for theories on which the proposition

[12] Rabern [2012] seems to miss this point when he writes: "In an important sense, then, we only need to assign expressions a single semantic value, from which the other values can be derived." And then in a footnote attached to this sentence, writes: "King [2003] gives the opposite impression when glossing the view which denies the identification thesis, he says: '…in addition to assigning sentences propositions relative to contexts, [such a view] must assign sentences semantic values relative to those contexts…' But there is nothing really additional to do, since once we have assigned semantic values everything else is determined.' (p. 88) This is just incorrect. There *is* something else to do: formulate the rule or whatever by means of which propositions are derived from compositional semantic values! This is made obvious by the fact that theorists who assign *the same* semantic values to sentences in contexts can assign *different* "propositions" to sentences in contexts (e.g. Lewis' horizontal propositional content, Lewis' diagonal propositional content, things that are or determine functions from world/time pairs to truth-values, etc.).

expressed at a context *just is* the compositional semantic value assigned at that context. Hence advocates of such theories need not provide the additional theory her opponents must provide. But then her theory is simpler and so all-other-things-being-equal preferable. Lewis [1980] himself admits this in a famous passage, albeit in a somewhat disparaging way:

> It would be a convenience, nothing more, if we could take the propositional content of a sentence at a context to be its semantic value. But we cannot…For an adequate treatment of shiftiness we need not just world dependence but index dependence—dependence of truth on all the shiftable features of context. World is not the only shiftable feature.[13]

Here Lewis *agrees* that theories that identify sentential semantic values with propositions are simpler ("more convenient"), but essentially argues that the correct semantic theory precludes the identification so that we are stuck with the more complex theory that distinguishes sentential semantic values from propositions. We think Lewis is clearly right that the theory that identifies compositional semantic values with propositions, as the classical picture does, is simpler. This is why we said above that the classical picture is the one we should adopt unless there is some reason not to.

The second aside is that we are now in a position to see that the arguments given by Ninan [2010, 2012] against King [2003, 2007] fail. In both papers, Ninan claims that King [2003, 2007] holds that if the index of your semantic theory does not contain a feature X, then the semantic theory entails that the semantic values the theory assigns to sentences (in contexts) do not vary in truth-value over X (we have been focusing on the case where X is *time*). And he claims that this claim is false. We agree! But King

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And that, of course, is because there *is* something further to do for such theorists after the assignment of semantic values in contexts and our imagined theorists do *different* things.
[13] p. 39

[2003, 2007] did *not* claim that if the index of your semantic theory does not contain a feature X, then the semantic theory entails that the semantic values the theory assigns to sentences (in contexts) do not vary in truth-value over X. Rather, the main point King [2003, 2007] makes is actually one Ninan seems to agree with (focusing now on times, but the point holds for locations, etc. too): if times *are* in indices, sentential semantic values (relative to contexts) *must* vary in truth-value over time. This in turn would *preclude* the identification of sentential semantic values (relative to contexts) with propositions. Once times are not features of indices, King claims, there is nothing that prevents us from having sentential semantic values relative to contexts that don't vary in truth-value over times (similarly for location and standard of precision). That is, nothing prevents us from retaining the classical picture and identifying propositions with sentential semantic values relative to contexts. As was just argued, if nothing precludes availing ourselves of that option, we should do so.

It is worth mentioning in this context that King [2007] explicitly stated that the approach to tense he favors *allows* for temporally neutral sentential contents. Considering the following English sentences and their (admittedly overly simple) LF regimentations:

6.   a. Maggie is happy.
          b. $\exists t$ (t = t* &Maggie be happy(t))
7.   a. Maggie was happy.
          b. $\exists t$ (t<t* & Maggie be happy (t))
8.   a. Maggie will be happy.
          b. $\exists t$ (t*<t & Maggie be happy (t))

King [2007] writes:

> If we consider the contents of [6–8] when the term 't*' is not assigned any
> value, we see that they will be contents that determine functions from
> times to propositions (i.e. they determine functions from a time t_0 to the

propositions expressed by [6–8] when t_0 is assigned to 't*'). *Thus the present account allows for temporally neutral contents.* And in fact I think we often talk about temporally neutral contents, as when you say 'America is the moral leader of the world' and I respond 'That might have been true ten years ago, but it isn't now.' I might have even responded 'I believed that ten years ago but I don't today.' But despite this I think that the objects of our attitudes and what we assert etc. are not temporally neutral. I hope to elaborate on this elsewhere. *But my main point here is that the present account yields temporally neutral contents.*"[14]

Obviously if King [2003, 2007] had been arguing that the theory of tense he favors *entails* that sentential compositional semantic values (relative to context) are time specific as Ninan claims, he would not have explicitly stated that the theory he favors allows for temporally neutral sentential contents. For nothing about the theory of tense King favors *requires* him to choose the temporally specific sentential contents for the semantic values of sentences at contexts as opposed to the temporally neutral sentential contents he recognizes his account allows. But, again, King's thought is that if there is no reason *not* to identify sentential compositional semantic values with time specific sentential contents—propositions—one should do so. King [2003, 2007] in effect argues that there is no reason not to do so.[15] So his defense of the classical picture amounts to rejecting Lewis' [1980] claim that the proper semantics of certain expressions precludes accepting it.

Let's summarize the main morals of the present section. Lewis [1980] gave an argument to the effect that the proper syntax and semantics for tense, locatives and standard of precision expressions precludes the identification of sentential compositional values relative to contexts and propositions. King [2003, 2007] and Glanzberg [2011]

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[14] p. 188 note 36; our emphasis

[15] Here, as in other places in the present discussion, we are pretending that the choice is only between sentential semantic values that determine functions from world time pairs to truth-values vs. sentential semantic values that determine functions from worlds to truth-values (i.e. propositions).

respond by saying that a proper appreciation for the syntax and semantics of these expressions does not preclude the identification. Given that we should accept the classical picture unless there is some reason not to, this vindicates the classical picture. The main force of the argument is empirical: in fact the syntax and semantics of natural language does not preclude the identification, and on simplicity grounds, this favors making it.

IV. The new Lewis style arguments against the classical picture

In recent years, a number of authors have attempted to revive Lewis' conclusion that sentential compositional semantic values relative to contexts cannot be identified with propositions. Like Lewis' own argument, their arguments claim that the proper syntax and semantics for certain expressions preclude the identification. Ninan [2010] and Yalcin [2007, 2011] consider the case of epistemic modals. Rabern [2012, 2013] and Yli-Vakkuri [2013] take up the case of quantification, and particularly, binding and compositionality. We'll focus on this last set of issues. This new debate brings up issues that were important in the old debate. It also sheds light on a number of independently interesting issues. We'll focus on Rabern [2013], but what we say applies to Yli-Vakkuri [2013] as well.

Rabern [2013] argues that a compositional treatment of binding and quantification requires semantic values to be relativized to assignment functions (suppressing contextual sensitivity here). For simplicity and following Rabern, we'll look at a purely extensional semantics in the Heim and Kratzer [1998] style where sentences are of type t. So t is our proxy for propositions, given these simplifications. Rabern argues that a compositional treatment of quantification requires sentences to be of type $\langle \gamma, t \rangle$, where γ is the type of

assignment functions. So instead of having truth-values as the semantic values of sentences, Rabern says that we require functions from assignments to truth-values. Since t is our proxy for propositions, this means that sentential semantic values cannot be propositions. Just as in the old debate, Rabern (and others) are arguing that indices must have an additional parameter, in this case, an assignment function parameter. As in the old debate this precludes the classical view that sentential semantic values are propositional. Two caveats before proceeding. First, Rabern likes to put this in terms of quantification and binding being *monstrous* in Kaplan's [1977] sense, but this brings up complexities that are irrelevant to the core debate and so we'll ignore it for the most part (but see section VIII below). Second, a lot of Rabern's discussion concerns Kaplan's formal system in *Demonstratives*. We are going to skip this because what interests us is what the semantics of natural language requires and Rabern discusses this as well. That is, we are concerned with the question of whether the classical picture holds *for natural languages*.

However, for a warm up, we begin with some brief remarks about the standard Tarskian treatment of quantification. A standard Tarski-style treatment of first order quantification offered up in most introductory logic books runs as follows:

9. $\|\forall x \phi\|^g = 1$ iff for all g' differing from g at most on x, $\|\phi\|^{g'} = 1$.

This treatment of the quantifier doesn't tell us how to build the meaning of '$\forall x \phi$' out of the meanings of '$\forall x$' and 'ϕ'. Further it is *syncategorematic*: it does not assign any meaning to '$\forall x$' by itself. One might see syncategorematic treatments of quantifiers as non-compositional. We think this is a mistake, as we shall discuss more in a moment. Regardless, Rabern [2013] offers a more 'categorematic' treatment, that requires putting

assignment functions in the object language and analyzing binding as an operator on assignment functions. This makes semantic values relativized to assignment functions. As indicated, that is already enough to put pressure on the identification of semantic values with propositional contents, since the latter are represented by our proxy t. Hence, we have a Lewis-style conclusion, argued via the treatment of quantification.

The syntcategorematic nature of standard treatments of quantification is a clue to why one might worry about its compositional status, as Rabern et al. do, and it points towards why quantification might drive some to depart from the classical picture. With this preview, let's now look at quantification in natural language.

As indicated, we will work in Heim and Kratzer's [1998] extensional system in which sentence semantic values are of type t, which again is our proxy for propositions. Quantifiers like 'Every woman' are type $\langle\langle e,t\rangle,t\rangle$. Hence they require arguments of type $\langle e,t\rangle$. As a result, it is easy to account for sentences like 'Every woman skied', where 'Every woman' combines directly with an expression of type $\langle e,t\rangle$ (intransitive verb). However, as is well known, this approach has a *prima facie* problem when it comes to sentences with quantifiers in object position like

10. Eros [$_{VP}$loves [$_{DP}$every woman]]

The problem is that 'loves' is of type $\langle e,\langle e,t\rangle\rangle$ and 'every woman' is of type $\langle\langle e,t\rangle,t\rangle$. But semantic values of these types can't combine (neither can be the argument of the other). Hence, there appears no way to assign a semantic value to the VP. There are a variety of ways this problem could be addressed, but Heim and Kratzer [1998] adopt what many consider the standard solution, which is to repair the type mismatch by positing *quantifier movement*. The object quantifier

moves and adjoins to the S node, leaving behind a *trace*. This is a widely held

view, but Heim and Kratzer implement it in a very particular way, which will be

important as our discussion progresses. The quantifier movement introduces an

index into the LF, which is interpreted as a lambda binder. The resulting structure

is:

11. [s[DPevery woman][1[sEros[VPloves[t₁]]]]]

where '1' is interpreted as a lambda binder. Since 'every' is type

<<e,t>,<<e,t>,t>>, this will work as long as the following is of type <e,t>:

12. [1[sEros[VPloves[t₁]]]]

Heim and Kratzer get this result by means of a composition principle for expressions like

(12) that treats the index like a lambda binder. Their version reads as follows:

Predicate Abstraction Rule (PA)

Let α be a branching node with daughters β and γ, where β dominates only a numerical index i. Then, for any variable assignment a, $\|\alpha\|^a = \lambda x \, \varepsilon \, D_e \, . \, \|\gamma\|^{a\,x/i}$, (where a x/i is the assignment that differs from a at most in assigning x to i).[16]

In the intended applications, γ is of type t, so this makes α of type <e,t> as required.

Against this background, let's look at Rabern's [2013] argument. Rabern

complains that the Heim and Kratzer (and other standard) semantics is not compositional.

As we understand the complaint, it reduces to the objection that PA is syncategorematic:

it assigns no meaning to '1' (which is the lambda binder) and hence is not a rule that tells

us how e.g. the meaning of '1' composes with the meaning of the rest of (12) to give us

the whole meaning of (12). That, Rabern claims, is non-compositional. To get a

categorematic treatment for '1' (and numerical indices/lambda binders generally) and so

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[16] Heim and Kratzer [1998] p. 186, with some slight adjustment of notation.

a compositional semantics for (11), Rabern claims, requires introducing a type γ for

assignment functions and lifting the types of all expressions in (11) by relativizing them

to assignment functions, and assigning the appropriate meaning/semantics to '1'.[17]

Specifically, we now have:

13.   a. 'Eros loves t_1' is of type $<\gamma, t>$ (instead of t).

b. '1' is of type $<<\gamma,t>, <<\gamma,e>,<\gamma,t>>>$ (no type before).

c. (12) above is of type $<<\gamma,e>,<\gamma,t>>$ (instead of $<e,t>$).

d. 'Every woman' is of type $<<<\gamma,e>,<\gamma,t>>, <\gamma,t>>$ (instead of $<<e,t>,t>$).

e. 'loves' is of type $<<\gamma,e>, <<\gamma,e>, <\gamma,t>>>$ (instead of $<e,<e,t>>$).

f. 'Eros' and 't_1' are of type $<\gamma,e>$ (instead of e).

g. 'woman' is of type $<<\gamma,e>, <\gamma,t>>$ (instead of $<e,t>$).

h. (11) is of type $<\gamma,t>$ (instead of t).

Hence, Rabern's [2013] proposed best compositional semantics for quantification and

lambda binding forces sentences to be of type $<\gamma,t>$ instead of our proxy proposition type

t. Thus, on this semantic story sentential compositional semantic values cannot be

identified with propositions. Thus, this semantics requires rejecting the classical picture.

Though the particular phenomena and details differ, the basic argument is very much in

line with Lewis'. It tries to show that some mechanism in natural language forces

sentential semantic values to be relativized in a way that precludes the classical picture.

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[17] The types we go on to mention were suggested by Rabern (p.c.) and differ from those in Rabern [2013].
Related technical proposals, which explore the options for basic type assignments and ways to lift them, are
offered by Kobele [2010] and Sternefeld [1997] (cf. Kennedy [2014]). We focus on Rabern, as he is more
concerned with our main topic of the traditional view, while these authors are more concerned with some
empirical consequences of the modified types. Rabern's own presentation relies on a pronoun in (13a), and
is thus reminiscent of Montague's [1973] quantifier lowering.

V. Response to the new Lewis style argument: first pass

As we saw, Rabern's argument proceeds via some considerations of compositionality. In particular, he objected that the Heim-Kratzer Predicate Abstraction Rule (PA) for the lambda expression that a quantifier embeds is non-compositional. Specifically, he claimed the rule was syncategorematic and so non-compositional. This motivated producing a lexical entry for the lambda binder that in turn forced relativizing semantic values in such a way that sentential semantic values came out non-propositional.

We ultimately will reject the claim that principles like PA violate (well-motivated notions of) compositionality. But compositionality comes in many flavors. There are some strong forms that PA violates given certain other assumptions. Let's walk through this in a little detail. Assume that the relevant syntax for things like (12) above is as follows (which we assumed above):

14.

$$\alpha$$

                            S

    1   β
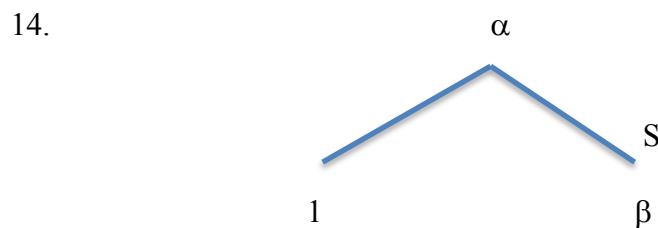
where β is of type t ('Eros loves t_1' above) and α is simply a label for the mother node.

To evaluate compositionality claims for such structures, we need to work in a more general framework. Think of the syntax of a language as consisting of set E of (simple and complex) expressions and a set of "syntactic rules" F such that each rule in F is an n-ary partial function f (for some n) taking n members of E as arguments and yielding a member of E as value if f is defined for the arguments in question. So we can

identify the syntax of a language with a *partial algebra* <E,F>, with E and F understood as above. The members of F in such partial algebras are often referred to as *operations on* E. So, for example, one member f_{DP} of F will take 'most' and 'dogs' as arguments, and yield $[_{DP}[_{D}most][_{NP}dogs]]$ as value (i.e. $f_{DP}(most, dogs) = [_{DP}[_{D}most][_{NP}dogs]]$).[18] Now consider a meaning assignment μ that is a function from E to the set M of meanings for expressions in E; and consider f ε F an n-place operation on E.[19]

With this apparatus, we can define notions of compositionality, and see how they apply to our main case. For instance, we can define:

Strong Compositionality

μ is *strongly compositional with respect to* f iff there is a n-place meaning operation r_f (a function from M^n to M) such that given expressions $e_1,…,e_n$ ε E for which f is defined, $μ(f(e_1,…,e_n)) = r_f(μ(e_1),…,μ(e_n))$.[20]

μ is *strongly compositional* iff it is strongly compositional with respect to every f ε F.

We can understand the syntax and semantics of (14) in such a way that it indeed fails to satisfy strong compositionality so-defined. Suppose there is a 2-place syntactic operation $f\lambda$ that applies to '1' and β to yield (14). Then our meaning assignment μ $(= ||\ ||^a$; we ignore that fact that our meaning assignment is relativized to assignment functions, since it won't matter) is strongly compositional with respect to $f\lambda$ iff there is a 2-place meaning operation $r_{f\lambda}$ such that $μ(f\lambda(1, β)) = r_{f\lambda}(μ(1), μ(β))$.[21] But this last condition is not met

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[18] Note that we are assuming that complex members of E have constituent structure.
[19] This approach was developed by Hodges [2001]. See Pagin and Westerståhl [2010a] for background, precedents, and alternatives. They point out that we might want μ to be partial e.g. if we want to distinguish between meaningfulness and grammaticality.
[20] Cf. Westerståhl [2012] p. 204; Pagin and Westerståhl [2010a] p. 254; and Szabó [2012b] section 2, and references therein.
[21] Note that in a case of the sort under consideration, we say that a composition rule (here PA) is compositional/non-compositional just in case the meaning assignment in question (here $||\ ||^a$) is compositional/non-compositional with respect to the relevant syntactic rule (here $f\lambda$). When a syntactic

since our syncategorematic treatment of 1 has it that there is no μ(1). Thus, things can be set up so that the standard treatment of 1 by means of PA fails to be strongly compositional, (hence we agree with Rabern [2013] on this point).[22]

Ultimately, we will argue in the next section that we should not accept the assumptions that lead to this conclusion, and that even a form of strong compositionality can be preserved. But first, we want to consider whether the argument via strong compositionality really has any force.

As Pagin and Westerståhl [2010b] and Szabó [2012a, 2012b] point out, the usual arguments in favor of compositionality fail to support anything so strong as strong compositionality. Considerations of learnability, productivity, and methodology only support a much weaker notion. A more usual definition of compositionality, put informally, is this (e.g. Szabó [2012a]): The meaning of a complex expression is a determined by the meaning of its constituents and the way they are combined. PA satisfies this, with the syntax assumed in (14). PA tells us how the meaning of the complex expression α is determined by the meanings of its constituents and their mode of combination. The interpretation as a λ expression relies crucially on the mode of combination, to which PA makes explicit reference. But that is no barrier to satisfying the usual definition of compositionality, which allows for such reference. So, even if we grant that PA fails to satisfy strong compositionality, in virtue of the index '1' lacking a

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rule like fλ is associated with a composition rule like PA, we'll sometimes say that the syntactic rule is *governed by* the composition rule.

[22] Whether this is so probably depends on the precise nature of the algebras, but we aren't going to worry about that because we'll be defending a different view. Generally, with enough flexibility in syntax and semantics, even strong compositionality can be easily satisfied, as various mathematical trivialization results make vivid. As Westerståhl [1998] notes, the empirical force of compositionality often comes from how it can be satisfied in the face of other empirically significant constraints. See again Pagin and Westerståhl [2010b] and Szabó [2012b] for further discussion. In the next section, we will present a way that compositionality can be preserved that we think best achieves this.

meaning, this is not a failure of compositionality in the usual sense. (We will grant this for now, but will argue against it later.) The moral here is that our meaning assignment via PA *is* compositional in the sense of compositionality that is supported by the usual arguments for compositionality.[23] But then there is no motivation from considerations in favor of compositionality for abandoning it in favor of Rabern's alternative.

Further, the approach using PA is familiar, simple and works well. In contrast, the kind of approach Rabern advocates has some difficulties. Lifting semantic values for lexical items makes them have much more complex types than we might have expected, and these lifted types do not well-reflect the basic semantic functions of lexical items. The core semantic function of lexical items as they build a clause is to provide properties and the objects that bear them, which combine to describe eventualities.[24] This indicates semantic values for predicates that are (extensionally) sets of individuals, *not* functions from functions from assignments to individuals to functions from assignments to truth-values. For names, it indicates individuals as semantic values, *not* functions from assignments to individuals. And so on for quantifiers and other expressions of more complex type. Rabern's raised types fail to reflect the core semantic functions of expressions, and they likewise fail to reflect speakers' basic understanding of what their expressions mean. The familiar, intuitive semantic values we usually use fare better on this score, and so, they should be kept if possible. That would not be possible if the

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[23] Pagin and Westerståhl [2010a] call what seems to be justified by the usual arguments 'recursive semantics' rather than 'compositionality' and they note a number of technical differences between it and common formulations of compositionality. For technical purposes, it may be wise to keep the notions separate, but we here follow the causal use of 'compositional' in which it is accepted that semantic theories should be compositional. As Pagin and Westerståhl and Szabó note, the resulting notion is quite weak.
[24] Of course, in a fully inflected clause, a lot else happens too, including placing the eventuality in time and giving it a distinctive event structure. But the core content comes from the way lexical items provide objects and properties. See the discussion in Glanzberg [2011]

general, and well-motivated, compositionality principle was undermined by them. But such poorly motivated principles as strong compositionality do not provide a reason to abandon the simple and intuitive semantic values.

A few comments about this sort of argument are in order. It may be possible to have lexical items enter at their usual types, and then raise those types in the compositional apparatus.[25] But that will require more complex modes of composition. Objections to PA will carry over to those modes of composition, so this route will not really provide an alternative to those like Rabern who insist only on simple modes of composition. (We return to these issues below.)

Also, we pause to note that, in keeping with our general outlook in this paper, the argument here is about what is all-things-considered the best option to take, given the empirical situation. We do not think there is a general conceptual requirement that semantic values must be exactly like our intuitions about meaning say they are. Rather, our point is that those intuitions reflect speakers' knowledge of their language, and they also reflect how clauses function, and the simpler semantic values capture those aspects of language better. So, absent a strong reason to abandon them, we think it is better to keep them. As we noted, compositionality considerations do not provide such a reason.

Finally, being forced to posit these rather bizarre types for quite ordinary expressions is bound to complicate our metasemantic story about how lexical items get semantic values in the first place. Presumably the correct story here will have speakers in some sense having beliefs and intentions regarding the properties and objects they express using those lexical items. But if the semantic values of even very simple

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[25] Kobele [2010] explores some options along these lines.

expressions like names and predicates of individuals involve things that ordinary languages users don't have beliefs or intentions about, the story about how lexical items came to have these semantic values is bound to be much more complex than it would otherwise have to be. Again, we do not rule that out in principle, and indeed, one of the authors thinks that lexicalization can be a very complex process.[26] But again, all things considered, it is better not to lose that simple starting-point for the metasemantics if possible.

In short, having a little well understood syncategorematicity seems well worth the cost of avoiding these complex types. Compositionality itself gives us no reason not to.

To summarize our first pass at a response to Rabern [2013], an approach to quantification and binding using PA only violates a very strong version of compositionality (strong compositionality as defined above), and only with some additional supporting assumptions. However, usual arguments in favor of compositionality involving learnability, productivity and methodology only support much weaker notions of compositionality (or perhaps even the claim that by and large languages obey strong compositionality, but this would not be enough to argue against isolated violations like PA—see Szabó [2012a,b]). The approach using PA is compositional in the weaker sense. Further, the approach using PA is simple, familiar, works well *and* allows us to keep simple intuitive types instead of the complex and rather bizarre types Rabern's approach requires. Finally, adopting Rabern's types will surely complicate the metasemantic story as to how lexical items get their semantic values. Hence absent a strong argument against PA—like the one from compositionality that we

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[26] Glanzberg [2014].

claim fails—we should stick with a well working theory with much simpler types rather than adopting Rabern's alternative.

Though we view the foregoing as a successful response to Rabern [2012, 2013] on behalf of the classical picture, we in fact think there is an even stronger response.

VI. Response to the new Lewis style argument: second pass

We begin by noting that the only composition rule employed in Rabern's [2013] derivation of truth conditions for (11) is Functional Application:

Functional Application (FA)

If α is a branching node and $\{\beta,\gamma\}$ the set of its daughters, then, for any assignment a, α is in the domain of $\| \ \|^a$ if both β and γ are, and $\|\beta\|^a$ is a function whose domain contains $\|\gamma\|^a$.   In this case, $\|\alpha\|^a = \|\beta\|^a(\|\gamma\|^a)$.[27]

Indeed, it appears that Rabern precisely changed the types in the way he did to achieve strong compositionality relying only on FA.

However, even a standard semantics textbook like Heim and Kratzer [1998] employs other composition rules. Consider Predicate Modification, which is designed to cover constructions like 'grey cat':

Predicate Modification (PM)

If α is a branching node and $\{\beta,\gamma\}$ the set of its daughters, then, for any assignment a, α is in the domain of $\| \ \|^a$ if both β and γ are, and $\|\beta\|^a$ and $\|\gamma\|^a$ are both of type $<e,t>$. In this case, $\|\alpha\|^a = \lambda x : x \ \varepsilon \ D_e$ and x is in the domain of $\|\beta\|^a$ and $\|\gamma\|^a$. $\|\beta\|^a(x) = \|\gamma\|^a(x) = 1$.[28]

This rule is designed to apply when a mother node has $<e,t>$ expressions at both daughter nodes. Obviously, FA cannot apply in such a case, since there is a type mismatch. Of

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[27] Heim and Kratzer [1998] p. 105
[28] Heim and Kratzer [1998] pp. 105-06, with slight adjustment of notation. As we are quoting, we here follow Heim and Kratzer's conventions for specifying domains of partial functions, even though that is not important to the issues at hand.

course we could think that there is a type shifting rule that applies to one of the <e,t>

daughters making it of type <<e,t>,<e,t>> so that FA can apply after all. Heim and

Kratzer [1998] consider this option but tentatively decide in favor of PM. The crucial

point is that we could, and we think should, view *PM itself* as adjusting the type of one of

the daughters so that functional application can occur. This can be made salient by

writing PM as follows:

Type Adjusting PM

If α is a branching node and $\{\beta,\gamma\}$ the set of its daughters, then, for any
assignment a, α is in the domain of $\| \ \|^a$ if both β and γ are, and $\|\beta\|^a$ and $\|\gamma\|^a$ are
both of type <e,t>. In this case, $\|\alpha\|^a = [\lambda f \ \varepsilon \ D_{<e,t>} . [\ \lambda x : x \ \varepsilon \ D_e$ and x is in the
domain of $\|\beta\|^a$ and $\|\gamma\|^a . \|\beta\|^a(x) = f(x) = 1]](\|\gamma\|^a)$.

Type adjusting PM uses β's <e,t> meaning to build up a function of type <<e,t>,<e,t>>

$([\lambda f \ \varepsilon \ D_{<e,t>} . [\lambda x \ \varepsilon \ D_e . \|\beta\|^a(x) = f(x) = 1]])$ which it then applies to $\|\gamma\|^a$. The upshot is

that some modes of composition, like PM, have the effect of adjusting types as part of the

composition process. Restating PM in its type adjusting form makes this vivid. Surely,

there is nothing in principle objectionable about a composition rule like PM that adjusts

types in the relevant construction so that function application can occur. Such rules may

well be necessary in the sense that the simplest semantics uses them. Indeed, this is in

effect what Heim and Kratzer [1998] say in adopting PM instead of doing type shifting or

adopting some other approach.[29]

As we have noted, Heim and Kratzer [1998] are working in a largely extensional

system, where extensions of expressions are what generally compose. For example, FA

in effect says: apply the function that is the extension of β relative to a $(\|\beta\|^a)$ to the

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[29] pp. 65-73.

extension of γ relative to a ($\|\gamma\|^a$). However, near the end of Heim and Kratzer [1998], they consider how to handle verbs of propositional attitude. They note that such verbs are sensitive to more than the extensions of their complements. To handle such verbs, they introduce a new type s for worlds. They assign attitude verbs the type $<<s,t>,<e,t>>$. They then note that when they try to apply their semantics to a sentence like 'Mary believes Jan is loyal', they get stuck at line c below:[30]

15.   a. $\|$Mary$[_{vp}$believes $[_s$Jan is loyal$]]\|^w = $ (FA)

b. $\|$believes $[_s$Jan is loyal$]\|^w(\|$Mary$\|^w) = $(lexical entry for 'Mary')

c. $\|$believes $[_s$Jan is loyal$]\|^w$ (Mary)

The problem is that 'believes' applies to something of type $<s,t>$ (function from worlds to truth-values) but $\|$Jan is loyal$\|^w$ is a value of type t. In effect, we have a type mismatch at line c above. Heim and Kratzer's solution is to introduce a new composition rule they call *Intensional Functional Application*:

Intensional Function Application (IFA):

If α is a branching node and $\{\beta,\gamma\}$ the set of its daughters, then, for any possible world w and any assignment a, if $\|\beta\|^{w,a}$ is a function whose domain includes $\lambda w'$ $.\ \|\gamma\|^{w,a}$, then $\|\alpha\|^{w,a} = \|\beta\|^{w,a}(\lambda w'\ .\ \|\gamma\|^{w',a})$.[31]

Like our formulation of PM above, IFA is a compositional rule that adjusts a type mismatch so that functional application can happen. IFA abstracts over the world feature of the index yielding a function from a world w to $\|\gamma\|^{w,a}$ (i.e. a possible worlds proposition). Like PM it is hard to see why anyone would find IFA objectionable; and like PM it may be required for a semantic theory since the best/simplest intentional

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[30] p. 307. Following Heim and Kratzer, we suppress assignment functions here.
[31] Heim and Kratzer [1998] p. 308.

semantics may be one that includes it. Indeed, though variants of IFA take a number of forms, virtually all intensional semantic systems make use of something like it. We think it is safe to say that something like it is required for an empirically adequate intensional semantics.[32]

As indicated, in Heim and Krazter's IFA, $\lambda w'$ is a way of abstracting over the world feature of the index, but we can have a version where the lambda binds a variable in a sentence:

Variable IFA

If α is a branching node and $\{\beta,\gamma\}$ the set of its daughters, β is of type $<<a,b>,c>$ and γ is of type b and contains a free variable indexed i of type a, and (λx_a . $\|\gamma\|^{g \, x/i}$) is in the domain of $\|\beta\|^g$, then $\|\alpha\|^g = \|\beta\|^g$ (λx_a . $\|\gamma\|^{g \, x/i}$).

(We changed our assignment function from a to g, as a is a type in this rule.) Here the rule provides $\|\beta\|^g$ with an argument of type $<a,b>$, as required. So e.g. if $\|\gamma\|^g$ is of type t, and a is type e, λx_a . $\|\gamma\|^{g \, x/i}$ is a function from individuals to truth-values (= type $<e,t>$). Notice that if we were to have world variables (of type s) in the object language, then IFA would be an instance of Variable IFA.

The crucial point here for our concerns is that Heim and Kratzer's syncategorematic rule PA is also doing the work of a version of IFA and we can replace it with an IFA style rule as follows:

Quantificational IFA (QIFA)

If α is a branching node and $\{\beta,\gamma\}$ the set of its daughters, with β of type $<<e,t>,t>$ having index i and γ of type t containing a free variable with index i of type e, and ($\lambda x \, \varepsilon D_e$. $\|\gamma\|^{g \, x/i}$) is in the domain of $\|\beta\|^g$, then $\|\alpha\|^g = \|\beta\|^g$ ($\lambda x \, \varepsilon D_e$. $\|\gamma\|^{g \, x/i}$).

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[32] Some traditional approaches following Montague [1973] use the apparatus of "caps and cups" (ˆ, ˇ) instead of formulating a rule of IFA, but the effect is the same. See von Stechow and Zimmermann [2005] for further discussion.

QIFA is essentially Variable IFA with a type e variable, with $<<e,t>,t>$ for $<<a,b>,c>$. It also includes indices linking to variables. We have formulated QIFA as an autonomous semantic rule, but the role of indices will be clearer if we view it together with the syntax of quantification. As before, we are assuming that quantifier scope and type mismatch for quantifiers in object position are handled by QR. Hence, QIFA is Variable IFA as it applies to QR configurations. In this case, the variable in γ will be a trace t_i, and the index on β is generated as part of the syntactic movement operation. We thus assume that quantified sentences look as follows at LF:

16.
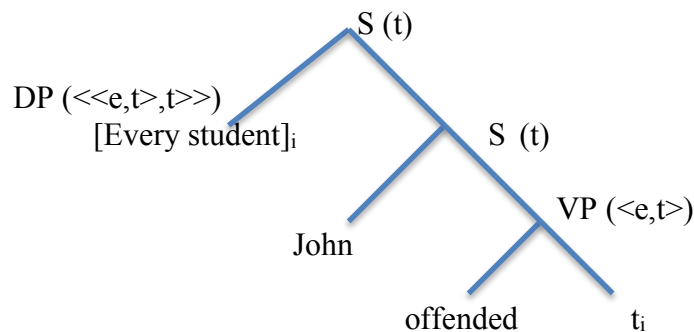
In the simple case of one quantifier, we make no use of the index on the raised DP, but this will play a role in multiple quantifier cases, and so, we have added it to QIFA (even though we will not make use of it in our discussion here). Like PM and our other versions of IFA, Quantificational IFA simply adjusts the type of one of the daughter nodes (here, the S of type t 'John offended i' becomes type $<e,t>$) so that composition can proceed. But its distinctive contribution is just type adjusting, as with all the principles we have reviewed in this section.[33]

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[33] We owe the observation that a form of IFA applies in QR configurations to Ezra Cook. See his forthcoming dissertation, and work in progress with Glanzberg, for investigation of the empirical

A few features of QIFA are worth mentioning. First, it allows us to simplify the

syntax of QR, and does not require a distinct index node, as Heim and Kratzer do. It

allows the standard syntax of quantification, in the tradition of May [1985]. The rule of

QIFA replaces Heim and Kratzer's PA rule. It might be that we can simply eliminate PA

in favor of a single, highly general IFA rule, along the lines of Variable IFA.[34] Even if

QIFA is a distinct rule, its form makes vivid that it is a composition principle that adjusts

types in the course of composition, and furthermore, that this is a commonplace operation

in natural language. It applies in predicate modification, in intensional domains, and in

quantification.

In summary, we think QIFA gives an elegant, well-motivated account of the

semantics of QR configurations. It is a variant of the standard, syncategorematic

approach, as is Heim and Kratzer's, but we think it is a cleaner version.[35]

With our favored account of quantification on the table, let's return to

considerations concerning compositionality with an eye to responding to Rabern's

argument.[36] Though syncategorematic, QIFA has an air of compositionality about it.

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consequences of this approach for binding. Similar observations have been made in various other settings.
Notably, Reinhart [1983] invokes a similar rule, in a more traditional Montagovian framework.

[34] One of the authors, Glanzberg, thinks this is likely so. But King [2003] would at least want to treat the
effect of IFA for worlds differently. See Glanzberg [2009] for some thoughts on the role of worlds in
semantics.

[35] Why not put a node in the syntax where type shifting takes place, and avoid it in composition principles?
Generally, we are not opposed to there being such nodes in some cases. But here, we preserve what we
think are otherwise well-motivated ideas about what the syntax and semantics should be by invoking a type
adjusting composition principle. We do note that rules like QIFA are in a way construction-specific. QIFA
requires indices and variables in constituents, and we might suppose that these arise precisely in QR-
generated environments. The more general form of variable IFA applies in a wide range of 'binder meets
variable' environments (though it is much less clear if a syntactic process like QR is responsible for all of
them). As we will discuss more below, we think this is a virtue, as we think it shows ways that some
syntactic environments or syntactic processes can make very modest contributions to meaning. As we are
supposing a highly restricted range of composition principles, perhaps linked to highly general syntactic
processes, we are not thereby committed to any further construction-specific rules or effects.

[36] Thanks to Josh Dever for finding a really horrific error in our earlier discussion of these issues.

More accurately, it ensures that types match at each stage of the compositional process, and it starts with ordinary semantic values for terminal nodes. It thus might seem as if it simply shows us how to compose those meanings. In avoiding the index nodes used by Heim and Kratzer, we avoid nodes without semantic values, and we achieve what looks like ordinary semantic composition. Indeed, one of our original motivations for formulating QIFA was to avoid the extra structure in Heim and Krazter's syntax that seems to invite Rabern-style arguments through compositionality.

Even so, we note that a straightforward application of the notion of strong compositionality defined above to IFA and QIFA has them failing to be strongly compositional. Let's look at QIFA. Consider our partial algebra $<E,F>$ as before and consider the 2-place $f \, \varepsilon \, F$ such that if [every ϕ]$_i$ is a DP (of type $<<e,t>,t>$) and ϕ is an S (of type t) and contains t_i free, $f(\text{every } \phi_i, \phi) = [_s[\text{every } \phi]_i \, [_s \, \phi \,]]$. Then our meaning assignment $|| \, ||^g$ is *strongly* f *compositional* iff there is a 2-place meaning operation r_f such that $||[_s[\text{every } \phi]_i \, [_s \, \phi \,]]||^g = r_f(||[\text{every } \phi]_i||^g, || \, \phi \, ||^g)$. But this latter condition fails because there could be two choices for ϕ, ϕ_1 and ϕ_2, such that though $|| \, \phi_1||^g = || \, \phi_2||^g$, $||[_s[\text{every } \phi]_i[_s \, \phi_1]]||^g \neq ||[_s[\text{every } \phi]_i[_s \, \phi_2]]||^g$. The situation is the same for IFA.

But one can't help but feel that the notion of strong compositionality being currently deployed isn't the appropriate notion for assessing IFA and QIFA. The mismatch between the apparently transparent semantic composition the rule provides and the fact we just observed makes this vivid. The problem, we maintain, is that the notion of strong compositionality we have been examining is not the right one to apply where there are substantial type adjusting rules, like IFA or QIFA. After all, in general with type adjusting rules we must distinguish between *the meaning assigned to an expression*

by our meaning assignment (relative to parameters) and *the meaning of the expression as adjusted by a type adjusting composition rule (relative to parameters)*. We can put the point this way. If α is a branching node, $\{\beta,\gamma\}$ the set of its daughters and a type adjusting rule R assigns a meaning to α relative to parameters (in the above rules, the semantic values relative to assignments or worlds as parameters, like $\|\alpha\|^g$ or $\|\alpha\|^{w,a}$). Then the R *type adjusted meanings of* β *and* γ *relative to parameters,* such as $T_R(\|\beta\|^g)$/ $T_R(\|\beta\|^{w,a})$ *and* $T_R(\|\gamma\|^g)$/$T_R(\|\gamma\|^{w,a})$ (depending on which parameters are involved), are the meanings that R composes in determining the meaning of α relative to parameters.

As examples, let us focus on IFA and QIFA. The IFA *type adjusted meanings of* β *and* γ *relative to* w *and* a, which we will write $T_{IFA}(\|\beta\|^{w,a})$ and $T_{IFA}(\|\gamma\|^{w,a})$, are $\|\beta\|^{w,a}$ and $\lambda w'$. $\|\gamma\|^{w',a}$, respectively. The QIFA *type adjusted meanings of* β *and* γ *relative to* g, which we will write $T_{QIFA}(\|\beta\|^g)$ and $T_{QIFA}(\|\gamma\|^g)$-- are $\|\beta\|^g$ and $\lambda x\ \varepsilon D_e$. $\|\gamma\|^{g\ x/i}$, respectively. So for both rules IFA and QIFA, though the IFA/QIFA type adjusted meanings of β relative to parameters are the same as β's meanings relative to parameters ($=\|\beta\|^{w,a}$ and $\|\beta\|^g$, respectively). This is not so for γ: $\|\gamma\|^{w,a}\neq(\lambda w'$. $\|\gamma\|^{w',a})$ and $\|\gamma\|^g\neq$ ($\lambda x\ \varepsilon D_e$. $\|\gamma\|^{gx/i}$). But given that a type adjusting compositional rule R composes R type adjusted meanings relative to parameters rather than just meanings relative to parameters, the notion of strong compositionality doesn't seem like the appropriate notion to apply to type adjusted rules. Intuitively, we want to know whether the meaning the type adjusted rule R assigns to a complex expression α is determined by the meanings R associates with α's (immediate) constituents and composes—*the* R *type adjusted meanings relative to parameters*—together with the way those constituents are combined. Our notion of strong compositionality, however, does not look at the R type adjusted meanings of α's

immediate constituents; it looks only at their "normal" meanings. But to repeat, these latter aren't even the meanings a type adjusting rule is composing! Small wonder that type adjusting rules sometimes don't fare well when looked at with such a microscope.

If we think of what should be required for a type adjusting rule R to be compositionally kosher, intuitively two conditions should be met. First, the R type adjusted meanings of expressions should be defined up from the meanings originally assigned to those expressions, which in our case will be the semantic values of these expressions, relative to parameters. We should be able to get the type adjusted meanings from the meanings assigned by our semantic theory. Note that IFA and QIFA meet this condition. The IFA adjusted meaning of γ relative to w and a is $(\lambda w' . \|\gamma\|^{w',a})$. This function is defined using $\|\gamma\|^{w,a}$ by varying w. But these are all meanings assigned to γ relative to worlds and assignment functions by our semantics. Similar remarks apply to the QIFA type adjusted meaning of γ relative to an assignment $(= \lambda x \; \varepsilon D_e . \|\gamma\|^{g \; x/i})$. Second, as indicated above, we should require that the meaning assigned to a complex expression by a type adjusting rule R relative to parameters be determined by the R type adjusted meanings of its (immediate) constituents relative to parameters and the way the constituents are combined.

Before spelling this second condition out more precisely and showing that IFA and QIFA meet it, let's say a bit more about type adjusted meanings and "normal" meanings of expressions. We'll focus on QIFA for definiteness. Looking at our formulation of QIFA we can see that in general γ will contain free occurrences of the variable i. Hence $\|\gamma\|^g$ will be sensitive to what g assigns to i: what a given g assigns to i will affect $\|\gamma\|^g$. So we should really think of γ as having a *family of meanings relative to*

g corresponding to different choices of what gets assigned to i. As a result, we can't think of $\|\gamma\|^g$ for a specific choice of g as capturing the meaning of γ in any intuitive sense. For of course, it may be that $\|\gamma\|^g = \|\psi\|^g$ even though for another choice of assignment function g', $\|\gamma\|^{g'} \neq \|\psi\|^{g'}$ and γ and ψ intuitively mean different things ('i skis' vs. 'i surfs'). Hence, it is only the family of meanings that in any intuitive sense captures the meaning of γ. The crucial point is that the QIFA type adjusted meaning of γ relative to g—$\lambda x \, \varepsilon D_e$. $\|\gamma\|^{g\ x/i}$—captures this family of meanings had by γ relative to g since it precisely gives us γ's meanings relative to assignments like g except that they assigns different individuals to i. Rules like IFA and QIFA show that in certain constructions we need more than the meaning assigned to γ by our meaning assignment (=$\|\gamma\|^g$). In the case of QIFA, what is needed is what we've called the family of meanings of γ relative to g: namely, $\lambda x \, \varepsilon D_e$. $\|\gamma\|^{g\ x/i}$. Similar remarks apply to IFA and the IFA type adjusted meaning of γ relative to w and g.

As we've indicated, since the IFA and QIFA type adjusted meanings relative to parameters are the meanings relevant to such constructions in that they are what gets composed by rules like IFA and QIFA, we should have a notion of compositionality for such rules that requires that the meaning of the mother node is determined by the IFA/QIFA type adjusted meanings of the parts and how the parts are combined. Here is an attempt to do just that. As before, consider the syntax of a language as *partial algebra* <E,F>, with E and F understood as above. Parameters are important for type adjusted meanings, so we will need to make them explicit in our meaning assignments. A meaning μ is thus a function $\mu(\alpha,j)$ from E and the relevant set of parameters j to the set

M of meanings relative to j for expressions in E.[37] Now, suppose we have a type adjusting rule R. R needs to work with type adjusted meanings for appropriate constituents. Those type adjusted meanings are built from families of meanings we get by manipulating parameters in j. So, a type adjusted meaning of α is given by a function $T_R(\mu, j, \alpha)$.[38] Consider an n-place operation $f \varepsilon F$ on E, and suppose it is governed by type adjusting rule R. Then R will provide potentially distinct type adjusting functions for each argument place i, which we can write $T^i_R(\mu, j, e_i)$.[39] We define a notion of strong compositionality appropriate to our language with type adjusting composition rules as follows:

Strong Type Adjusting Compositionality

μ is *strongly type adjusting compositional with respect to* f (governed by rule R) iff there is a n-place meaning operation r_f (a function from M^n to M) such that given expressions $e_1,\ldots,e_n \varepsilon E$ for which f is defined, for every (value of parameters in) j, $\mu(f(e_1,\ldots,e_n),j) = r_f(T^1_R(\mu,j,e_1),\ldots,T^n_R(\mu,j,e_n))$.

μ is *strongly type adjusting compositional* iff it is strongly type adjusting compositional with respect to every $f \varepsilon F$.[40]

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[37] j might be the set {g} containing only an assignment function or the set {w,a} containing a world and assignment function or etc. depending on what parameters meanings are defined relative to.

[38] Actually, for rules like QIFA, we also need an index i among the inputs to T_R, but it is harmless to suppress it.

[39] For the cases considered here, it is sufficient to have one type adjusting function $T_R(\mu,j,e_i)$ that applies to each of the arguments of $f(e_1,\ldots,e_n)$. But we formulate Strong Type Adjusting Compositionality allowing for distinct type adjusting functions $T^i_R(\mu,j,e_i)$ to insure generality.

[40] Our type adjusting compositionality is similar to the notion of general compositionality of Pagin and Westerståhl [2010c], and we found their version helpful for formulating ours. In some special cases, type adjusting compositionality can be identified as a special case of their general compositionality. Happily, this allows us to adapt their proof of non-triviality (their Fact 7) to our setting almost verbatim. However, there are differences between our versions, both conceptual and technical. Technically, their general compositionality has shifted meanings computed compositionally from other shifted meanings. Our type adjusting compositionality only shifts meanings locally, in the process of composition. Thus, our type adjusted meanings are not technically meaning assignments, while those of Pagin and Westerståhl are. Other than these local adjustments, the semantics only uses ordinary non-shifted meaning assignments, and these are the inputs to composition. Type adjustment can access parameterized families of these meanings at certain points, but these meanings are computed in the ordinary compositional way with ordinary meaning assignments, not via a distinct family of meaning assignments. Also, Pagin and Westerståhl use a very general characterization of syntactic environment (i.e. syntactic context). This allows meanings to be adjusted in composition as the result of parts of syntactic environments that can be highly non-local to the

Let us see how this applies to a rule like QIFA. We have assumed that quantified

sentences look as follows at LF (in (16), repeated here):

17.
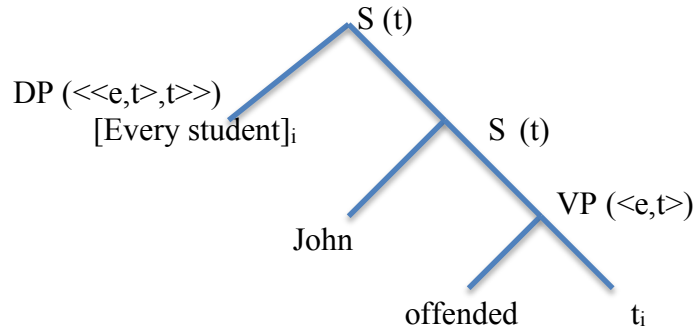
Consider again our partial algebra $<E,F>$ and consider as we did above, the 2-place $f \varepsilon F$

such that if $[every \phi]_i$ is a DP (of type $<<e,t>,t>$) and ϕ is an S (of type t) and contains t_i

free, $f([every \phi]_i, \phi) = [_S[every \phi]_i [_S \phi]]$. So f applies above to $[Every student]_i$ and

$[_S John[_{VP} offended t_i]$ to yield the above LF. And of course QIFA is the composition rule

governing f and so applies to the daughters of the top node of the tree. To keep the

parallel with the formulations above, represent our meaning assignment $\| \|^g$ as $\mu(,g)$.[41]

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constituent adjusted, and a complex syntactic environment can make multiple adjustments. This is useful
for their intended applications, to quotation in Pagin and Westerståhl [2010c], and to the 'evaluation
switcher semantics' for intensional contexts developed by Glüer and Pagin [2006, 2008]. Our focus on
composition principles leads us to prefer our more restricted version, as composition always occurs
locally—each composition principle applies to sister nodes. We do not need multiple type adjustments
with respect to any single application of a type adjusting rule (though we can iterate rules like QIFA in the
presence of multiple quantifiers). Generally, as we stressed when we introduced type adjusting
compositionality, we see it as an aspect of how meanings combine, and how that can add some content
from highly local syntactic environments, not a matter of introducing extra meanings to feed operators
higher up in a sentence. Though this indeed induces a 'switch' (in Glüer and Pagin's terminology), it is a
very limited sort of switch, triggered by composition rather than an operator. As Peter Pagin mentioned to
us (p.c), if this is triggered by a general rule like variable IFA, it can have the effect of triggering switching
across a range of operators (tenses, intensional operators, quantifiers, etc).
[41] Above we said that where we had $\mu(\alpha,j)$ for some expression α, j was the *set* of parameters that
meanings are assigned relative to. So we should really have $\mu(,\{g\})$ here. But since meanings are defined
relative to only one parameter here (g, the assignment function), we'll omit the set brackets for easier
reading.

μ is *strongly type adjusting compositional with respect to* f iff there is a 2-place meaning operation r_f such that $\mu([_s[\text{every } \phi]_i \ [_s \ \phi \ ]],g) = r_f(T^1_{QIFA}(\mu,g,[\text{every } \phi]_i,), T^2_{QIFA}(\mu,g,\psi))$. But QIFA tells us exactly what r_f is: r_f maps the pair of meanings $<T^1_{QIFA}(\mu,g,[\text{every } \phi]_i)$, $T^2_{QIFA}(\mu,g,\psi)>$ to the meaning $\mu([_s[\text{every } \phi]_i \ [_s \ \phi \ ]],g)$ by functionally applying $T^1_{QIFA}(\mu,g,[\text{every } \phi]_i)$ $(=\|[\text{every } \phi]_i\|^g)$ to $T^2_{QIFA}(\mu,g, \phi)$ $(=(\lambda x \ \varepsilon D_e . \| \phi \|^{g \ x/i})$. Hence, μ *is* strongly type adjusting compositional with respect to f. Indeed, this sustains the intuition with which we began, that rules like QIFA simply tell us how to compose provided semantic material, and so should not violate the relevant forms of compositionality. Once we pay due regard to where type shifting happens, that is just what we see.

Returning to Rabern's argument, the main consequence of reformulating our rules to include QIFA is that it allows us to provide a strongly compositional account of quantification and variable binding. In the previous section, we provisionally assumed that quantification would violate strong compositionality, and argued this was not a reason to alter the account of quantification. But we can now make the further claim that the notion of strong compositionality that should be applied to rules like QIFA is not violated by it.

So unless there is some principled reason for not adopting type adjusting rules like PM, IFA, and QIFA, there just is no argument *even from what we think is the relevant notion of strong compositionality* against the classical picture that identifies propositions with compositional semantic values of sentences. It is very hard for us to see what such a principled reason would be. In discussing weaker forms of compositionality, we noted that all forms of compositionality rely on a stock of modes of composition. FA is not the only mode of composition available, and we preserve the

relevant notion of strong compositionality by invoking the right such mode, in the right syntactic setting.[42]

So now we have a treatment of quantification using QIFA that is strongly type adjusting compositional and preserves the classical picture. We don't see what stronger response could be made to Rabern's argument on behalf of the classical picture.

VII. Tense again

We have shown how to give a strongly type adjusting compositional treatment of quantification using QIFA. In discussing King's [2003] response to the original Lewis argument, we noted that it depends on defending the view that tense would be handled by putting time variables and devices for manipulating them into the syntax. To see how the points made about quantification carry over to tense, let's adopt a simple quantificational account of tense.[43] First, let's introduce new type i for times. We then assume predicates of individuals now also take an argument τ of type i:

18. $\|\text{dance}(x, \tau)\|^g = 1$ iff g(x) dances at $g(\tau)$

So the type assigned to a predicate like 'dance(x,τ)' here is t. We assume that the syntax of a tensed sentence looks like this:

19. $[_{TP}\ldots[_{VP}\ldots]]$

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[42] As we noted in footnote 40, we can adapt a result of Pagin and Westerståhl to show that type adjusting compositionality is a mathematically non-vacuous requirement. But of course, whether it is substantial in practice depends on how much and what sorts of type adjustments—how many sorts of T_R—are allowed. As we have stressed throughout, we are assuming there will be a highly limited range of composition rules, and so highly limited range of type adjustments. Thus, we do see type adjusting compositionality as a substantial empirical requirement. For our purposes here, the only type adjustment we need is λ-abstraction. We think this is deeply embedded in the semantics, as is shown by the range of environments where rules like IFA apply. So, we think there are good empirical reasons to include it. We have no general reason to insist there will not be a small range of further type adjustments, though we note that it does not really appear to be known yet just what that range might be.
[43] As we mentioned in footnote 11, this is for ease of illustration only. See the references there for more linguistically sophisticated options.

And we assume the semantics of past tense is as follows:

20. $\|PAST\|^g = \lambda \tau_i . \lambda P_{<i,t>} . (\exists \tau' < \tau . P(\tau') = 1)$

We also assume that in unembedded cases, τ here gets assigned the utterance time/time of the context. So let's relativize semantic values to context and assignment function and assume we have structures that look like this:

21. $[\tau_1 \ PAST_2 \ [\ dance(John, \tau_2)]]$

The problem is that $\|dance \ (John, \tau_2)\|^{g,c}$ is type t, whereas PAST is looking for an $<i,t>$ argument. This, of course, was exactly the situation we encountered with [Every $\phi_i[\ \phi \ ]$], where the quantifier wanted an $<e,t>$ argument but was being fed a t argument. And, of course, our proposed solution is the same:

Tense Quantifier IFA

If α is a branching node and $\{\beta, \gamma\}$ the set of its daughters, with $\|\beta\|^{c,g}$ type $<<i,t>,t>$ and having index n and γ type t and containing the variable with index n of type i, and $\lambda r \ \varepsilon \ D_i . \|\gamma\|^{c,g \ r/n}$ is in the domain of $\|\beta\|^{c,g}$, then $\|\alpha\|^{c,g} = \|\beta\|^{c,g} (\lambda r \ \varepsilon \ D_i . \|\gamma\|^{c,g \ r/n})$

In this formulation, β is PAST having already been supplied with the time of the context of utterance and so is of type $<<i,t>,t>$ (i.e. $\|PAST\|^{c,g} \ \varepsilon \ D_{<<i,t>,t>}$). So in the case of both tense and quantification, IFA style composition rules allow us to give strongly type adjusting compositional treatments on which sentential semantic values are propositional. If we treat tenses as genuine object language quantifiers that bind object-language variables, then we might even reduce Tense Quantifier IFA to QIFA. But perhaps the case of tense further illustrates how composition rules like IFA, in various forms, are deeply embedded into natural language semantics. As we mentioned, we know of no way to avoid something like them. To repeat, we can see no objection to IFA style

composition rules and in any case they might well be independently required for intensional constructions. So once again, here a strongly type adjusting compositional account of tense allows us to retain the classical picture. And, the cases of tense and quantification are mutually supporting, as they both illustrate the centrality of type-adjusting composition principles.

We have now reached our main conclusion, though we will take up a few related issues below. We see no reason to depart from the classical picture. This is an empirical claim. In previous work, we observed that the syntax and semantics of tense, as it in fact occurs in natural language, gives us no such reason. Here, we have extended this claim to quantification, contra Rabern and others. As we noted at the outset, the classical picture is the simpler one, so we hold that absent any reason to depart from it, we should hold it. The persistent failure to find reasons to depart from it makes us think it is the correct theory. Of course, like any empirical claim, it is responsible to the data, and we have not surveyed all possible phenomena that might relate to it. But, we rest our claim on the observation that each time we look closely at the data, the simpler classical view appears to be the right one.[44]

Our discussion of quantification relies on one other empirical claim, which we

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[44] We do pause to note one aspect of the empirical status of our claim about quantification. In the case of tense, we offered a battery of evidence that the treatment of tense that manipulates temporal variables is superior, and that formed the core of our response to Lewis. The response to Rabern is slightly different. We did not offer any new data about natural language quantification as part of it. Rather, we offered a composition rule which we claimed captures the standard data better, and is in the appropriate sense compositional. Our claim is still empirical, in that we claim that the facts about how natural language quantification works, when properly understood, offer no reasons to depart from the classical picture. But much of the work in understanding those facts involves care in formulating composition principles, and that is not new data. Actually, one of the authors (Glanzberg, as part of ongoing work with Ezra Cook), suspects there might be data that shows the QIFA formulation to be superior to the PA formulation (cf. Kennedy 2014). That would add support to our case, but we still hold that offering a superior explanation of the basic and familiar facts about quantification is enough to conclude that the classical picture in fact holds for natural languages as they happen to function. That is an empirical claim. (Thanks to Malte Willer and David Beaver for raising this issue.)

think is closely connected with our main one. Natural languages have a range of composition principles; not just one, and not just FA. They have something like IFA, and it applies to quantification, tense, and perhaps other phenomena.[45] One reason the classical view is sustained is that the syntax and semantics of natural language in fact collaborate to make it so, and part of that collaboration is the role of these kinds of composition principles. We think the conclusion that there are multiple modes of composition is interesting in its own right; but we here want to highlight the point that all aspects of syntax and semantics, including how semantic composition in fact works, are important for the success of the classical view.

VIII. Whither schmentencism?

In a famous passage in Lewis [1980], which contained his original argument that sentential compositional semantic values relative to contexts cannot be identified with propositions, he considered the strategy of opposing his argument by claiming that the things that are embedded under his alleged operators are never genuine sentences. This was a way to get around genuine sentential semantic values relative to contexts being functions from the features of indices to truth-values. The semantic values of things that are embedded by operators *are* functions from features of indices to truth-values. But these aren't the semantic values of *sentences*; they are the semantic values of different kinds of things: *schmentences*. Lewis famously disapproved of the schmentencite strategy:

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[45] We find support in the discussion of von Fintel and Matthewson [2008. P. 190], who conclude "[T]here are only a small number of universally available composition principles, including Functional Application and a few others." As they note, cross-linguistic work that has sought to minimize the stock of composition principles, such as Bittner [1994], do wind up needing apparatus for lambda binding and type adjusting. We think the close connection between these and IFA-like principles give us good reason to include the latter, which are indeed variants on function application, among the composition principles.

> There is always the schmentencite way out: to rescue a generalization, reclassify the exceptions. If we said that the seeming sentences involved in shiftiness of features other than world (and perhaps time) were not genuine sentences, then we would be free to say that the semantic value of a genuine sentence, in context, was its propositional content. But what's the point?[46]

So Lewis is claiming that schmentencism is just an ad hoc, cheap trick.

To what extent are we schmentencites? On the one hand, in the case of both tense and quantification, the embedded element is type t. This is the type of genuine sentences and it our proxy type for propositions. We pause to stress this. Type t is the usual semantic value for sentences, is consistent with the classical picture, and our semantics assigns this perfectly ordinary value. Still, these embedded things of type t, call them *schmentences*, are importantly different from full-fledged sentences. First, *all* expressions of type t are assigned semantic values (truth values in an extensional system) relative to assignment functions. However, *genuine sentences*—which lack free variables-- are not sensitive to this parameter, taking the same truth-value regardless of the assignment function. *Schmentences*, by contrast, are generally sensitive to this parameter, as we suggested earlier. We think this indicates a real difference in the semantics of sentences and schmentences. Second, the semantic values that schmentences contribute to composition after having IFA style rules adjust them are not of type t: they are of type <e,t> or <i,t>. QIFA and Tense Quantifier IFA make it look as though schmentences have <e,t> or <i,t> values. This is only within composition, not a change in their semantic values outside of the composition process, but it is a genuine feature of schmentences. Third, though sentences are assertable, schmentences are not.

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[46] Lewis [1980] p. 39

In the quantificational case, the embedded schmentence will contain unbound traces.[47] Nothing of that sort can be used to make an assertion. Traces are *essentially* bound, being the result of movement. So there would be no way to utter something with a free trace. In the tense case, the embedded schmentence will be something like a tenseless VP or vP. Again, this sort of thing cannot be used to make an assertion. Depending on the details of the quantificational analysis, this too may have a trace. But in any case, there is no way to utter such a thing and make an assertion.

In a sense, then, we are schmentencites in that the things we claim tenses and quantifiers embed are importantly different from genuine sentences semantically, syntactically and in what we can do with them. But we stress, as Glanzberg [2011] did, that this is not an ad hoc trick. The embedded constituents are genuinely different from real sentences—fully inflected matrix clauses that can be asserted. This is clear from the syntax and the semantics of tenses and quantifiers, and is one of the features of these embeddings that our discussion, both of the old debate and the new one, helps to show.

Before turning to the question of whether Lewis' argument against schmentencism cuts against us, we want to highlight the way in which assignment functions are used by semanticists to play two quite different roles and the confusion that can result from this. On the one hand, semanticists often think of variable assignments as being determined in context to provide semantic values in context to deictic pronouns. On this way of thinking of variable assignments, they at least in part represent the context of utterance: they represent whatever it is about the context that determines that certain deictic pronouns have the semantic values in that context that they do. A standard way of

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[47] Of course this claim depends on accepting the standard syntactic account of quantification involving QR, etc. See the discussion of these issues in Glanzberg [2011].

implementing this is to index pronouns with numerical indices and making variable assignments (partial) functions from indices into the set of individuals (D_e).[48] Note that in this role, it is virtually inevitable that assignment functions will be *partial*. Whatever it is about a context that determines what gets assigned to a given index, contexts generally won't determine semantic values for the entire denumerable set of indices. On the other hand, semanticists think of variable assignments as what quantifiers shift when they are evaluated: when a quantified formula is evaluated relative to an assignment function g (suppressing other parameters), the quantifiers look at some, all, or most variable assignments that differ from g in at most the assignment to one index. Note that this is a *very* different role for variable assignments. To put it one way, there is no assignment function that is *both* the thing determined by context as providing semantic values to deictic pronouns *and* the thing that is shifted in the evaluation of quantifiers. To see this, suppose that something about the context c determines that 1 is to be assigned the individual o. (To illustrate, we might think that speaker intentions do this, or such intentions together with what idealized hearers would take the speaker to intend.[49]) Now suppose that the following sentence is produced in c:

22. Everyone$_1$ believes he$_1$ is smart.

But this indexing just couldn't occur in c! Given that something about c determines that 1 is assigned o, instead of (22) we could only get (23), where 'he$_1$' is a deictic pronoun referring to o and 'Everyone' quantifiers over a (contextually restricted) domain of individuals:

23. Everyone$_2$ believes he$_1$ is smart.

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[48] See Heim and Kratzer [1998] pp. 109-112; pp. 242-45
[49] See King [2013, 2014a, 2014b].

But if the assignment determined in context that assigns semantic values to indices on deictic pronouns really was the thing that quantifiers shift, (22) would be a possible indexing in c. It isn't. Looking at things the other way around, suppose one of us walks into his class the day after giving an exam and says, discourse initially so to speak:

24. I am sure every student$_1$ hopes she$_1$ passed the exam.

Let's ask what the variable assignment determined by the context of his utterance assigned to the index 1? Surely that is an absurd question.[50] But then here again, there is nothing that is determined by context and then shifted by the quantifier.

Another way to see the two different roles of assignment functions—assigning values to deictic expressions in context vs. being shifted by quantifiers—is to note the Heim and Kratzer [1998] definition of *a context c being appropriate for an* LF ϕ:

Appropriateness Condition

A context c is appropriate for an LF ϕ only if c determines a variable assignment g_c whose domain includes every index which has a free occurrence in ϕ.[51]

Here the context is *excused* from determining an assignment function that assigns values to bound indices in order to be appropriate for the relevant LF (indeed, we argued above a context *cannot* do that!). That, again, is because context does not fix something that is then shifted by a quantifier.

Finally, we noted above that in their role as things determined by context to assign values to deictic pronouns via their indices, we have to take assignment functions

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[50] Unless the answer is that the variable assignment is undefined on 1. Perhaps the best thing to do would be to say that the context determines the totally undefined assignment function in such a case. But it is an artifact of this way of modeling what is going on that we say that context *determined* an undefined function. What the context "did" was to fail to assign anything to 1 or any other index. That's a matter of the context *failing* to do something.
[51] P. 243.

in general to be *partial* functions. Note that there is nothing in their role as the things shifted by quantifiers that motivates assignment functions being partial. Sentences with deictic pronouns are sensitive to the values assigned to those pronouns by contexts. Not every context will contain information fixing the values of every such pronoun under every indexing. But quantified sentences are not sensitive to the value of any single assignment function. It is indeed common practice to treat the assignment function for quantifiers as if it were a point of evaluation, written as e.g. a superscript of a semantic value like $\|\alpha\|^g$. But unlike the case of genuine effects of context, quantified sentences are not sensitive the values of g. All they are sensitive to is the whole space of possible assignments—all the different functions that can be compared to g. The particular value of g in $\|\alpha\|^g$ is irrelevant. It can be arbitrary, or it can be some default value. So long as the space of functions is right, it does not matter. Hence, there is no pressure to make assignments for quantification partial.[52] But also, the difference in where sensitivity to assignment functions emerges reflects the very different roles assignment functions play in the two cases.

The moral of the story here is that a quantifier being sensitive to assignment functions just isn't being sensitive to contexts. We believe that Rabern's talk about quantification being monstrous is precisely the result of conflating the role of assignment functions qua things shifted by quantifiers with the role of assignment functions qua things determined by context to assign semantic values in context to deictic pronouns.

Returning to the main thread—our version of schmentencism and Lewis'

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[52] Well, nothing about the way assignment functions get values suggests they should be partial. We can imagine some other considerations, about how indices for quantificational expressions get generated, that might be congenial to partiality. But, these will still suppose that we have a full range of functions, even if they were to be defined only on certain indices.

argument against schmentencism--does Lewis' argument that schmentencism is an ad hoc, cheap trick cut against us? Not at all! First, the schmentencite strategy is only an ad hoc trick if the original classification of the embedded elements as full-blown genuine sentences was well motivated to begin with. We think it wasn't and we are claiming there is *good empirical reason* for thinking the embedded elements are *not* genuine sentences ([King 2003, 2007], Glanzberg [2011]). Our observations about different roles for assignments confirm this. Our schmentences are embedded in binding configurations, and so they display the distinctive dependence on assignments that goes with quantification. That makes them not sentences on their own, because they need something to control how they search the space of assignment functions. Confusing the two roles of assignment functions might have lead one to miss that this is a very distinctive semantic operation, making them need the quantifiers, tenses, etc. they combine with to function as sentences. Far from being a cheap, ad hoc trick, our schmentencism is an empirically well-motivated position. So we defang Lewis' argument against schmentencism.

IX. Compositionality and schmentences

Above we argued that the right kind of strong compositionality to ask for when we look at type adjusting rules is preserved by rules like QIFA and tense quantifier IFA. Strong type adjusting compositionality holds for our treatment of tenses and quantifiers, and that is all the compositionality one should want. But, type adjusting compositionality has some distinctive features. We argued that they are the ones we should have for type adjusting rules. Here, we further observe that the right understanding of schmentences further motives and justifies our formulation of type adjusting compositionality.

As we introduced type adjusting compositionality, it works with families of meanings. That much is what we should expect, as type adjustment generates families of meanings, and we need to be able to access the range of them to capture how a type adjusting rule composes meanings. But furthermore, we allowed that the family of meanings is fixed by some parameter. In our main applications, the meanings are semantic values, and the parameter that fixes the families of meanings is the assignment function. That might not be how we thought of compositionality working. We might have thought that the assignment function helps determine the values at terminal nodes, but then it is no longer relevant to composition. Hence, one might find this feature of strong type adjusting compositionality ad hoc.

It is not ad hoc; rather, it is just what we should expect when we are composing schmentences. In particular, as we just observed, schmentences are sensitive to the assignment function or time parameter. Schmentences have essentially free variables, though the assignment function fixes their values and so allows them to appear as type t. But we know that in composition, it is their 'open' meanings that we need to use. To access those open meanings in a setting where g resolves them to 'closed' or type t values, we need to vary g. So, any reasonable way of composing meanings with schmentences should see parameters like g or w. Our version of strong type adjusting compositionality does just that. In essence, the kind of type adjusting rules we have been considering access schmentence meanings and compose them. And, as we have stressed, it does so without changing the kinds of meanings genuine sentences have. Strong type adjusting compositionality is the right form of compositionality for that kind of composition. Strong type adjusting compositionality really is just schmentence

compositionality.

One thing that the discussion of strong type adjusting compositionality highlights is the way in which type adjusting rules like QIFA add meaning in the course of composition. This was always their function, but it deserves some further comment. Some of the most familiar forms of type shifting seem to do something weaker: they make changes in semantic values that intuitively seem to us to be neutral about meaning. A familiar example is 'Montague raising' or 'lift' in the terminology of Partee [1987], which takes an expression of type e, like a proper name, and raises it to quantifier type $<<e,t>,t>$, effectively by generating the set of sets which contain the bearer of the name. Intuitively, one might see this as keeping the basic meaning of the name, and adding braces around it. More technically, the operation is invertible. We have already seen that not every type shift is quite so devoid of content. For instance, the kind of shift embodied in type adjusting PM supplies the content of intersection. But we might think that the kind of shift supplied by our intensional composition principles—IFA and its descendants—is different in character. It seems to produce a much more rich, or perhaps fine grained, content. This is made clear by the discussion of strong type adjusting compositionality as well. It reminds us that we are, in shifting types in these rules, taking a range of meanings $||\gamma||^{g\,x/i}$ and using them to build the richer single meaning , $\lambda x\,\varepsilon\,D_e$. $||\gamma||^{g\,x/i}$.

That is so, but it is also the right result. Though more substantial than some type shifts, λ-abstraction is a well-defined operation on types, and indeed a fundamental one. More importantly, the enriched meanings our type adjustment creates are just the kind appropriate for schmentences in composition. After all, what our type adjustment does is

make the semantic values genuinely predicative, by lambda-abstracting over the relevant variable. We see this with tense. A VP under a tense is interpreted as temporally specific, but a temporally neutral meaning is required to compose with a tense. By accessing the family of meanings it can generate, and appropriately lambda-abstracting, that meaning is passed to the tense in composition, just as required. But the status of a VP under tense is just the status of a schmentence, and the richer meaning is the one that is appropriate for a schmentence. So again, we see that the rich meanings our type adjusting rules provide is what we should expect. When it comes to quantifiers, we get the same result, for the same reason. The embedded constituent is a schmentence, and we should expect composition to require the appropriately enriched meaning to compose a schmentence.

We conclude, as we did above, that the kind of type adjusting rules we propose, and the form of compositionality that goes with them, are in fact fundamental features of the ways our languages operate. As we have said repeatedly, it is not a conceptually necessary one. We can easily imagine many ways abstract systems could be implemented that work differently. But the way the syntax and semantics of natural languages works does in fact rely on these features pervasively, in many different constructions across a number of domains. Because of this, we have shown, the classical view is sustained, along with a form of schmentencism.

X. Innocent until proven guilty

It's probably worth saying a few words about semantic innocence and the view we are endorsing here. We take semantic innocence to be something like the view that expressions contribute the same semantic values (relative to parameters) in all syntactic

environments. It may appear that our view violates this principle. Things that are of our propositional proxy type t sometimes have type t semantic values and sometimes type $\langle a,t \rangle$ for some other type a (in the cases we considered, e,i, and s).[53] But we don't think this is the right way to look at the phenomena. Type t expressions always feed into semantic composition type t semantic values (relative to parameters). In some cases, those where the relevant composition rule is some version of IFA or PM, the relevant expressions feeds its usual type into the semantic composition (t or $\langle e,t \rangle$) and then *the composition rule* adjusts its type in a rule governed way. It does so, in part, by accessing a parameter used to fix the value of the expression, and lambda-abstracting.

This does not look to us like a loss of semantic innocence; at least, not anything of the kind that is at issue for most discussions of innocence with respect to attitude reports (e.g. Davidson [1968]). But as we observed in the previous section, in a certain, fairly modest way, rules like IFA do contribute content of their own. Now, they do not contribute distinctively lexical content: they do not add new properties or objects, or ways of looking at things or events. But they do adjust types, and in particular, they do so by adding the content of lambda abstraction, as we mentioned. This is a highly abstract kind of grammatical glue, rather than lexical content. But it can, fairly enough, be called content. Though we do not think we depart in any serious way from semantic innocence, we do think that some semantic composition principles can add this sort of content.

We like to describe this as a modest variety of meaning from syntactic structure. Though the content is specifically provided by the composition principles, those principles apply because we encounter specific syntactic configurations. We apply

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[53] In the case of PM, we appear to have an expression (e.g. 'grey') that is sometimes of type $\langle e,t \rangle$ and sometimes of type $\langle \langle e,t \rangle, \langle e,t \rangle \rangle$.

Quantificational IFA because we encounter binding configurations, and we apply the temporal version because we encounter tense constructions. Hence, it is the configurations of binding or tense, etc., which trigger application of composition principles that add our modest amount of grammatical content. If you want a source for that content, it is the syntactic configurations themselves. This might have been mistaken for loss of innocence, but it is something different. And, we think one of the insights to be gleaned from our investigation of composition principles is that we do find this particular kind of meaning from structure.[54]

The way we retain innocence also highlights once again our version of schmentencism. It is important that the expression whose semantic value is fed into versions of IFA is one that is sensitive to the relevant parameter that its semantic value is relativized to. In the cases crucial for the present paper, the parameter is an assignment function assigning indices to individuals or times. If the expression feeding its semantic value into a version of IFA were one whose value didn't vary relative to assignment functions, we would essentially have vacuous quantification, which is widely thought to be lead to infelicity. Hence, in this sense it is crucial that what gets fed into IFA is a *schmentencite* type t semantic value (one that is sensitive to assignment functions) and not one of a genuine sentence.

XI. Summing up

In this paper, we have defended the classical picture that semantic values are propositional, and along the way, we have done a few other things as well. First and foremost, we offered a defense of the classical picture. Our defense started with the old

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[54] To be clear, we see this as very different from the kind of meaning from structure advocated by construction grammar (e.g. Fillmore et al. [1988]).

debate over tenses and (and related 'shifty' elements). We reviewed reasons to hold that in this case, the empirical situation provides no reason to depart from the classical picture. As we take the classical picture to be the preferred option, on grounds of simplicity and naturalness, we take this to be reason to hold to the classical picture. We stressed that the argument is primarily empirical. Our claim is that natural language in fact follows the classical picture, not that this is the only possible option, or the only conceptually coherent one. We then went on to defend the classical picture against a more recent challenge, based on quantification. We argued that the same results as we reached in the old debate apply to the new one. A correct understanding of how quantification works in natural language gives no reason to depart from the classical picture. Indeed, we infer that the classical picture is right, given its robustness as we carefully examine specific cases.

Along the way, we advocated an approach to quantification that we think is elegant. It departs in some ways from the popular view a developed by Heim and Kratzer, and to the extent that it does, we think it is an improvement. As part of this approach, we invoked a small range of type adjusting composition principles, and we developed a notion of strong compositionality that is appropriate for such principles. Indeed, our defense of the classical picture relies on this to retain strong type adjusting compositionality, and thereby show how considerations of compositionality do not genuinely challenge the classical picture. We argued that the kinds of composition principles we need are well-established in natural language, and take their role in securing compositionality to be part of our general view that it is the whole body of facts about syntax and semantics that supports the classical picture.

We also noted that these kinds of principles have a number of interesting consequences. They help show why a form of schmentencism is a semantically, syntactically, and pragmatically principled view. They also reveal modest ways that composition can contribute certain abstract sorts of content. Ultimately, we believe, it is the syntactic structures that trigger these composition rules that are the sources of these content; and hence, we find a modest way that syntactic structure can contribute meaning. These, again, illustrate the complex web of empirical facts that make us think the classical picture is indeed correct.

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