Presuppositional Indexicals

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Abstract

Kaplanian, two-dimensional theories secure rigidity for indexicals by positing special contexts and semantic mechanisms reserved only for indexicals. The result is a deep and unexplained chasm between expressions that depend on the extra-linguistic context and expressions that depend on the discourse context. Theories that treat indexicals as anaphoric, presuppositional expressions (e.g. Hunter & Asher 2005, Maier 2006 and 2009, Roberts 2002, Zeevat 1999) have the potential to be more minimal and general than Kaplanian, two-dimensional theories—the mechanism of presupposition, unlike that of Kaplanian character, is useful for the semantics of a great many expressions. Maier (2006, 2009), however, has argued that presuppositional theories of indexicals must be supplemented with a two-dimensional semantics in order to secure rigidity for indexicals. If this is right, then presuppositional theories of indexicals will suffer from the limitations of Kaplan's system. This article argues that Maier is not right on this point: presuppositions can completely replace Kaplanian characters. A presuppositional theory can secure rigidity for indexicals without positing two independent dimensions of meaning that can never interact; in particular, it can do so without positing that indexicals have a special kind of meaning that by its nature can never interact with the kind of meaning that Kaplan called 'content'. The result is a more general, minimal, and flexible theory that better handles the data on indexicals.

Kaplanian, two-dimensional theories secure rigidity for indexicals by positing special contexts and semantic mechanisms for indexicals that cannot be extended to treat expressions, like third person pronouns, that are intuitively similar to indexicals but can depend on the discourse context. Theories that treat indexicals as anaphoric, presuppositional expressions (e.g. Hunter & Asher 2005, Maier 2006 & 2009, Roberts 2002, Zeevat 1999) have the potential to be more minimal and general than Kaplanian, two-dimensional theories—the mechanism of presupposition, unlike that of character, is useful for the semantics of a great many expressions. Maier (2006, 2009), however, has argued that presuppositional theories alone cannot secure rigidity for indexicals; a presuppositional theory must be supplemented with a two-dimensional one if it is to treat indexicals. Accordingly, Maier (a) adopts contexts that divide extra-linguistic information (information about utterance events, perception, etc.) and information introduced via discourse and (b) adds an anchoring mechanism for the extra-linguistic level of his contexts so that discourse referents at this level will receive a rigid interpretation. He then goes on to (c) treat dependence on the utterance context and dependence on the discourse context as two different and independent kinds of meaning and (d) force dedication to one kind of meaning (extra-linguistic context dependence) into the semantics of indexicals. If Maier is right that a presuppositional theory must take steps **c** and **d**, then we lose the minimality and generality promised by such a theory and are left with the limitations of a Kaplanian one. This article argues that while steps **a** and **b** are necessary to secure rigidity for indexicals in a presuppositional theory, steps **c** and **d** are not only not necessary, but they are also not supported by the data on indexicals. Steps **a** and **b**, together with Hunter & Asher (2005)'s resolution strategies, are sufficient to secure rigidity for indexicals in a presuppositional theory. Adopting these three

ingredients does not amount to adopting a two-dimensional semantics—these ingredients do not entail the existence of two distinct kinds of meaning that can never interact. The result is that a presuppositional theory can secure the advantages of a two-dimensional theory without suffering from its drawbacks.

§1 offers more detailed background to frame the main arguments in this article. §2 reviews two presuppositional theories of indexicals, Hunter & Asher (2005) and Maier (2006, 2009). Both of these theories offer crucial ingredients that will be used by the final theory, offered in §3. The final theory extends Hunter & Asher (2005) by adding pointed models and more structured contexts and it differs importantly from Maier (2006, 2009) by not adopting a two-dimensional framework.

1 Background

Kaplanian two-dimensional theories secure rigidity for indexicals by first ensuring that an indexical is assigned a value relative to a situation treated as 'actual' and then by ensuring that this value cannot vary from one circumstance of evaluation to the next, regardless of what logical operators may be lurking in the vicinity (Kaplan 1989a & 1989b). This second task is achieved on the one hand by giving indexicals entirely context-sensitive meanings in the sense that an indexical's extension is determined entirely by its character together with a context. The character of an indexical contributes an individual, i.e. the referent of the indexical, to content_k, and an individual isn't the sort of thing that can get bound by an operator or that varies from one circumstance of evaluation to another. On the other hand, contexts and circumstances are kept strictly apart to prevent any operators from quantifying over contexts: contexts contain only individuals and contexts are not included in circumstances of evaluation. The fact that indexical contents are invariable in Kaplan's theory therefore follows, at least in part, from a general prohibition on interaction between content_k and the linguistic meaning of a context sensitive expression.

Kaplanian, two-dimensional theories remain attractive because they secure rigidity for indexical expressions. But they do so at a high cost. Kaplan's contexts are not designed to include the contents_k of expressions that may serve as antecedents for, or otherwise bind, anaphoric expressions. As a result, his theory sheds no light on the intuitive connection between extra-linguistic context sensitivity and discourse context sensitivity, the latter being exhibited by expressions that can be bound and/or anaphorically linked to antecedents introduced in discourse. Consider the third person pronoun *he*. Used demonstratively, *he* will refer to an individual in the extra-linguistic context and its content will be as referential or rigid as that of an indexical. Yet the linguistic meaning of *he* can also, unlike the meanings of Kaplan's indexicals and demonstratives, exhibit sensitivity to content_k: the value of *he* can vary depending on what antecedent has been offered by the incoming discourse and it can even be bound by a quantifier. This shortcoming of Kaplan's theory is no accident: the theory could not be amended to provide a unified account of *he* and other expressions whose interpretations can be sensitive to the discourse context (content_k). Adding contents_k to Kaplan's contexts would open the door to interaction between contexts and content_k—interaction that must be prohibited in Kaplan's system if rigidity is to be ensured.[1] Kaplan is therefore forced to treat any expression that can be sensitive to both the extra-linguistic context and the discourse context as ambiguous. Given that a great many expressions—including third person pronouns, demonstratives and, I will argue, some indexicals—appear to have these different uses, this is indeed a costly consequence.

Theories that treat indexicals as anaphoric, presuppositional expressions along the lines of

[1] For an interesting discussion of Kaplan's prohibition on such interaction, see Dever (2004).

van der Sandt (1992) are well suited to replace Kaplanian, two-dimensional theories (e.g., Zeevat 1999, Roberts 2002, Hunter & Asher 2005, Maier 2006, 2009). If the lexical meaning of an indexical is treated as a presupposition, then the claim that the lexical meaning never makes a novel contribution to truth-conditional or dynamic update content falls out naturally: it does not make a novel contribution because it is bound to or satisfied by an entity in the incoming context. And the fact that the lexical meanings of indexicals are never bound by operators can be understood by saying that they always project. One advantage of a presuppositional theory is that it employs mechanisms already in place for other types of expressions and constructions and does not, at least prima facie, require a special semantic mechanism reserved only for indexicals.[2] Moreover, because a presuppositional theory of indexicals that unites presupposition and anaphora will provide an account of binding and anaphoric dependence, such a theory paves the way for a unified theory of expressions whose interpretations can depend either on the extra-linguistic context or the discourse context.

The immediate problem facing presuppositional theories of indexicals is how to secure rigid, referential interpretations for indexicals. Semantic theories used to treat anaphoric expressions, such as Discourse Representation Theory (DRT), and in particular van der Sandt's DRT with presuppositions, and Dynamic Predicate Logic (DPL), are typically concerned with interpretations of pronouns that are bound by quantifiers or anaphorically linked to an antecedent introduced in discourse, not with referential expressions or referential uses of expressions.[3] A presuppositional theory of indexicals must therefore be supplemented with a mechanism that can assign to a given indexical occurrence a referent from a situation treated as actual. Moreover, presuppositional theories of third person pronouns and definite descriptions readily allow interaction between the presupposed content of such expressions and the contents of other expressions in the discourse context—this is precisely why these theories are useful for third person pronouns and definite descriptions, which can be bound or otherwise linked to antecedents introduced in discourse. But the lexical meanings of indexicals do not interact as freely with the contents of other expressions. Presuppositional theories of indexicals must therefore be further supplemented with some mechanism for restricting this interaction in order to handle rigidity as well as Kaplan's theory does.

The aim of this paper is to show that a presuppositional theory of indexicals can successfully address these problems and treat rigidity as well as a Kaplanian theory can—and that it can do so without positing a special dimension of meaning for indexicals or the unintuitive ambiguities that arise in Kaplan's theory. Certain ingredients of Kaplan's theory will show up in the theory offered here: a presuppositional theory must appropriately restrict interaction between the lexical meanings of indexicals and the surrounding discourse context and it must have a mechanism for ensuring rigid, referential interpretations for expressions when necessary. The final result, however, will be importantly different from Kaplan's. The theory that I will propose here is an extension of Hunter & Asher (2005), which argued for the use of specific resolution strategies for indexical presuppositions. These resolution strategies allowed Hunter & Asher to appropriately restrict interaction between the presuppositions of indexicals and the surrounding discourse context, but as Maier (2006, 2009) has pointed out, Hunter & Asher's theory did not go far enough in ensuring rigidity for indexicals. The proposed strategies only ensured that indexical presuppositions take scope over embedding operators, but as Kripke (1980) and others have forcefully

[2]Or, for those that treat proper names as having a character, a special mechanism reserved only for indexicals and proper names (e.g., Maier (2006, 2009), Recanati (1993)). Proper names are not my focus, though I will touch on issues concerning them throughout the paper.

[3]A semantic theory of presupposition needs a semantic framework that models interaction between presupposed content and an input context. I assume here that such interaction is the fundamental feature of dynamic theories, ignoring the debate about dynamic vs. static evaluation. Thus my use of 'dynamic' is general enough to encompass DRT, which has a dynamic construction algorithm but a static semantics.

argued, the rigid behavior of an expression cannot be reduced to a requirement that it take wide scope over operators. The theory offered here remedies this deficiency by introducing new structure into discourse contexts and a means for 'anchoring' the interpretations of indexicals to individuals in the actual world. The upshot will be that all definites—indexicals, demonstratives, third person pronouns, proper names, definite descriptions—use the same structure of contexts. Indexicals differ from other definites not in requiring extra structure or dimensions of meaning, but only in how they use the same structure to find their referents.[4] Contrary to claims made in Maier (2006, 2009), we do not need, and have no reason to want, to hard-wire a two-dimensional semantics into the lexical entries of indexicals or any other definites.

2 Building a presuppositional theory of indexicals

I treat indexicals as presuppositional in the following, general sense. Each indexical is associated with a context-invariant linguistic meaning that never makes a novel contribution to truth-conditional/update content but serves only to pick out a contextually given individual that fits the property denoted by the linguistic meaning. If this meaning successfully picks out an appropriate individual in the context, then this individual is the indexical's sole contribution to truth conditions. Should the linguistic meaning fail to pick out an appropriate individual, the utterance of the indexical will not be felicitous in that context. In other words, should the context fail to provide a referent for an indexical token, the sentence containing that token will not express a complete semantic content in that context and the question of truth or falsity will not arise. In terms of the dynamic semantic framework that I will adopt, the function of an indexical's lexical meaning is to locate an antecedent discourse referent so that the discourse referent introduced by the lexical meaning of the indexical can be bound to it and new information concerning that discourse referent, or rather the individual that it represents, can be added to the discourse context. If the indexical binds to a discourse referent, then the indexical will pass on only this discourse referent to the logical form of the asserted content of the associated utterance. If the indexical fails to find an antecedent, update will not be successful.

Before turning to the positive proposal, I discuss two recent presuppositional treatments of indexicals, namely Hunter & Asher (2005) and Maier (2006, 2009), in order to assemble a picture of how an ideal presuppositional account should look. The final theory, presented in §3, will use Hunter & Asher's resolution strategies and more finely structured contexts similar to, but importantly different from, Maier's contexts.

2.1 Hunter & Asher (2005)

Hunter & Asher (2005) focused on the task of restricting interaction between indexical presuppositions and asserted content in order to capture the general insensitivity to operators exhibited by indexicals. The idea was that by assigning resolution strategies specific to the presuppositions of indexicals, one can appropriately restrict interaction between indexical presuppositions and asserted content without introducing a special kind of context or a special kind of meaning reserved only for indexicals. All definites were assumed to be presupposition triggers with specific resolution strategies and all definites were allowed to make use of the same

[4] I classify indexicals (demonstrative or non-demonstrative), proper names, third person pronouns and definite descriptions as definites on the basis that I treat them as having something like a presupposition of familiarity following Heim (1982). However, it is not important for my argument that one agree with this classification. I will continue to use this label because it is far less cumbersome than listing each type of expression every time I want to refer to these expressions as a group, but nothing hangs on it.

kinds of contexts; definites were supposed to differ only with regard to how they make use of those contexts.

Hunter & Asher present their theory in the language of DRT and I will continue to use this language because I find it intuitive. The theory could potentially be implemented in another dynamic framework, however, so long as it employed similarly structured contexts and treated existential quantifiers as mechanisms for introducing discourse referents. To see how Hunter & Asher's resolution strategies work, we must first ensure that discourse contexts contain information about utterance events. Let x, y, z, t, w be discourse referents that represent the agent, addressee, location, time and world of an utterance event e. Hunter & Asher, following Zeevat (1999), assume that e, made in a context c represented by a DRS K, will trigger two updates to K. First, it will trigger the addition of the discourse referents x, y, z, t, w in the universe of the most global level of K along with the addition of conditions like $ag(x)$, which says that the individual picked out by x is the agent of the current utterance event, and so on. Next, the DRS K′ that results from this update will be updated with the content conveyed by the utterance. Consider an example without indexicals or any other presuppositional expressions for now:

(1) Someone is hungry.

(1') $K \rightarrow_e$ | x, y, z, t, w | ag(x) ... | $K' \rightarrow_{(1)}$ | x, y, z, t, w, x' | ag(x) ... hungry(x') | K''

For simplicity, we assume that the initial DRS K is empty. Update with information about the utterance event, signaled by the arrow $\rightarrow_e$, results in the DRS K′.[5] Update of K′ with the content of (1), signaled by $\rightarrow_{(1)}$, results in the final DRS K″.

Hunter & Asher next introduce two operators, $\uparrow$ and $\Uparrow$, which when given scope over the presupposition of an indexical determine a particular resolution strategy for that indexical. $\Uparrow$ is a strict operator that says that material in its scope (the presupposition of an indexical in this case) must be resolved in the most global DRS if it is resolved at all. This operator was posited for English *I*, which seems to always receive a Kaplanian reading. $\uparrow$ is less strict; it requires material in its scope to be resolved in the most global context when possible, but allows that in certain situations, resolution in a lower context might be allowed. $\uparrow$ was posited for indexicals like *now, actual*, *actually*, and *here*, whose presuppositions can sometimes interact with the contents of other expressions in a discourse:

(2) Brutally, the banks knowingly gamed the system to grow their balance sheets ever faster and with even less capital underpinning them in the full knowledge that everything rested on the bogus claim that their lending was *now* much less risky.[6]

(3) Let's suppose that developing it took two years with 10 people working on it; I don't have the actual numbers, but that should do. Now let us suppose that the average salary of those working in it, including fringe benefits and company overhead, was $150,000

[5] K′ would also contain the following conditions: ad(y), loc(z), time(t), world(w), for the addressee, location, time and world, respectively, of the event e. It might also contain conditions that represent objects in the perceptible environment as having certain perceptual properties.

[6] *The Guardian*, 'Now we know the truth. The financial meltdown wasn't a mistake—it was a con,' April 18, 2010, http://www.guardian.co.uk/business/2010/apr/18/goldman-sachs-regulators-civil-charges

per year. That means that the development costs would have been $1,500,000, which is not inconsiderable and probably the *actual* cost would have been considerably greater.[7]

(4) And what would terrify the right, of course, is the likelihood that genuine socialized medicine would *actually* win that competition.[8],[9]

(5) All over England folk began to hear of the wonderful saint who lived alone in the desert island, and from all parts the troubled and unhappy came to seek his help. He was like some famous doctor to whom sick folk come; and no doctor ever cured bodies so skilfully as he cured souls and hearts and troubled minds. He built a house by the landing-place on the island for his visitors to stay in, and *here*, too, his monks would come on festivals to have a talk with him.[10]

In (2), *now* is anaphorically linked to a time given earlier in the discourse; in (3), *actual* is sensitive to *let us suppose*; in (4), *actually* is sensitive to *would*; and in (5), *here* refers to a location introduced in discourse.[11] I will say more about these examples in section 2.3.

Hunter & Asher suggested a lexical entry of the following sort for *I*:

$$[\![\mathrm{I}]\!] = \lambda P(p : \Uparrow \exists x'(\mathrm{ag}(x') \ \wedge \ x' = ?; \ a : P[x'])$$

P is a variable for a property; λP shows that the lexical entry for I seeks to combine with a property denoting term such as *hungry*. The label 'p :' marks material after the colon as presupposed material; the label 'a :' marks material after the colon as asserted material. The formula '$x = ?$' shows that x is anaphoric; the question mark should ultimately be replaced by a discourse referent in the incoming context thereby binding x to that discourse referent. The fact that '$x = ?$' falls in the scope of the operator $\Uparrow$ means that an antecedent for x must be found in the most global context, if one is found at all. Consider an example. Let K′ be the result of updating an empty DRS with information about a given utterance of (6)

(6) I am hungry.

(6')

x, y, z, t, w
$\mathrm{ag}(x)$
...

K'

The next step is to update K′ with the content of the utterance of (6). Following van der Sandt (1992), Hunter & Asher assume that *I* triggers the introduction of a preliminary DRS. That is, it triggers the construction of a DRS for presupposed material that must be resolved somewhere in K′.

[7] Comment from *A Philosopher's Blog*: 'Is Piracy a Theft?' http://aphilosopher.wordpress.com/2011/03/08/is-piracy-theft/

[8] Paul Krugman, 'Why Not A Public Option for Medicare?' http://krugman.blogs.nytimes.com/2011/04/12/why-not-a-public-option-for-medicare/?scp=28&sq=actual&st=cse

[9] For more examples in which *actual* and *actually* do not depend on the actual world, see Cresswell (1990).

[10] Project Canterbury, *The Little Lives of the Saints*, told by Percy Dearmer and illustrated by Charles Robinson. London: Wells Gardner, Darton & Co., 1904. http://anglicanhistory.org/dearmer/lives/06.html

[11] As presented in Hunter & Asher (2005), $\Uparrow$ and $\uparrow$ are operators that force presuppositions in their scope to take wide scope over logical operators (when possible). The anaphoric binding observed in (2) and (5), however, is a separate issue from syntactic scope. Hunter & Asher's contexts are not sufficiently rich to make a distinction between an example in which an indexical presupposition is resolved to some feature of an utterance event and an example in which it does not take scope under any operators but is anaphorically bound to an antecedent introduced in discourse. Maier (2006, 2009)'s criticism of Hunter & Asher's theory, which I will discuss below, brings out this problem.

(6_p) $\Uparrow$

x'
$\text{ag}(x') \wedge\ x = ?$

The operator $\Uparrow$ requires that the presupposed material be satisfied in the most global context if satisfied at all. Here this is trivial as there is only one layer of context in K$'$. The discourse referent x' is identified with x in K$'$. With this identity in place, the information provided by (6_p) is redundant and so it is discarded. The final DRS K$''$ looks like this:

(6")

x, y, z, t, w
$\text{ag}(x)$ ... $\text{hungry}(x)$

K''

The final result looks very similar to that for (1). The difference is that while update with the content of (1) led to the introduction of a new discourse referent, x', update with the content of (6) does not lead to the introduction of any discourse referents but only to the addition of new information about an old discourse referent.

$\Uparrow$ makes a difference when an indexical presupposition is triggered in a context created by an embedding operator:

(7) Maybe I am hungry.

In this case, the modal introduces a subDRS inside of K$'$ and the presupposition of *I* will be faced with a choice of where to find an antecedent. In the end, however, because of the semantics of $\Uparrow$, the presupposition of *I* will project outside of the subDRS created by the modal to be resolved in the most global context. Taking K$'$ as input yet again, x' in the presupposition of *I* will be identified with x in the universe of the global level of K$'$.

(7")

x, y, z, t, w
$\text{ag}(x)$ ... $\Diamond$: [$\text{hungry}(x)$]

K''

While their focus was on indexicals, Hunter & Asher suggested that other definites might adopt strategies other than $\Uparrow$ or $\uparrow$ that would not force their presuppositions to take wide scope. Definite descriptions, for example, might adopt the strategy proposed by van der Sandt (1992): LOCAL BINDING $\rightarrow$ GLOBAL BINDING $\rightarrow$ GLOBAL ACCOMMODATION $\rightarrow$ LOCAL ACCOMMODATION, where '$x \rightarrow y$' indicates that x is chosen over y when possible. Again, the idea offered by Hunter & Asher was that by moving away from a general strategy for presupposition resolution, like van der Sandt's, and towards tailored resolution strategies for different presuppositional expressions, one can capture the important differences between different kinds of definites without positing an extra dimension of meaning or extra structure in the contexts reserved solely for indexicals.

As Maier (2006, 2009) has rightfully pointed out, however, Hunter & Asher's account did not give a clear account of rigidity. $\Uparrow$ and $\uparrow$ force indexical presuppositions to take wide scope, at least most of the time, but as Kripke (1980) made clear, an expression's taking wide scope—or rather, not taking narrow scope—will not ensure a rigid interpretation for that expression. Consider the following two examples:

(I) *I* am speaking.

(S) *The speaker* is speaking.

Echoing elements of Kripke's argument against wide-scope theories of proper names, Maier argues that a wide-scope theory like Hunter & Asher's cannot do justice to the observation that *I* in (I) has a rigid interpretation while *the speaker* in (S) need not because $\Uparrow$ and $\uparrow$ only make a difference when scope is at issue, which is not the case in simple sentences like (I) and (S). Hunter & Asher's theory treats all definites, including definite descriptions, as presuppositional and predicts that the presuppositions of both *I* in (I) and *the speaker* in (S) will prefer to be resolved to an antecedent in the most global context. (Assuming that (I) and (S) are uttered in empty contexts, there's no reason why the presuppositions would be resolved in a lower context since there are no operators in (I) and (S) to take scope over them.) If the presuppositions are resolved to the same antecedent, then (I) and (S) will receive the same interpretation, leaving unexplained the intuition that (S) has a reading that is unavailable for (I). If they are somehow bound to two different antecedents, it's still not clear how to ensure that one expression would receive a rigid reading while the other wouldn't as their presuppositions are surely descriptively similar and $\uparrow$ and $\Uparrow$ only make a difference when syntactic scope is an issue.

Hunter & Asher's account needs a way of anchoring the antecedent of *I* to the actual agent of a given utterance of (I) without requiring that the antecedent of *the speaker*, for an utterance of (S), be so anchored. In other words, borrowing from Kamp (1985) and Kamp & Reyle (1993)'s notion of an *external anchor*, what is needed is a way of constraining the possible embedding functions for the DRS of (I) so that all permissible embedding functions map the antecedent of *I* in (I) to the same individual a in the domain (of a given model). The anchoring mechanism for indexicals should not be external to the DRS construction and evaluation procedure in the way that external anchors are, however. The external construction procedure for external anchors was motivated by arguments that crucial reference determining factors for proper names are not 'in the head' (Putnam 1975); in particular, it is motivated by Kripke's arguments that reference determination for proper names is an extra-linguistic matter (Kamp 1985, Kamp & Reyle 1993, Kripke 1980). In contrast to proper names—at least as analyzed by Kripke—each indexical has a fairly robust linguistic meaning that (largely) determines its interpretation in a context. Treating the lexical meaning of an indexical in the same fashion in which Kripke treated reference-fixing mechanisms for proper names would not do justice to this point. Moreover, an account of indexicals that analyzed their reference-fixing contents entirely in terms of mechanisms external to a DRS would be very different from existing presuppositional treatments of other definites, where these presuppositions are treated as semantic contents that belong inside of a DRS and that can bind to available discourse referents or add content to a DRS when an antecedent is not available. An external anchor based approach is therefore not ideal as it stands for a theory that aims to capture what indexicals have in common with other presupposition triggers, in particular, other definites.

2.2 Maier (2006, 2009)

Motivated by the need for a semantically incorporated, i.e. not external, anchoring mechanism, Maier (2006, 2009) introduces a new 'layer' into standard DRT whose role is to determine an anchor for discourse referents introduced by proper names and indexicals. This layer, which Maier calls the *kk-layer* after Kripke and Kaplan, performs the function of Kamp & Reyle's external anchors in that it allows for rigid interpretations of certain discourse referents; however, unlike Kamp & Reyle's external anchors, Maier's anchoring mechanism is fully representational and incorporated into the DRT architecture. Maier's *Layered* DRSs (LDRSs) look almost exactly

like normal DRSs except that some of the discourse referents and conditions inside of them bear a *kk* subscript. Likewise, the presuppositions of proper names and indexicals look like normal presuppositions except that they, too, are marked for the *kk*-layer. Given the evaluation of the *kk*-layer, which I will explain below, the *kk* marking entails that proper names and indexicals trigger rigid presuppositions. The presuppositions of definite descriptions, on the other hand, will be bound in the *fr-layer*, after Frege, which will ensure non-rigid interpretations for definite descriptions.[12] The *fr*-layer is the only layer in standard DRT; the distinction between *Layered* DRT (LDRT) and DRT lies entirely in the *kk*-layer.

In brief, LDRT captures the difference between (I) and (S) by saying that the presupposition of *I* in (I) is bound in the *kk*-layer of the LDRS for (I) while the presupposition of *the speaker* in (S) is bound in the *fr*-layer. This layer-sensitive binding ensures that despite the fact that *I* in (I) and *the speaker* in (S) have the same syntactic scope, the discourse referent to which the presupposition of *I* is resolved will have a rigid interpretation while the discourse referent to which the description's presupposition is resolved will have a non-rigid interpretation.

In more detail, Maier divides expressions into two camps: those that are lexically rigid and those that are not. Proper names and indexicals are classified as rigid expressions and thus trigger rigid, i.e. *kk*-labeled, presuppositions. Let the first LDRS below, LDRS K, be the input LDRS for an utterance of (I). LDRS $K_{(I)}$ is the LDRS for (I), which needs to be incorporated into K. $K_{(I)}$ contains a preliminary LDRS, marked with '***p***:'. This LDRS contains the presupposed content of *I* and must be incorporated into K before the asserted content of (I), $speaking_{fr}(x)$, can be incorporated.

(I) *I* am speaking.

(I') y_{kk} | $\text{speaker}_{kk}(y)$ K $\oplus$ $\text{speaking}_{fr}(x)$ | ***p*** : x_{kk} | $\text{speaker}_{kk}(x)$ $K_{(I)}$

Resolution of this presupposition involves finding an antecedent discourse referent for x in the *kk*-layer such that that the discourse referent is identified with x. Once a proper *kk*-layer antecedent has been found for x, the asserted *fr*-layer content will be added to the LDRS. Continuing with our example from (I'), x will be identified with y. Update then proceeds with the asserted content of (I).

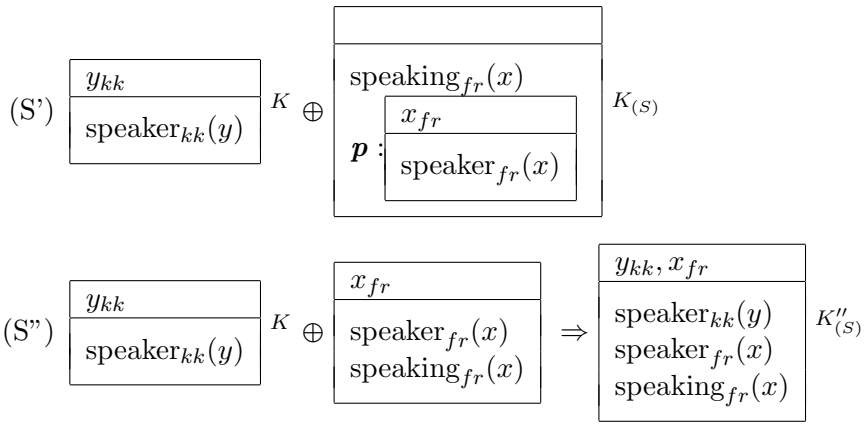
(I") y_{kk} | $\text{speaker}_{kk}(y)$ $\oplus$ $\text{speaking}_{fr}(y)$ $\Rightarrow$ y_{kk} | $\text{speaker}_{kk}(y)$, $\text{speaking}_{fr}(y)$ $K''_{(I)}$

Fr-conditions can contain discourse referents bound in the *kk*-layer. This reflects the general observation that proper names and indexicals pass along only their referents to truth-evaluable content.

Definite descriptions and non-NP presupposition triggers, which are classified as descriptive rather than rigid, will trigger non-rigid, *fr*-layer presuppositions and their evaluation will take place entirely at the *fr*-layer. Compare the update process for (S) with that of (I).

(S) *The speaker* is speaking.

[12] In Maier (2006, 2009), Maier argues that one may need more than two layers to account for other dimensions of meaning. I am simplifying his view here because only the *kk*-layer and the *fr*-layer matter for our purposes.



In (S), the presupposed content of the definite description is fundamentally the same as that of the asserted component. Because both the presupposed and asserted components are marked for the fr-layer, the result after evaluation will be that *the speaker* is interpreted non-rigidly and (S) expresses the claim that there is a speaker who is speaking.

Evaluation of an LDRS takes place one layer at a time. Evaluation of $\mathrm{K}''_{(I)}$, for example, will require two procedures: evaluation of the kk-layer, during which all fr-conditions are ignored, and evaluation of the fr-layer, during which all kk-conditions are ignored. Let's start with the kk-layer. Evaluation of the kk-layer will, as in Kaplan's theory, take place relative to a context rather than an entire world. An anchor for the kk-layer will be 'the smallest truthful embedding of the kk-layer with respect to c which has the kk-labelled discourse referents in its domain'. In the case of $\mathrm{K}''_{(I)}$, then, we are looking for the smallest truthful embedding that has y_{kk} in its domain and which verifies at a given context c the condition $speaker_{kk}(y)$. That is, we're looking for the smallest embedding that assigns y_{kk} to the individual who is actually speaking in c, assuming there is exactly one; the anchoring procedure will be defined for (I') only if the context c contains a unique speaker. The point of using contexts rather than worlds is to ensure that predicates like *speaker* or *Mary* have singleton extensions. This way, the kk-layer of an LDRS will have at most one verifying embedding at a given context c.

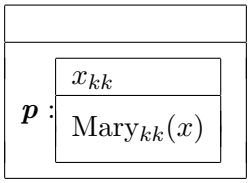
Once evaluation of the kk-layer has produced an anchoring function—a unique verifying embedding relative to the chosen context c—it is time to evaluate the fr-layer. Evaluation of the fr-layer involves extending the anchoring function to a proper embedding for the fr-content. Looking at $\mathrm{K}''_{(I)}$ again, the fr-content, $speaking_{fr}(y)$, will be true at a world w just in case the anchoring function f_a determined by evaluation of the kk-layer at c maps y to an individual who is in the extension of *speak* at w. That is, just in case the person who is speaking in c is speaking at w.

Maier's proposal is largely faithful to Kaplan's two-dimensional account of indexicals. There is a type of content, namely kk-labelled content, that is designed to never interact with a second type of content, fr-labelled content. The former type of content is evaluated relative to contexts; the latter, relative to full circumstances. Also, the lexical entries of expressions in LDRT determine whether they are evaluated at the kk-layer or at the fr-layer just as the lexical entries of expressions in Kaplan's Logic of Demonstratives (LD) determined whether they were evaluated relative to the context of utterance or at a given circumstance of evaluation. Finally, the anchoring mechanism is fully incorporated into the semantics in LDRT as it was in Kaplan's LD (but not in Kamp & Reyle's external anchoring system).

Nevertheless, Maier departs from Kaplan on some important points. First, he broadens the notion of context used for indexicals in order to handle proper names. Proper names, like indexicals, trigger rigid presuppositions in LDRT and therefore have as much of a 'character' as indexicals do. Following Geurts (1997), the presupposition of the proper name *Mary*, for

example, is that there is someone named *Mary*. Maier's presupposition is something like this:

(8)



Proper names thus have a minimal descriptive content, though this content does not suffice to determine a referent, just as Kripke said it wouldn't. Contextual information is also needed: the descriptive content of the name *Mary* serves to pick out the *salient* Mary, acting more as a tie between a new utterance and an individual already figuring in the context. A consequence of this treatment of proper names is that Maier has to allow for the notion of a salient individual and his contexts must be rich enough to potentially include any individual in the domain of individuals. This takes us away from Kaplan's limited notion of an utterance context.

Maier also departs from Kaplan on the question of interaction of content. In Kaplan's system, the character of a context-sensitive expression can *never* be affected by the content$_k$ of another expression. Proper names, though they do not have a 'character' in Kaplan's sense, are also prohibited from interacting with content$_k$. Definite descriptions, on the other hand, always contribute their meanings to content$_k$ and therefore *never* receive a referential interpretation unless figuring in a *dthat* term.[13] Kaplan's approach for securing rigidity was to separate the character and content$_k$ dimensions in such a deep way as to prevent them from ever interacting. Maier seems to support this distinction when he says:

> Following Zimmermann's (1991, 2004) "Hypothesis (L): lexical items are always deictic or absolute", I take it that an expression's reference either depends on the context and is intensionally rigid, or has intensional content but is contextually inert. In LDRT terms, the representational content of an expression either wholly resides in *kk*, or in *fr*, and which of the two, is specified by the (L)exicon, and should therefore be reflected in the PrelLDRS. This implies that there are two kinds of presuppositions: *kk* presuppositions triggered by lexically rigid items such as names and indexicals, and *fr* presuppositions triggered by definite descriptions and other, non-NP triggers.

Maier even introduces a constraint, called LayerFaith, which requires each expression to be interpreted in the layer for which it is labeled.

On closer examination, however, Maier abandons Hypothesis L, and Kaplan's prohibition on interaction along with it, because he allows proper names to violate this constraint and 'hop' down to the fr-layer. This exception is meant to account for certain data concerning proper names that are bound or accommodated. I offer here two examples discussed by Maier. For a more thorough discussion of these and other data on proper names, see Geurts (1997).

(9) If a child is christened Bambi and Disney Inc. find out about it, they will sue *Bambi*'s parents.

(10) If presidents were elected by alphabetical order, *Aaron Aardvark* might have been president (from Bach 1987).

[13] Certain definite descriptions, such as *the square of four*, will have constant contents in Kaplan's LD. For the purposes at hand, I will follow Kaplan and Kripke in assuming that this does not make them referential or *de jure* rigid.

Geurts argues that (9) involves a non-rigid, bound use of *Bambi* while *Aaron Aardvark* has a non-rigid, locally accommodated reading in (10). To analyze these examples, Maier allows the proper names *Bambi* and *Aaron Aardvark*, which normally carry a kk subscript, to hop down to the fr-layer. In other words, the italicized occurrences of the proper names in (9) and (10) introduce the conditions $Bambi_{fr}(x)$ and $Aaron\text{-}Aardvark_{fr}(y)$, where x and y are fr-labeled discourse referents in the universes of the LDRSs for (9) and (10), respectively. Dedication to the kk-layer, then, is actually a default resolution strategy and not a hard and fast rule. In this sense, kk-presuppositions—at least for proper names—are a bit like Hunter & Asher's $\uparrow$ presuppositions; kk-presuppositions strongly prefer to bind in the kk-layer, but under certain conditions, they can bind in another layer. The story is different for indexicals. Maier does not allow indexicals to hop layers, so kk-presuppositions for indexicals are more like Hunter & Asher's $\Uparrow$ presuppositions. LayerFaith is a stronger constraint for indexicals than for proper names.

Maier is not entirely clear on whether he sticks to Hypothesis L for definite descriptions or whether he allows layer hopping from the fr-layer to the kk-layer. He mentions layer hopping for definite descriptions but then proceeds to explain the referential reading of (S) in terms of bridging, not layer hopping, saying that the referential reading of (S) results from a bridging inference to the effect that the fr-layer speaker is the same as the speaker given by the context (i.e., the speaker represented in the kk-layer). To defend this choice, Maier appeals to the 'referential hierarchy', in which proper names and indexicals are ranked higher than definite descriptions (Prince (1981), Zeevat (1999)). Maier interprets the hierarchy as enforcing a constraint on the use of definite descriptions: don't use a definite description when you can use a name or indexical. The use of a definite description supposedly signals that reference is not desired. In his words: "It seems to follow that if something is available in the kk-layer, and thus available to be picked up by a demonstrative or higher, we can no longer use a definite description or indefinite to refer to it". But this does not follow. Suppose I have just had a meeting with my daughter's principal about my daughter's disruptive behavior at school. I walk out of the office and my daughter is waiting for me. I can say to her, "so I just had a little chat with the principal". I know the principal's name, my daughter knows the principal's name, the principal is salient in the context (perhaps my daughter even saw the principal when I opened the door). It would have been perfectly felicitous for me to use the principal's name, or even the pronoun *her* accompanied by an appropriate demonstration, in this context, but I chose to use the description in order to call attention to the fact that my daughter got in trouble and to the principal's authoritative position. The referential hierarchy is not going to tell us to not treat this as a referential use; it's mum on that point. Nor will bridging help here unless we assume that the principal *qua principal* is salient in the context. And once we do this, we might as well allow layer hopping up from fr to kk.

Such movement between the kk-layer and the fr-layer suggests that LDRT's layers are not as deeply independent as Kaplan held his dimensions to be. Why fuss with layer dedication at all? Why not give up Hypothesis L and let expressions move freely between the kk- and fr-layers? This question is particularly poignant when we consider that this is precisely what Maier does for third person pronouns. Third person pronouns are not marked for either the kk- or the fr-layer in order to account for the generally accepted observation that third person pronouns are regularly used in both deictic and bound/anaphoric constructions.

2.3 Interaction

Maier's adaptation of Kaplan's two-dimensional view maintains some of the more positive features of LD, such as the ability to secure rigid interpretations for indexicals and proper names.

At the same time, because it allows proper names to 'hop' layers when bound or locally accommodated, it is more empirically adequate than a Kaplan-style view that disallows any interaction between the lexical meanings of 'referential' expressions and the surrounding discourse context. Nevertheless, Maier's proposal does not go nearly far enough in shedding the two-dimensional paradigm. The data simply do not motivate the sharp distinction between supposedly rigid, referential and non-rigid, non-referential expressions that underlies Kaplan's two-dimensional program. We should abandon Hypothesis L, or at least Maier's interpretation of it, altogether.

Maier's argument for his layered account of indexicals is based largely on the distinction between (I) and (S). Yet examples like (I) and (S) show at most that definite descriptions have an interpretation in examples like (S) that indexicals (or proper names) cannot have.[14] They do *not* show that indexicals and proper names always receive referential, rigid interpretations, nor do they show that definite descriptions cannot receive the same kinds of interpretations as indexicals receive. Moreover, when we run Kripke-like tests on multi-sentence discourses, assuming that, say, a definite description and a demonstrative can have the same type of interpretation can be crucial for ensuring the coherence of a conversation. Suppose I am standing in front of a painting and I tell you, "the painting behind my head is one of the most beautiful of Vermeer's paintings" and imagine you follow up on my utterance by saying, "wow, you're right—that *is* beautiful". If we consider the discourse as a whole, there is good reason to treat my use of *the painting behind my head* as referential—or at least to treat it as being as referential as your use of *that*. Let the referent of the demonstrative *that* be the painting p and suppose that the denotation of my utterance of *the painting behind my head* is allowed to vary from one world to another as Kripke would have it. If we consider the question of what worlds would verify the discourse as a whole, then it seems to me that when we consider a world in which my use of *the painting behind my head* denotes something other than p, the discourse should sound incoherent because we will be talking about different objects and you won't be agreeing with me at all despite your use of "you're right". Yet the discourse sounds perfectly coherent.[15] Kripke-style tests involving examples like (I) and (S) do not by themselves support the deep wedge that Maier wants to drive between indexicals and proper names on the one hand and definite descriptions on the other.

Maier's treatment of indexicals is also unjustifiably restrictive as evidenced by examples (2) through (5) above. The occurrence of *now* in (2) is difficult to interpret if we imagine that (2) is the first sentence of a discourse. This is not so if we put the example in the present tense:

(2') Brutally, the banks are knowingly gaming the system to grow their balance sheets ever faster and with even less capital underpinning them in the full knowledge that everything rests on the bogus claim that their lending is *now* much less risky.

In (2), the occurrence of *now* needs an antecedent; the discourse must provide a time on which the occurrence depends. In examples like (2)—of which there are many—*now* is every bit as anaphoric as *he, she* and *it* can be.[16] In (3) and (4), *actual* and *actually* are sensitive to modals.

[14] At least *some* definite descriptions. It is important not to forget that the Kripke test does not work so well for certain definite descriptions. Try, for example, running the test on: *the table is brown*. This is not so different from running the test on *that table is brown* where there is no demonstration but we are simply meant to consider situations in which an utterance of the sentence would be true.

[15] There is a reading of this discourse in which the denotation of both *that* and *the painting behind my head* are allowed to vary. Either way—whether both are interpreted referentially or both are interpreted non-referentially—this example works against using a Kripke-like test to motivate the traditional distinction between referential and non-referential expressions.

[16] I argue in Hunter (2012) that *now* can be given a unified semantics such that the presupposition of *now* simply looks like this: $\uparrow \exists t(time(t))$. The contrastive feel found in many examples involving anaphoric uses of *now* is explained in terms of the semantics of *now* together with features of the discourse in which such uses of *now* figure. I do not have the space to expand on this theory here, however.

In (3), *the actual cost* denotes the final cost of the hypothetical development under discussion; in other words, *the actual cost* falls in the scope of the modal introduced by *let us suppose*. Such examples are easy to find on the internet and equally easy to create.

Here is perhaps the most flexible among the indexical expressions that I am discussing. Even before we take discourse contexts into account, it has demonstrative uses that allow it to pick up on locations and representations of locations (e.g. a point on a map) as well locations more broadly construed. For example, imagine a director showing an actor a sketch of a series of scenes from a movie that he is going to make. He points at one square and says, "you will enter here" meaning that the actor will enter in that scene or at that point of the movie. When we move to discourse uses, we find an extension of the same flexibility. *Here* can pick out locations introduced in discourse as in (5) and thus has an anaphoric use like we have seen with *now* and *actual/ly*. It can also pick out non-spatial 'locations' introduced in discourse as when one is explaining something and says, "what I'm getting at *here* [i.e. at this point in my explanation/story/argument] is...". It also seems to have something like a demonstrative use when used to point at other material in a discourse:

(11) **Here**'s The Japan Times describing Sandel's 2010 visit: "Few philosophers are compared to rock stars or TV celebrities, but that's the kind of popularity Michael Sandel enjoys in Japan."[17]

Maier disregards examples like the ones I am offering here and suggests that they show that *now, actual, actually* and *here* are not indexicals and that they are therefore not counterexamples to his theory. Yet these expressions serve as three (counting *actual* and *actually* as variations) out of the four paradigmatic indexicals; they depend directly on three out of the four coordinates of Kaplan's contexts. Were we to jettison these expressions from the class of indexicals, as Maier suggests, we would be left with a funny lot.[18] We would have, perhaps, English *I* and some temporal indexicals. This looks like a far less interesting class semantically than the original set of indexicals. Moreover, even when used anaphorically or demonstratively, these expressions still have a lot of the features that made indexicals look like an interesting and semantically cohesive class of expressions in the first place. Clearly they are context dependent so long as we count discourse context dependence as a form of context dependence, as we should. They also appear to pick out their antecedents directly in the sense of not contributing a descriptive complex to logical form but only an individual, though we will have to construe 'individual' in the broader sense that one often does for anaphoric pronouns to include, say, discourse referents. Finally, these expressions all seem to be 'perspectival' in some sense (Recanati 2004, Hunter 2010, Hunter 2012). A past tense use of *now*, though it does not pick out the utterance time, still has the effect of centering the narrative or discourse on the time that it denotes. It somehow brings the addressee or reader closer to the events being described than would a use of *then* in its place. Parallel remarks can be made for *here* and *actual/ly*.

The fact that *now, here* and *actual/ly* can be anaphorically bound to antecedents introduced in discourse provides additional motivation for the kind of view that Maier, along with Hunter & Asher and others, is promoting. In a theory like Maier's or Hunter & Asher's, indexicals are *always* treated as anaphoric expressions; it's just that sometimes, and perhaps most of the time, their antecedents are not given explicitly in discourse but are somehow made salient in the extra-linguistic context. This approach to indexicals already has the advantage of being more general: if we treat all deictic uses of definites as anaphoric uses, we not only get a tighter

[17] 'Justice Goes Global,' Thomas L. Friedman, *The New York Times*, June 14, 2011. http://www.nytimes.com/2011/06/15/opinion/15friedman.html?scp=32&sq=here&st=cse.

[18] Recanati (2004) also suggests that *now* and *here* are not indexicals on the basis of examples like those I am discussing here.

connection between indexicals and other expressions that can be used deictically, we also get a more unified picture of third person pronouns and demonstratives, which clearly have both deictic and discourse anaphoric uses. The fact that *now, here* and *actual/ly* have discourse anaphoric interpretations should be welcome news, because it gives one independent reason to treat indexicals as anaphoric expressions and strongly suggests that anaphoric theories of indexicals have been on the right track in doing so.

Maier's framework could be easily amended in order to account for the data on *now, here* and *actual/ly* by allowing layer hopping for indexicals. The result would come closer to the $\uparrow$ presuppositions that Hunter & Asher posited for these expressions. It is important to realize that in doing so, however, Maier would be abandoning Hypothesis L and the two-dimensional framework that it motivates. Allowing layer hopping for proper names was already a step in this direction. The fact that the lexical meaning of a proper name can simply change labels, from a kk-labeled expression to an fr-labeled expression, shows that the labeling and layer-dedication is not an integral part of its meaning. Proper names and indexicals don't really have a different kind of meaning from definite descriptions even in Maier's theory, despite Maier's many suggestions to the contrary. They just have a different resolution strategy.

A more straightforward way of approaching indexical (and proper name) semantics would be to drop layer dedication and allow interaction, while explicitly adopting different resolution strategies for different kinds of definites as Hunter & Asher did. On such an approach, information from the extra-linguistic context need not be represented in a different layer of a DRS, but merely a separate level; information can be presented explicitly in discourse or it can be presented by the extra-linguistic context. What the data show is that most expressions regularly cross the boundary between the two kinds of context, so there is no reason to treat dependence on one kind of context or another as a different dimension of meaning. Approaching the matter from this point of view will show clearly that presuppositions actually replace Kaplanian characters and will allow us to shed the restrictions of the overly-simplistic Kaplanian picture of indexicals. I turn now to an extension of Hunter & Asher's approach using tailored resolution strategies.

3 Wider scope

A theory of indexicals needs to account at least for the following features of indexicals: (a) each indexical has a constant lexical meaning that determines its semantic value in a context, (b) this lexical meaning does not make a novel contribution to truth-conditional content, (c) the lexical meaning can sometimes interact with content in the surrounding discourse context in the sense that it can be bound to antecedents introduced in discourse, though such interaction is more restricted for indexicals than for many other kinds of expressions, (d) indexicals can have rigid interpretations. Hunter & Asher focused on (a)-(c) by treating the lexical meanings of indexicals as presuppositions with a specific resolution strategy. A drawback of the theory was that it did not account for (d).

To remedy Hunter & Asher's proposal so that it can account for (d), I propose that all we need are appropriately structured contexts and pointed models. Resolutions strategies will tell expressions where to look for their antecedents and the structured contexts will give them the necessary places to find them. Pointed models together with structured contexts will allow us to secure rigidity for indexicals when necessary without forcing rigidity into indexical presuppositions. The idea is that when an expression finds its antecedent in the most global level of a structured context, it will receive a rigid interpretation; when it finds one lower down, a rigid interpretation will not be ensured.

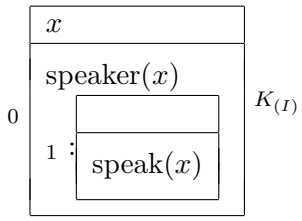
3.1 Structured Contexts

I introduce a new level into standard DRSs to house information from the extra-linguistic context. This level, which I simply call 'K_0', is the most global level of a given DRS K. It serves the function of Maier's *kk*-layer in the sense that evaluation of it determines an anchor function that ensures rigid interpretations for certain occurrences of indexicals and proper names. The important difference between K_0 and Maier's *kk*-layer is that K_0 is more general—it is potentially accessible to any presuppositional content that can be resolved in the extra-linguistic context—and it should not be viewed as a different layer of a DRS. The distinction between K_0 and its sub-DRSs, K_1-K_n, is just like the distinction between any other two levels in a DRS from the point of view of an expression looking for an antecedent; presuppositions can potentially choose an antecedent from any of them. Indexicals and proper names are not different from other expressions in virtue of requiring extra structure, but only in the way they use one and the same structure to find an antecedent.

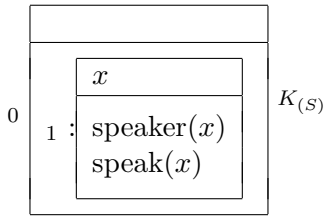
The information in K_0 will, as I will explain in more detail in the next subsection, be evaluated relative to a world taken as actual. Most facts about the way the world is—who the speaker is for a given utterance, who the President of Iran is, what water is, for example—cannot be affected by what is said in a discourse. I cannot describe a circumstance and expect my description to have any effect on the nature of the actual world whatsoever.[19] On the other hand, the nature of the actual world regularly affects the interpretation of things that we say, as when we use proper names, indexicals, demonstratives, natural kind terms, and so on. The information in K_0 is determined by the nature of the actual world; the fact that it is more global than the discourse context, represented by K_1-K_n, reflects the asymmetrical dependence of the discourse context on the actual world.

As an example of the distinction between K_0 and K_1-K_n, I provide simplified versions of the DRSs for (I) and the attributive reading of (S) below. My aim here is to show the structural distinction between the DRSs for (I) and (S), not to fully specify the contents of the DRSs.

(12)



(13)



The outermost DRS, K_0, is marked with "0" for both $K_{(I)}$ and $K_{(S)}$; K_1 is marked with "1". What we're interested in for the attributive reading of (S) is possibilities—we want the description to denote a possibly different individual at different circumstances of evaluation. This is exactly what one gets from the evaluation of a definite description in standard DRT or dynamic semantics. For (I), as well as the referential reading of (S), we are only interested in picking

[19] Performatives are an exception. Demonstratives are not. While speaker intentions and actions do help determine a demonstratum, they cannot effect the nature of the object thereby demonstrated. This is why a speaker, despite her intentions, can succeed in referring to an object that she did not intend to refer to when she thinks she is demonstrating an object other than the one she is actually demonstrating.

out whoever is the agent or speaker in the actual world and then predicating things of *that* individual. In this case, the presupposition of *I* or *the speaker* is bound in K_0, the content of which will be anchored to the actual world.

K_0 is designed not just for the presuppositions of indexicals or proper names but for any anaphoric/presuppositional expression whose need for an antecedent can be satisfied by the extra-linguistic context. It can also be used to track information introduced through perception, like demonstrations and other gestures, that can effect the interpretation of utterances. The presupposition trigger, *too*, for example, is like indexicals and third person pronouns in that it must bind to an antecedent, i.e. it cannot be accommodated, but its antecedent need not be explicitly mentioned in discourse. When my friend shows up at my house wearing a dress exactly like one that I own, I can point at the dress and say, "I have that dress, too!". I don't need to say, "You have that dress and I have it, too"—the extra-linguistic context (perhaps together with my demonstration) provides the needed information to secure an antecedent for *too*.

Epistemic modals are—like definites, *too*, and discourse connectives—sensitive to the incoming information state. If I say, "It's raining," it is infelicitous for me to continue with "it might not be raining" unless it is clear that I am correcting myself. Likewise, if we are looking out of the window and watching the rain pour down, I cannot felicitously say, "It might not be raining". I don't need to first say, "It's raining" to get this result; the fact that it's raining is obvious from the extra-linguistic context. NP-deletion can also be licensed in certain cases without an explicit antecedent as when I start to inspect the bouquet of one of my bridesmaids and say, "Hmm, Jill's looks healthier than yours," where Jill is another one of my bridesmaids (Elbourne 2005).

One of the main ideas motivating presuppositional theories of indexicals is that indexicals can be, and usually are, anaphorically linked to antecedents presented in the extra-linguistic context without being explicitly introduced in discourse. When I make an utterance, that suffices to make it known in the context that I am the agent of the utterance; I do not need to say anything about being the agent. Indexicals, despite the way in which they are normally treated, exhibit behavior that is part of a much more general trend: a kind of anaphoric dependence on features of the extra-linguistic context. Of course, there are a lot of constraints on this kind of anaphoric dependence—as there are on discourse anaphoric dependence—that are not well understood, and we know that extra-linguistic and discourse content do not always pattern together.[20] Nevertheless, the fact that certain expressions that require an antecedent

[20] As one reviewer for this paper pointed out, certain anaphoric expressions or constructions prefer that their antecedents be explicitly given.

(14) a. I dropped ten marbles and found all of them, except for one. *It* is probably under the sofa.

b. I dropped ten marbles and found only nine of them. ∗*It* is probably under the sofa. (Partee/Heim)

(15) a. Every man who has a wife is sitting next to *her*.

b. ∗Every married man is sitting next to *her*. (Elbourne 2005)

Despite the fact that an interlocuter will no doubt conclude after hearing the first sentence of (14b) that there is a single missing marble, *it* cannot refer to this missing marble. And despite the fact that world knowledge would lead someone to conclude that every married man has a wife, (15b) is infelicitous (and would be no better if the example used *her or him* to allow for same sex marriages). Similar observations have been made about *too*:

(16) Sam lives in New York too.

World knowledge to the effect that someone else lives in New York is not sufficient to make an utterance of (16) felicitous; *too* requires its antecedent to be somehow more salient.

Still, *too* does not require that its antecedent be made explicit by the discourse context, as I explained above. Neither does *it*: an utterance of *It is probably under the sofa* can be perfectly felicitous without an explicit antecedent as when the speaker utters this sentence after seeing someone count up the marbles and then start searching around the room. While it is true that the constraints on both extra-linguistic and discourse anaphora

can have this requirement met via the extra-linguistic context without explicit mention in the discourse is clear. Contexts like the ones I am defending here are a powerful and necessary tool for the construction of a full semantics of these expressions.

With the distinction between K_0 and K_1 in place, let's return to (I) and (S). The referential readings of *I* and *the speaker* in (I) and (S), respectively, arise when the definites' presuppositions are bound at K_0. The descriptive reading of (S) arises when the presupposition of the definite description does not go out and attach to a (representation of a) real-world individual; i.e. when it is bound or accommodated at K_1. For the definite description, the difference in interpretation depends on whether or not the rest of the information provided by the sentence in which it figures is about a specific individual or not. When I read a newspaper and it says, "The President of Iran has denied that the Holocaust took place," I get information about a very specific individual. If it had said instead, "Mahmud Ahmadinejad has denied..." or "The President of Iran, Mahmud Ahmadinejad, has denied..." I would have received the same information about the same, specific, real-world individual, although the demands placed on me to figure out who the individual was would have been different. In other cases, as in Kripke-type scenarios for sentences like (S), it is clear that the sentence containing the definite description is not being used to connect new information to an existing store of information about a real world individual. In this case, the definite description can either be bound to a quantifier or an antecedent that is not interpreted at K_0 or it can be accommodated. The difference between indexicals and definite descriptions that is relevant for (I) and (S) comes down in my theory to the fact that indexicals, like some other presuppositional expressions, cannot be accommodated. Why this should be is an interesting question, but I will not pursue an answer here for it would take us too far afield and, moreover, it is a question that everyone working with indexicals has to answer in one guise or another. In Kaplan's theory, for example, the question comes down to why the lexical meanings of indexicals never figure in content_k. In his theory, as in mine, the fact that they don't is treated as a lexical fact and no deeper explanation is offered.[21]

3.2 Rigidity

Rigid interpretations are ensured for discourse referents in K_0 by evaluating K_0 relative to a world taken as actual. The full evaluation procedure is explained in an appendix; I present the basics of the semantics here in order to show how rigidity is secured and how the theory that I am offering differs from a two-dimensional theory of indexicals. We will adopt pointed models of the form $\langle D, I, W, a\rangle$, where D is a domain of individuals, I is an interpretation function, W is a set of worlds, and $a \in W$ is a world that serves as the actual world. In addition to the discourse

need to be better understood, the fact that there are differences in the way that different presuppositional expressions pattern is perfectly in line with the idea of tailored resolution strategies motivating this paper.

[21] A related question, brought up by a reviewer for this paper, is why it should be if we adopt van der Sandt's strategy for definite descriptions that a definite description like *the speaker* does not always bind in K_0, as binding is predicted to be preferable to accommodation at any level. This question, too, is beyond the scope of this paper. My focus is on indexical resolution strategies and I have adopted a simple-minded version of van der Sandt's strategy for definite descriptions for the sake of making my main point about resolution strategies. If the strategies for definite descriptions end up being more complicated than sketched here, that does not necessarily challenge the fundamental claims of the paper.

Nevertheless, the question is an interesting one. The reviewer who raised this question brought up the possibility of an optimality theoretic solution to the effect that refering to the speaker with a definite description is somehow less optimal than using an indexical or demonstrative, which leads to a preference for an unbound reading of the definite description (cf. Zeevat 2000). I suspect that something along these lines is probably true. Here we can look to the referential hierarchy mentioned in section 2.2. All things being equal, *I* provides a better means for referring to oneself than does *the speaker* or similar description. One needs a special reason to use a definite description when an indexical, demonstrative or proper name is available (cf. my principal example in section 2.2).

referents for utterance event features discussed in section 2.1, an utterance event will introduce a discourse referent e_π into K_0 that represents a dedicated utterance event in a as well as a corresponding condition $U(e_\pi)$ where U is a condition that gives the spatio-temporal coordinates of the event represented by e_π. I will adopt a dynamic semantic evaluation procedure so that the evaluation of a DRS K will take place relative to an incoming information state, where an information state is a set of pairs each containing a world and an assignment function. Update of the incoming information state with the content of K will yield an output information state, the nature of which is determined by the incoming information state and the semantics of the conditions contained in K. A successful update is one that yields a non-empty information state as output.

To evaluate a DRS K, we start by evaluating its most global level, K_0, relative to an information state containing a single world-assignment pair: the pair $\langle a, g_\emptyset \rangle$, where a is a privileged world, taken as the actual world, in a pointed model M. The assignment function $g_\emptyset$ is the empty assignment function. Successful update of the information state $\{\langle a, g_\emptyset \rangle\}$ with K_0 will yield the state $\{\langle a, g_a \rangle\}$, where g_a is the anchor function for K_0, i.e. the unique assignment function that satisfies the atomic conditions in K_0 given a. Once the anchor is determined, we proceed with the evaluation of K by moving down through each of its sub-DRSs in order starting with K_1. Evaluation of each sub-DRS will take place in such a way that the assignment to discourse referents in K_0 will be carried down through the evaluation process. That is, for a DRS K_n embedded in K_0, all admissible assignment functions for K_n will be extensions of the anchor function g_a. The general idea, then, is that rigidity for a discourse referent in K_0 will be ensured by fixing the value of the discourse referent relative to a and then ensuring that this value cannot be affected by the evaluation of sub-DRSs below K_0.[22]

Evaluation of each subcontext K_n of K_0 will proceed as is standard in dynamic semantics. That is, evaluation of each subDRS will transform an incoming information state—a set of world-assignment pairs—via operations determined by the semantics of the conditions in K_n.[23] For example, evaluation of a DRS K_m in the scope of a negation will require looking at all of the world-assignment pairs in the incoming context that could be successfully updated with K_m and then discarding those possibilities so that update with $\neg K_m$ yields the set of only those pairs from the incoming context that would not verify K_m. In order to evaluate a condition of the form $\Box K_m$, on the other hand, we first shift to consideration of the the modal alternatives of the possibilities available in the incoming context, i.e. the set of world assignment pairs $\langle w', f \rangle$ such that wRw' for $\langle w, f \rangle$ in the incoming context. Update with $\Box K_m$ will return the set of pairs $\langle w, f \rangle$ from the incoming context such that $\langle w', f \rangle$, where wRw', can be successfully updated with K_m. Thus update with $\Box K_m$ returns only those world assignment pairs whose modal alternatives support update with K_m. Evaluation of K_1 will require a similar modal extension of the incoming information state $\{\langle a, g_a \rangle\}$. In order to evaluate K_1, we shift to consideration of all of the modal alternatives to a; that is, the set of pairs $\langle w, g_a \rangle$ such that aRw. Evaluation of the conditions in K_1 then takes place relative to this set of alternatives. The shift from K_0 to K_1 reflects the idea that a sentence must ultimately be evaluated relative to a whole set of possible worlds.

[22]It is possible for someone who has been looking at his reflection in the mirror not realizing that the reflection was his own to finally realize, *hey, I am that man!*. The evaluation procedure laid out here does not capture the epistemic state of the speaker before or after his realization but only the semantic value of his utterance. If one is interested in capturing the epistemic state of the speaker, one should adopt non-pointed models and let the reference-fixing conditions in K_0 vary in their interpretations from one world of evaluation to another.

[23]The semantics that I will adopt differ from those of standard DRT in that evaluation is dynamic and takes place relative to sets of world-assignment pairs. The fact that evaluation takes place relative to a set of world-assignment pairs, as opposed to a single world-assignment pair, is also a point of difference between the semantics that I will offer and standard DPL. Again, the details of the semantics are given in the Appendix.

The treatment of rigidity that I am offering here is importantly different from that offered by a two-dimensional theory. While I use a world designated as the actual world for the evaluation of K_0, evaluation of K_0 does not require a special evaluation procedure. We start with a single world-assignment pair for update with K_0 but update relative to this pair proceeds normally: the assignment function $g_\emptyset$ is extended and update can even fail, leading to the elimination of a. When we move from K_0 to K_1, we move to consideration of all worlds accessible to a, not just a. This may look like a special move, but it is not. When we update with modals, we also change the set of world-assignment pairs before updating with content in the scope of the modal. So while a in each model M is a privileged world, it doesn't follow that evaluation of K_0 gives us a different kind of meaning in the way that Kaplan's character was meant to be a different kind of meaning from his content. Finally, because my models are pointed, I don't have a second 'dimension' of content. Moving along a dimension of contexts or worlds other than that used for evaluation is impossible.[24]

4 Conclusion: from character to presupposition

Once we adopt a presuppositional theory, we no longer need a two-dimensional semantics for indexicals, contra Maier (2006, 2009). Moreover, data like those discussed in §2.3 strongly suggest that we should resist a two-dimensional theory because they do not conform to a claim like Hypothesis L, which provides the main motivation for a two-dimensional theory. That presuppositions can fully replace Kaplanian characters is no surprise if we view Kaplan's theory through the lens of a presuppositional one. In fact, from the point of view of the theory I am offering here, Kaplan's account of indexicals can be recast as a rudimentary presuppositional view. In Kaplan's system, too, each indexical is associated with a context-invariant linguistic meaning that never shows up in truth-conditional content but serves only to pick out an individual that fits the property denoted by the linguistic meaning. Should a context serving as input to a character function fail to provide a referent for an indexical token, the token will not contribute an individual to content_k. The content_k will therefore be incomplete and the question of truth or falsity will not arise. Although Kaplan designs his contexts so that reference failure is never an issue, such failure can easily arise for *you* and the demonstratives, as well as demonstrative uses of *here* and third person pronouns, so a full semantic theory of indexicals cannot ignore it. The linguistic meanings of indexicals in Kaplan's system are like presuppositions with a very special resolution strategy, that given by $\Uparrow$, and his K_0 is limited to information about utterance events (and demonstrata). Kaplan's indexical meanings can therefore be viewed as a special case in the much more general and flexible presuppositional account that I have presented.

I have modeled the tendency of indexicals to bind to features determined by utterance events with the $\uparrow$ and $\Uparrow$ operators. Ultimately, a more complete theory would offer a deeper explanation of when different indexicals will bind in K_0 and when they will bind in other contexts; however, $\uparrow$ and $\Uparrow$ suffice for the purposes at hand. They represent the fact that indexical presuppositions prefer, though they do not all require, resolution in K_0—a strategy that is not exhibited by other definites. To the extent that indexicals form a unified, semantically interesting class, it

[24] One might worry that ensuring rigidity for all discourse referents in K_0 yields a rigid interpretation for too many noun phrases. What's to stop an indefinite noun phrase from finding its way to K_0 and receiving a rigid interpretation, for example? I assume that in general, an indefinite leaves open a choice as to which individual it picks out and so its value should be left to vary from one world of evaluation to another. This is the result that we get if we distinguish K_0 from K_1: if we assume that indefinites are not presuppositional, then they will not project up to K_0 but will rather be evaluated *in situ*, meaning at K_1 or below, as desired. One might wish to allow certain specific uses of indefinites to be evaluated in K_0. I remain agnostic about how this could work and assume that in general the use of an indefinite indicates that a specific interpretation is not required.

is not because because they must all rigidly designate individuals in the extra-linguistic context or because they all have lexical meanings that cannot interact with the contents of other expressions. Indexicals are interesting because they do not make novel contributions to truth-conditional or update content despite having a fairly robust linguistic meaning, because their interpretive options are more restricted than, say, those of third person pronouns, and because they bring with them a certain 'perspective' that is not found with many other kinds of expressions. Even when used anaphorically, indexicals have the effect of centering the discourse, bringing the addressee/reader somehow 'closer' to the event or state being described.[25] My aim in this paper has been to show that we can capture the interpretive possibilities of indexicals without building something like a special dimension of meaning into their semantics. A deeper explanation of why indexicals require binding, and prefer binding in K_0, and why they carry a certain perspective is needed, but such an explanation will not challenge the argument that I have given here.

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Appendix: the Graph Semantics

Although I have presented my proposal in the language of DRT, I will move away from DRT's semantics in favor of a relational dynamic semantics which I will implement using graphs. While the semantics could be implemented in DRT, the treatment that I offer here is more general in that it is not tied to a particular representational language like DRT. I think that it is also more intuitive than the DRT-based treatment offered in Hunter & Asher (2005).[26] For those

[25] In Hunter (2012), I argue that *now* always depends on the topic time—the "now" of the discourse. Other expressions, like *she* and *then*, which are similar to indexicals in many ways, are not so constrained in where they can find their antecedents. This may partially explain why these latter expressions do not have the same centering effect, though the perspective carrying feature often assumed to go with indexicals admittedly deserves closer examination. It may be that perspective is not always associated with indexicals—*here* used demonstratively is a good candidate counterexample—but rather with certain uses of indexicals. Still, the perspective so often observed with indexicals is pronounced enough to deserve inclusion here pending further study.

[26] The semantics presented in this appendix grew out of the account offered in Hunter & Asher (2005), which built on ideas developed in van der Sandt (1992). Hunter & Asher, however, took a much more syntactic approach, in effect defining the semantics of the operator $\uparrow$ relative to a DRS instead of a model theoretic entity, as I will do here. To define $|\vdash$, Hunter & Asher simplified binding to a notion of DRS satisfaction $\models$ and accommodation as incorporation of a presupposition ϕ into a DRS $K|\!>\phi$. Let $K_0, \ldots, K_n$ be a sequence beginning with the global DRS K_0 such that $K_0 \geq \ldots \geq K_n$, and $\geq$ is the immediate superordination relation on DRSs. Then, $K_0, \ldots K_{l-1}, [K_l, \ldots K_n] \models \phi$ iff ϕ is a dynamic consequence of $K_l, \ldots K_n$ relative to any assignment to free variables occurring in $K_l, \ldots K_n, \phi$ that are declared in $K_0, \ldots K_{l-1}$ and satisfy the conditions in $K_0, \ldots K_{l-1}$. Then:

- $K_0, \ldots, K_i|\vdash\phi$ iff $\exists j \leq i$ and $\exists l \geq 0$ such that $K_0, \ldots K_{l-1}, [K_l, \ldots K_j] \models \phi$ or for some k, $0 \leq k \leq j$, $K_k|\!>\phi$, for ϕ a normal DRS or DRS condition.

familiar with Zeevat (1992)'s update semantics for stacks of information states, there are some important similarities between his account and mine. However, the accounts are not identical. For one thing, Zeevat does not countenance anything like K_0 and does not deal with rigidity. Another important difference is that my account uses graphs instead of stacks.

An exploration of the advantages and applications of graphs is beyond the scope of this paper but I will mention a few positive points before turning to the implementation of graphs. First, the graph semantics, like Zeevat's stack semantics, makes it clear that I am not positing movement of lexical material in order to get the interpretations of indexicals to come out as desired. Indexicals simply have two components to their content that contribute to the overall structure of a discourse in two different ways: the function of the non-$\Uparrow/\uparrow$-sensitive contents of indexicals is to build on the discourse, while the function of the $\Uparrow/\uparrow$-sensitive content is to make sure it is built up in the right place.

Two potential applications for graphs would be updating subordinate contexts and modeling the rhetorical structure of a discourse. Zeevat (1998) argues that stacks are particularly well-suited for updating subordinate contexts. His arguments would apply equally to graphs. In Hunter (2012) I argue that the interpretation of a discourse anaphoric use of *now* depends on the rhetorical structure of the discourse in which the occurrence of *now* figures and I implement my proposal in *Segmented Discourse Representation Theory* (Asher & Lascarides 2003) which makes use of graphs (rather than structures like stacks).[27]

Overview of Graph Semantics

The semantic value of a DRS will be a relation between sets of information states as is standard for a dynamic semantic approach. A graph strings out the interpretation of a DRS into a sequence of operations on information states. A graph G is a tuple $\langle G_n, <_G \rangle$. $G_n = \{\mathbf{0}, \ldots, \mathbf{n}\}$, for $n \in Nat$, is the set of nodes in the graph. $<_G$, the set of arcs in the graph, is a transitive preorder on G_n. Our graphs will be decorated such that a node $\mathbf{n}$ in a graph G will be labeled $\mathbf{n}_{f_G}$, where f_G is a function that maps each node in the graph G to a state (a set of world-assignment pairs). For a DRS K, each state in the decorated graph $\langle G, f_G \rangle$ for K will be the *output value* of a sub-DRS of K. An output value of a DRS K is the output information state from the semantic value of K, where the semantic value of K is a relation between information states. $<_G$ yields a tree structure, i.e. each graph G has a root node $\mathbf{0}$ ($\mathbf{0}_{f_G}$ with its decoration) and for each $\mathbf{n}$ in G, $n > 0$, $\mathbf{n}$ has a unique mother node.

Because our graphs will reflect the structure of DRSs, I first provide an example and its simplified DRS to illustrate how DRSs will be labeled. I omit some discourse referents and conditions for the utterance event to improve the readability of the DRS.

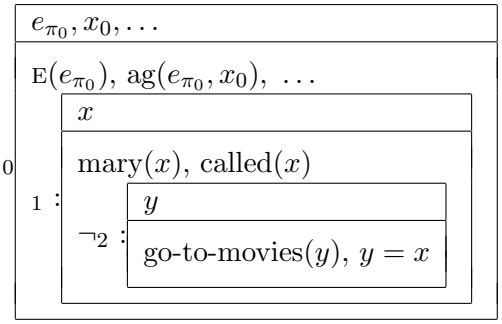
(17) Mary called. She is not going to the movies.

- $K_0, \ldots, K_i | \vdash \uparrow \phi$ iff there is some $j \leq i$ such that $K_0, \ldots K_j | \vdash \phi$ and there is no $k < j$ such that $K_0, \ldots, K_k | \vdash \phi$

Informally, a presupposition is resolvable in a sequence of contexts just in case some subsequence entails the presupposition or it is accommodated at some element in the sequence. Resolving the presupposition means choosing some witness for the existential quantifier. The clause for $\uparrow \phi$ then forces the binding or accommodation of ϕ in the outermost context possible.

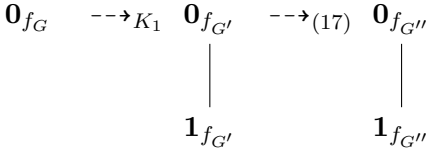
[27] The graphs used in this appendix are a simplification of those used in SDRT because they do not encode discourse relations and do not, therefore, distinguish between subordinating and coordinating relations or their semantic effects. The graphs presented here could nevertheless be made as complex as those used in SDRT.

(17')



K_0 is the global DRS, K_1 is immediately subordinate to K_0, and K_2 is immediately subordinate to K_1. In a decorated graph $\langle G, f_G \rangle$, $\mathbf{0_{f_G}}$ will label the state that is the output value of K_0, $\mathbf{1_{f_G}}$, the state that is the output value of K_1, and $\mathbf{2_{f_G}}$, the state that is the output value of K_2.

The root node $\mathbf{0}_{f_G}$ of a decorated graph $\langle G, f_G \rangle$ for a DRS K is determined by updating the pair $\langle a, g_\emptyset \rangle$ with the content of K_0. The function $g_\emptyset$ is the empty assignment function. Update with K_0 yields the pair $\langle a, g_a \rangle$ where g_a is the unique assignment that satisfies the atomic conditions of K_0 at a. Once g_a has been determined, the recursion carries this assignment through for the evaluation of all levels below K_0. The output assignment function g_a for K_0 constrains the interpretation of K_1: adding content from K_1 triggers the extension of our decorated graph to include a state $\mathbf{1}_{f_{G'}}$ in an updated graph $\langle G', f_{G'} \rangle$ that is exactly like $\langle G, f_G \rangle$ except that it has state $\mathbf{1}_{f_{G'}}$, which is a daughter of state $\mathbf{0}_{f_{G'}}$ $(= \mathbf{0}_{f_G})$, and state $\mathbf{1}_{f_{G'}}$ is the set of all world-assignment pairs $\langle w, g_a \rangle$ such that aRw. Update of the conditions in K_1 then takes place at state $\mathbf{1}_{f_{G'}}$. The figures below provide an illustration of how the move from K_0 to K_1 in (17) affects the decorated graph for (17). The dashed arrows indicate the update from one decorated graph to another and their subscripts indicate what triggered the update (the move to K_1, update with (17), etc.). For simplicity, I consider only the first sentence of (17); the second sentence, because it contains a negation, triggers the construction of the sub-DRS K_2 of K_1 and would, as a result, trigger the construction of an additional state in our decorated graph.

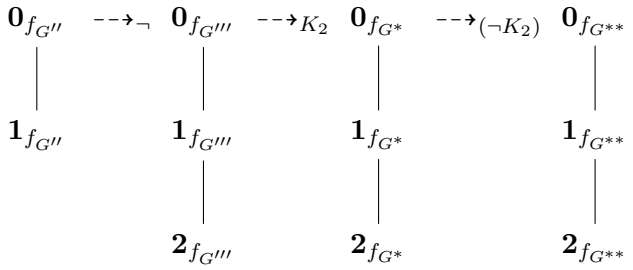


Again, $\mathbf{0}f_G = \{\langle a, g_a \rangle\}$ and $\mathbf{1}f_{G'} = \{\langle w, g_a \rangle \mid aRw\}$. $\mathbf{1}_{f_{G''}}$ will be the set of world assignment pairs that survive update with the sentence *Mary called*, i.e. those world-assignment pairs $\langle w, g_a \rangle$ from $\mathbf{1}_{f_{G'}}$ such that the denotation of *Mary* falls in the extension of *called* at w given some model M.

As explained above, when we move to K_1 we move to consideration of the modal alternatives of the actual world, which is what is offered by standard dynamic theories that do not handle rigidity. This is why we can handle the Kripke reading of (S) even though (S) is a simple sentence: once we move to consideration of all accessible possibilities, we can consider worlds w in which, say, whoever is speaking in w is speaking in w. Although (S) does not contain a modal operator, or any sort of hidden operator, it is clear that on a Kripke-style reading of (S), we are meant to consider possibilities, not reference to whoever is actually speaking in a.

Evaluation of the second sentence in (17) will lead to a vertical extension of the decorated graph $\langle G'', f_{G''} \rangle$; that is, it will lead to the addition of an arc and node in an updated graph $\langle G''', f_{G'''} \rangle$ which is just like $\langle G'', f_{G''} \rangle$ except that it has a node **2** which is a daughter of **1**.

$\mathbf{2}_{f_{G'''}}$ will initially be a copy of $\mathbf{1}_{f_{G'''}}$—this extension is triggered by the negation alone. Then once the decorated graph has been extended, the resulting state $\mathbf{2}_{f_{G'''}}$ will be updated with the content of K_2, yielding a decorated graph $\langle G^*, f_{G^*}\rangle$ which is just like $\langle G'', f_{G''}\rangle$ apart from the update at state $\mathbf{2}_{f_{G''}}$. Finally, we update $\mathbf{1}_{f_{G^*}}$ by subtracting from it all world-assignment pairs that can be extended to a pair $\langle w', h\rangle$ in $\mathbf{2}_{f_{G^*}}$. The output is a decorated graph $\langle G^{**}, f_{G^{**}}\rangle$ that is like $\langle G^*, f_{G^*}\rangle$ except at state $\mathbf{1}_{f_{G^{**}}}$. Thus the output value that would result from updating $\mathbf{1}_{f_{G''}}$ with K_2 is used to determine the output value of the update with $\neg\mathrm{K}_2$ as expected. Using the decorated graph $\langle G'', f_{G''}\rangle$ from above as our input graph, update with the second sentence of (17) will therefore affect our decorated graph as shown in the following pictures.

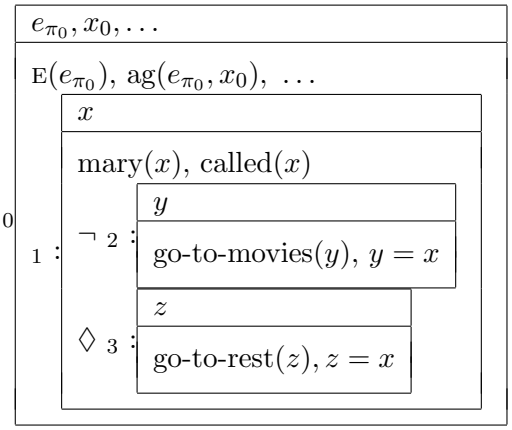


The evaluation of a decorated graph $\langle G, f_G\rangle$ should be understood relative to a model M. Our models will be $\langle D, I, W, a\rangle$ tuples, where D is a domain of individuals, I is an interpretation function, W is a set of worlds, and $a \in W$ is a world that serves as the actual world.

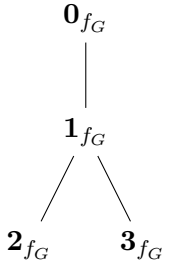
If a DRS K_j contains n complex conditions, a decorated graph $\langle G, f_G\rangle$ for K_j will contain n daughters for the corresponding state $\mathbf{j}_{f_G}$. In this case, we will number the DRSs in the order in which they are evaluated. For example, we could subscript the sub-DRSs for (18) as in (18'). The corresponding decorated graph is given in (18")

(18) Mary called. She is not going to the movies but she might go to the restaurant.

(18')



(18")



The Graph Semantics

I turn now to a more formal explication of the graph semantics introduced in the previous section, first introducing some general definitions relevant to the structure and construction of graphs and then moving onto the semantics.

A graph reflects DRT's accessibility relation—a transitive, reflexive, asymmetric relation that holds between DRSs and, indirectly, between discourse referents. Let K′ and K″ be sub-DRSs within a DRS K. If Con_K, the set of conditions in K, contains a condition of the form:

- ¬K′, then K is accessible to K′
- K′∨ K″, then K is accessible to K′ and K″
- K′ ⇒ K″, then K is accessible to K′ and K′ is accessible to K″
- □K′, then K is accessible to K′

Let A_K be the *accessible domain* of a DRS, i.e., $\text{A}_K = \{x : \text{K}' \text{ is accessible to K and } x \in U_{K'}\}$ (where U_K is the universe of K). Any discourse referent in a DRS K that must be anaphorically bound to another discourse referent—pronouns are the paradigm case, but I am extending this notion to indexicals—can find an antecedent only in its accessible domain A_K.

Let a DRS K_j be accessible to another DRS K_m. The output values of K_j and K_m in a decorated graph $\langle G, f_G\rangle$ will be states $\mathbf{j}_{f_G}$ and $\mathbf{m}_{f_G}$ such that $\mathbf{j}_{f_G}$ is either the mother of $\mathbf{m}_{f_G}$ or it is the mother of the mother, or the mother of the mother of the mother, and so on. In other words, for a state $\mathbf{m}_{f_G}$ in our graph, we will be able trace a line to the top state $\mathbf{0}_{f_G}$, and every state that lies on this line starting at $\mathbf{m}_{f_G}$ will count as an accessible state to $\mathbf{m}_{f_G}$. Thus,

- For a decorated graph $\langle G, f_G\rangle$ and DRSs K_j and K_m with output values $\mathbf{j}_{f_G}$ and $\mathbf{m}_{f_G}$, respectively, K_j is accessible to K_m just in case $\mathbf{j}_{f_G}$ is an ancestor of $\mathbf{m}_{f_G}$.

Our decorated graphs will ensure that the interpretation of a subDRS K_m will depend on assignments to discourse referents declared in superordinate DRSs but free in K_m.

A decorated graph $\langle G, f_G\rangle$ can be successfully updated with a DRS K at a state $\mathbf{i}$ to yield a decorated graph $\langle G', f_{G'}\rangle$ just in case (a) each world assignment pair $\langle w', g'\rangle$ in $\mathbf{i}_{f_{G'}}$ extends the assignment g from a $\langle w, g\rangle$ pair in $\mathbf{i}_{f_G}$ such that g' assigns a value to each of the discourse referents in K and (b) $\langle G', f_{G'}\rangle$ results from updating $\langle G, f_G\rangle$ at $\mathbf{i}$ with each of the conditions γ of K.

1. $\langle G, f_G\rangle[\![\text{K}]\!]_i\langle G', f_{G'}\rangle$ iff for all $\langle w', g'\rangle \in \mathbf{i}_{f_{G'}}$ there is a $\langle w, g\rangle \in \mathbf{i}_{f_G}$ such that $g \subseteq_K g'$ (i.e., $dom(g') = dom(g) \cup \{\text{DM}_K\}$), where DM_K is the set of discourse referents in K, and for all $\gamma \in Con(\text{K})$, $\langle G, f_G\rangle[\![\gamma]\!]_i\langle G', f_{G'}\rangle$

There are two ways of extending a decorated graph $\langle G, f_G\rangle$, both of which were introduced in our discussion of (17) above. A non-modal condition will extend the graph at a node $\mathbf{i}$ by adding a daughter $\mathbf{j}$ of $\mathbf{i}$ such that $\mathbf{j}$ is a copy of $\mathbf{i}$. This extension produces a new decorated graph $\langle G', f_{G'}\rangle$ such that the set of nodes in G' is the set of nodes in G, i.e. G_n, together with $\mathbf{j}$ and the set of arcs in G' is the set of arcs of G together with the arc between $\mathbf{i}$ and $\mathbf{j}$. The decoration function f_G is also extended so that it assigns $\mathbf{j}$ to the same state that it assigns $\mathbf{i}$ to. Once the graph has been appropriately extended, it is updated at $\mathbf{j}$ with the content of the condition, according to the semantics detailed below.[28] The result is a decorated graph $\langle G'', f_{G''}\rangle$.

[28]The extension and update of the graph could perhaps be done in one step, but separating the steps makes the distinction between intensional and extensional vertical extension clearer and is helpful for intensional vertical extension, which requires first moving to the set of worlds accessible to a world w' and then updating that set.

2. EXTENSIONAL VERTICAL EXTENSION for $\mathbf{i} \in G_n$, $\mathbf{j} \notin G_n$:
$\langle G, f_G\rangle \sqcap_{i,j,K} \langle G'', f_{G''}\rangle$ iff

   (a) $\exists\langle G', f_{G'}\rangle\ G' = \langle G_n \cup \{\mathbf{j}\}, <_G \cup \{\langle \mathbf{i}, \mathbf{j}\rangle\}\rangle$,
   (b) $f_{G'} = f_G \cup \langle \mathbf{j}, \mathbf{i}_{f_G}\rangle$ and
   (c) $\langle G', f_{G'}\rangle [\![K]\!]_j \langle G'', f_{G''}\rangle$

A modal condition will extend a decorated graph $\langle G, f_G\rangle$ at a node $\mathbf{i}$ in a similar fashion. The main difference between extensional and intensional extension is that $\mathbf{j}_{f_{G'}}$, daughter of $\mathbf{i}_{f_{G'}}$, will not be a copy of its mother state but rather the set of modal alternatives of its mother state, i.e. the set of all world-assignment pairs $\langle w, g\rangle$ such that $w'Rw$ for $\langle w', g\rangle$ in $\mathbf{i}_{f_{G'}}$ $(= \mathbf{i}_{f_G})$. Update with the modal formula will then take place at $\mathbf{j}_{f_{G'}}$ relative to this set of alternatives to yield a decorated graph $\langle G'', f_{G''}\rangle$.

3. INTENSIONAL VERTICAL EXTENSION for $\mathbf{i} \in G_n$, $\mathbf{j} \notin G_n$:
$\langle G, f_G\rangle \sqcap_{i,j,\wedge K} \langle G'', f_{G''}\rangle$ iff

   (a) $\exists\langle G', f_{G'}\rangle\ G' = \langle G_n \cup \{\mathbf{j}\}, <_G \cup \{\langle \mathbf{i}, \mathbf{j}\rangle\}\rangle$,
   (b) $f_{G'} = f_G \cup \langle \mathbf{j}, \{\langle w, g\rangle\ |\exists\langle w', g\rangle \in \mathbf{i}_{f_G},\ w'Rw\}\rangle$ and
   (c) $\langle G', f_{G'}\rangle [\![K]\!]_j \langle G'', f_{G''}\rangle$

Extension to K_1 is defined as an instance of intensional vertical extension.

4. EXTENSION TO K_1:
$\langle G, f_G\rangle \sqcap_{0,1,\wedge T} \langle G'', f_{G''}\rangle$, where T is a logical truth.

The following notion of the restriction of an information state will also be exploited by the graph semantics.

5. $(\mathbf{i}/\mathbf{j})_{f_G} = \{\langle w, g\rangle \in\ \mathbf{i}_{f_G} \mid \exists\langle w', g'\rangle \in\ \mathbf{j}_{f_G}$ such that $wRw' \wedge g \subseteq g'\}$

In (4), the state $(\mathbf{i}/\mathbf{j})_{f_G}$ is a substate of $\mathbf{i}$, namely the state that consists of those pairs $\langle w, g\rangle$ in $\mathbf{i}$ that are such that w' is accessible to w and the assignment function g can be extended to an assignment function g' for $\langle w', g'\rangle$ in $\mathbf{j}$.

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Where γ has one of the following forms:

1. $\langle G, f_G\rangle [\![R(x_1, \ldots, x_n)]\!]_i \langle G', f_{G'}\rangle$ iff

   (a) $G = G'$,
   (b) $f_{G'} = f_G \frac{\mathbf{i}_{f_G}}{\mathbf{i}_{f_G}[R(x_1,\ldots,x_n)]}$ and
   (c) $\mathbf{i}_{f_G}[R(x_1, \ldots, x_n)] = \{\langle w, g\rangle \in \mathbf{i}_{f_G} \mid \langle [\![x_i]\!]^g, \ldots, [\![x_n]\!]^g\rangle \in I^w(R)\}$

2. $\langle G, f_G\rangle [\![x = y]\!]_i \langle G', f_{G'}\rangle$ iff

   (a) $G = G'$,
   (b) $f_{G'} = f_G \frac{\mathbf{i}_{f_G}}{\mathbf{i}_{f_G}[x=y]}$ and
   (c) $\mathbf{i}_{f_G}[x = y] = \{\langle w, g\rangle \in \mathbf{i}_{f_G} \mid [\![x]\!]^{w,g} = [\![y]\!]^{w,g}\}$

3. $\langle G, f_G\rangle [\![\neg \mathrm{K}]\!]_i \langle G', f_{G'}\rangle$ iff
   (a) $\exists \langle G'', f_{G''}\rangle$, $\langle G, f_G\rangle \sqcap_{i,j,K} \langle G'', f_{G''}\rangle$ and
   (b) $f_{G'} = f_{G''} \frac{\mathbf{i}_{f_{G''}}}{\mathbf{i}_{f_{G''}} - (\mathbf{i}/\mathbf{j})_{f_{G''}}}$
4. $\langle G, f_G\rangle [\![\mathrm{K} \vee \mathrm{K}']\!]_i \langle G', f_{G'}\rangle$ iff
   (a) $\exists \langle G^+, f_{G^+}\rangle, \langle G, f_G\rangle \sqcap_{i,j,K} \langle G^+, f_{G^+}\rangle$,
   (b) $\exists \langle G'', f_{G''}\rangle, \langle G^+, f_{G^+}\rangle \sqcap_{i,k,K'} \langle G'', f_{G''}\rangle$ and
   (c) $f_{G'} = f_{G''} \frac{\mathbf{i}_{f_{G''}}}{\mathbf{i}_{f_{G''}} \cap ((\mathbf{i}/\mathbf{j})_{f_{G''}} \cup (\mathbf{i}/\mathbf{k})_{f_{G''}})}$
5. $\langle G, f_G\rangle [\![\mathrm{K} \Rightarrow \mathrm{K}']\!]_i \langle G', f_{G'}\rangle$ iff
   (a) $\exists \langle G^+, f_{G^+}\rangle, \langle G, f_G\rangle \sqcap_{i,j,K} \langle G^+, f_{G^+}\rangle$,
   (b) $\exists \langle G'', f_{G''}\rangle, \langle G^+, f_{G^+}\rangle \sqcap_{j,k,K'} \langle G'', f_{G''}\rangle$ and
   (c) (c) $f_{G'} = f_{G''} \frac{\mathbf{i}_{f_{G''}}}{\mathbf{i}_{f_{G''}} \cap ((\mathbf{i}_{f_{G''}} - (\mathbf{i}/\mathbf{j})_{f_{G''}}) \cup ((\mathbf{i}/\mathbf{j})_{f_{G''}}/\mathbf{k})_{f_{G''}})}$
6. $\langle G, f_G\rangle [\![\Box \mathrm{K}]\!]_i \langle G', f_{G'}\rangle$ iff
   (a) $\exists \langle G'', f_{G''}\rangle, \langle G, f_G\rangle \sqcap_{i,j,\wedge K} \langle G'', f_{G''}\rangle$ and
   (b) $f_{G'} = f_{G''} \frac{\mathbf{i}_{f_{G''}}}{\mathbf{i}_{f_{G''}} \cap (\mathbf{i}/\mathbf{j})_{f_{G''}}}$

$f_{G'} = f_G \frac{\mathbf{i}_{f_G}}{\mathbf{i}_{f_G}[\gamma]}$ means that $f_{G'}$ is like f_G except that state $\mathbf{i}_{f_{G'}}$ results from substituting for $\mathbf{i}_{f_G}$ the output of the update of $\mathbf{i}_{f_G}$ with the formula γ.

Adding Presupposition, $\Uparrow$, and $\uparrow$

Let K_{p_n} be the DRS for a presupposition triggered in a DRS K_n for some n and let $\langle G, f_G\rangle$ be the input graph for update with K_n. Before the graph can be updated with K_n in its entirety, we must resolve the content in K_{p_n} in the input graph. Binding of the content in K_{p_n} is understood in terms of binding at a state $\mathbf{n}_{f_G}$ in a graph $\langle G, f_G\rangle$, i.e. $\langle G, f_G\rangle, \mathbf{n}_{\mathbf{f_G}} |\vdash K_{p_n}$. Accommodation will be understood as the incorporation of the presupposition K_{p_n} into a state $\mathbf{n}_{f_G}$ of $\langle G, f_G\rangle$, i.e. $\langle G, f_G\rangle, \mathbf{n}_{\mathbf{f_G}} |\!> K_{p_n}$. For any DRS K, let U_K be the universe of K, i.e., the set of all discourse referents that are introduced in K. The general definitions for binding or accommodation at a state $\mathbf{n}_{f_G}$ are as follows:

- Binding at a state $\mathbf{n}_{\mathbf{f_G}}$ in a decorated graph $\langle G, f_G\rangle$ for a DRS K
  - $\langle G, f_G\rangle, \mathbf{n}_{\mathbf{f_G}} |\vdash \mathrm{K}$ iff $\langle G, f_G\rangle [\![\mathrm{K}]\!]_n \langle G', f_{G'}\rangle$ and $\forall x \in U_K, \forall \langle w, g\rangle \in \mathbf{n}_{f_G}, \exists y \in dom(g)$ such that $\exists \langle w, h\rangle \in \mathbf{n}_{f_{G'}} \wedge h(y) = h(x)$
- Accommodation at a state $\mathbf{n}_{\mathbf{f_G}}$ in a decorated graph $\langle G, f_G\rangle$ for a DRS K
  - $\langle G, f_G\rangle, \mathbf{n}_{\mathbf{f_G}} |\!> \mathrm{K}$ iff $\langle G, f_G\rangle [\![\mathrm{K}]\!]_n \langle G', f_{G'}\rangle$ and $\mathbf{n}_{f_{G'}} \neq \emptyset$

In words, the condition for binding says that a presupposition represented by a DRS K is bound at $\mathbf{n}_{\mathbf{f_G}}$ in a decorated graph $\langle G, f_G\rangle$ just in case each assignment g in $\mathbf{n}_{f_G}$ can be extended to an assignment h such that h identifies each discourse referent in the universe of K with some old discourse referent already in the domain of g. The condition for accommodation says that a presupposition represented by a DRS K is accommodated at $\mathbf{n}_{\mathbf{f_G}}$ in a decorated graph $\langle G, f_G\rangle$ just in case update with K at $\mathbf{n}_{\mathbf{f_G}}$ yields a consistent output $\langle G', f_{G'}\rangle$.

In van der Sandt's system, if a presupposition is triggered in K_n we first try binding at $\mathbf{n}_{f_G}$ and then if that fails, we move up to the mother of $\mathbf{n}_{f_G}$ and so on up to $\mathbf{0}_{f_G}$. If binding fails, accommodation is attempted at $\mathbf{0}_{f_G}$ and if that fails, we try accommodation at a daughter of $\mathbf{0}_{f_G}$ that is an ancestor of $\mathbf{n}_{f_G}$ and so on down to $\mathbf{0}_{f_G}$. If neither binding nor accommodation of the presupposed material is possible, the presupposition fails and update is undefined.

$\Uparrow$ and $\uparrow$ require binding at a particular state $\mathbf{m}_{f_G}$ in a decorated graph $\langle G, f_G\rangle$. $\Uparrow$ forces binding at $\mathbf{0}_{f_G}$ for a decorated graph $\langle G, f_G\rangle$; if binding at $\mathbf{0}_{f_G}$ is not possible, then update with the content of the presupposition is undefined. $\uparrow$ requires that material in its scope be bound at $\mathbf{0}_{f_G}$ when possible but allows that in certain circumstances, it can bind at a lower state. To incorporate $\Uparrow$ and $\uparrow$ in our semantics, we add the relevant clauses for conditions (to the standard set assumed for the semantics given above) and the clauses for accessibility.

- – If K is a DRS, then $\uparrow$K is a DRS condition.
  – If K is a DRS, then $\Uparrow$K is a DRS condition.
- – If K is a DRS and Con_K contains a condition $\uparrow$K′, then K is accessible to K′.
  – If K is a DRS and Con_K contains a condition $\Uparrow$K′, then K is accessible to K′.

In what follows, I will make the simplifying assumption that there is only a single utterance in the context.

The semantics for $\uparrow$ and $\Uparrow$ extend the basic relational semantics, as follows.

7. $\langle G, f_G\rangle, \mathbf{n_G}|\vdash \uparrow$K iff $\langle G, f_G\rangle[\![\mathrm{K}]\!]_n\langle G', f_{G'}\rangle$ and $\forall x \in U_K, \forall\langle w, g\rangle \in \mathbf{n}_{f_G}, \exists y \in dom(g)$ such that $\exists\langle w, h\rangle \in \mathbf{n}_{f_{G'}} \wedge h(y) = h(x)$ and there is no $\langle G'', f_{G''}\rangle$, $\langle G, f_G\rangle[\![\mathrm{K}]\!]_m\langle G'', f_{G''}\rangle$, $\mathbf{m} < \mathbf{n}$ such that $\forall x \in U_K, \forall\langle w, g\rangle \in \mathbf{m}_{f_G}, \exists y \in dom(g)$ such that $\exists\langle w, h\rangle \in \mathbf{m}_{f_{G''}} \wedge h(y) = h(x)$
8. $\langle G, f_G\rangle, \mathbf{n_G}|\vdash \Uparrow$K iff $\langle G, f_G\rangle[\![\mathrm{K}]\!]_0\langle G', f_{G'}\rangle$ and $\forall x \in U_K, \forall\langle w, g\rangle \in \mathbf{0}_{f_G}, \exists y \in dom(g)$ such that $\exists\langle w, h\rangle \in \mathbf{0}_{f_{G'}} \wedge h(y) = h(x)$

In words, (7) says that successful update with a condition of the form $\uparrow$K requires that the content of K be satisfied in a state $\mathbf{n}_{f_G}$ in the incoming graph $\langle G, f_G\rangle$ and that there be no higher information state that satisfies K. If this cannot be done, then K is not satisfiable. Thus, K will, if satisfiable at all, be satisfied by the highest information state possible in the output graph. (8) says that successful update with a condition of the form $\Uparrow$K requires that the content of K be satisfied at $\mathbf{0}_{f_G}$ for an input graph $\langle G, f_G\rangle$. If this cannot be done, then K is not satisfiable.

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