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Counterfactual Attitudes and Assignment-Sensitivity

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1. Introduction

I can imagine that Obama lost the 2008 US presidential election even though I know that he won. It might make sense for me to imagine this if, for example, I am trying to work out what would have happened to the auto industry if Obama had lost. Counterfactual attitudes are, roughly, attitudes that one can coherently take towards a content p even when one knows that p is false. In addition to imagining, the class of counterfactual attitudes includes dreaming, wishing, and hoping.

This paper concerns sentences that report *de re* attitudes, with particular attention to those that report counterfactual *de re* attitudes:

1. (a) Ralph imagined that Ortcutt was flying a kite.
   (b) Ralph wished that she had not opened the box.

I show that counterfactual attitudes cause a problem for the approach to *de re* attitude ascription standardly assumed in the formal semantics literature (Cresswell and von Stechow 1982), an approach based on Lewis's (1979; 1983a) centred worlds account of *de se* and *de re* attitudes.

In response to this problem, I explore an alternative account, one on which attitudinal alternatives are represented by *sequenced worlds*, worlds with multiple centres. I first show how this approach gets the truth conditions of counterfactual attitude reports right, and then examine how one might construct a compositional semantics that generates these truth conditions. The semantics I present is based on the idea that pronouns, indexicals, and proper names are essentially *variables*: their semantic values are sensitive to a variable assignment. This approach synthesises recent work on indexicals and pronouns (e.g. Schlenker 2002; Heim 2008) and on proper names (e.g. Geurts 1997; Dever 1998; Cumming 2008). Combined with the idea that attitude verbs are 'assignment-shifters' (cf. Cumming 2008), this account yields a semantics for attitude reports which avoids both the problem raised by counterfactual attitudes, along with a well-known compositional problem facing the standard account.

2. The standard account

Quine (1956) observed an ambiguity in attitude reports like (2):

2. Ralph believes that someone is a spy.

The first reading is boring: it says that Ralph, like most of us, believes that there are spies—he believes that *someone or other* is a spy. This is is the *de dicto* reading. The second reading is more interesting: it says that Ralph, unlike most of us, has a particular individual in mind who he believes to be a spy. This is the *de re* reading, which appears to be strictly stronger than the *de dicto* reading.

A natural way to try to capture this ambiguity in possible worlds semantics is as follows. The *de dicto* reading is true iff each of Ralph's belief worlds contains a spy. Importantly, this condition does not require there to be a particular individual who exists in all of Ralph's belief worlds and is a spy in all of them. The *de re* reading, on the other hand, is true iff there is an individual x such that, in each of Ralph's belief worlds w, x is a spy in w. On this reading, the identity of the spy must remain constant across Ralph's belief worlds. This ambiguity could be derived compositionally either by positing a scope ambiguity or by using world variables in the syntax (e.g von Fintel and Heim 2007, Ch. 7).

The problem with this account of *de re* attitudes – often called the 'problem of double-vision' – is well-known. Suppose Ralph sees a man in a brown hat behaving suspiciously one evening on the waterfront. Ralph comes to believe that this man is a spy. So, according to the above account, all his belief worlds are ones in which this man is a spy. Ralph also believes that Bernard Ortcutt, the local mayor, is not a spy; thus, it would seem that all of Ralph's belief worlds are ones in which Ortcutt is not a spy. But as it turns out, the man Ralph saw on the waterfront just *is* Ortcutt, which means that every world compatible with what Ralph believes must be such that that man (= Ortcutt = man on the waterfront) both is and is not a spy. Since no world meets that condition, no worlds are compatible with what Ralph believes—we represent Ralph as believing a contradiction. While it may be possible to believe a contradiction, that doesn't seem to be Ralph's plight. For all we've said, he might have a completely coherent picture of the world.

Following Quine, Kaplan, and Lewis, formal semanticists have tended to favour a descriptivist solution to this problem.[1] The descriptivist move is familiar: when Ralph thinks to himself, "That man is a spy" the content of his belief is 'really' a descriptive proposition. For example, if Ralph sees that 'that man' is wearing a brown hat, perhaps the proposition he believes is that the man in the brown hat is a spy. And when Ralph thinks to himself, "Mayor Ortcutt is no spy", the content of his belief is a different descriptive proposition, perhaps the proposition that the man called "Bernard Ortcutt" is not a spy. These two propositions are compatible: the first is the set of worlds that contain a unique

[1] Quine (1956); Kaplan (1968); Lewis (1979); Cresswell and von Stechow (1982); von Stechow (1982); Heim (1992, 1994); Abusch (1997); Anand (2006); Maier (2006, 2009).

man with a brown hat who is also a spy, the second is the set of worlds that contain a unique man called "Bernard Ortcutt" who is not a spy. The intersection of these two sets is non-empty.

Ralph employs two different ways of thinking about Ortcutt, which we can think of as *descriptive concepts*, or (possibly non-constant) functions from possible worlds to individuals. The proposed truth condition for the *de re* reading of (2), then, is this:

> $[\![\text{Ralph believes that someone is a spy}]\!]^{c,i} = 1$ iff
>
> there is an individual y and a suitable descriptive concept f such that:
>
> (i) $f(w_i) = y$, and
>
> (ii) every world w compatible with what Ralph believes in w_i is such that $f(w)$ is a spy in w.

The restriction to 'suitable' descriptive concepts is intended to handle the (alleged) fact that not any old descriptive concept will underwrite the truth of a *de re* ascription. Kaplan (1968), for example, argued that the *de re* reading of (2) is not made true merely by Ralph's believing that the shortest spy, whoever that is, is a spy. The question of just what suitability involves is difficult and contested, and we won't delve into it any further here.

That takes care of the initial problem, but another difficulty awaits, one which concerns *de se* attitudes. Consider Perry's character, Rudolf Lingens, an amnesiac lost in the Stanford Library (Perry 1977). Suppose that, upon finding a number of fake passports on his person, Lingens concludes that he is a spy, i.e. he thinks, "I must be a spy." In such a scenario, it would seem that the *de re* reading of (3) is true:

3. Lingens believes that someone is a spy.

If Lingens believes that he himself is a spy, then there is a particular person to whom he ascribes spyhood, which should be enough to guarantee the truth of (3).

On the proposed theory, (3) is true at point of evaluation $\langle c, i\rangle$ just in case there is a suitable descriptive concept f such that:

(i) $f(w_i) =$ Lingens, and

(ii) every world w compatible with what Lingens believes in w_i is such that there is such that $f(w)$ is a spy in w.

The problem is that, although (3) is intuitively true in this situation, this truth condition will not be met. For well-known reasons, the content of Lingens's *de se* belief that he is a spy cannot be represented by a descriptive possible worlds proposition (Perry 1979; Lewis 1979). Suppose, for example, that Lingens is the tallest philosopher in Palo Alto. Still, the content of Lingens's belief that he is a spy is not to be identified with the proposition that the tallest philosopher in Palo Alto is a spy. For Lingens might believe that he is a spy without also believing that the tallest philosopher in Palo Alto is a spy; that might happen if he failed to realise that he was the tallest philosopher in Palo Alto. It's not hard to see that – given Lingens's lack of knowledge about himself – we can repeat this argument for any candidate descriptive proposition we can think of. So the content of Lingens's belief cannot be a descriptive possible worlds proposition. And that means that there will be no suitable descriptive concept meeting the second of the two conditions laid down above.

We can solve this problem if we adopt Lewis's 'centred worlds' account of *de se* attitudes, and then adjust our theory of the *de re* accordingly. Lewis (1979, 1983a) offers a number of arguments and examples designed to show that we should identify doxastic (epistemic, etc.) alternatives not with possible worlds, but with *centred worlds*, a finer-grained type of possibility. A centred world is a triple consisting of a possible world, a time, and an individual ('the centre') who exists at the world and time in question. Lingens's belief that he is a spy is now identified with the set of centred worlds $\langle w, t, x\rangle$ such that that x is spy at t in w. Crucially, the centred worlds proposal doesn't require Lingens to possess a descriptive concept which correctly picks Lingens out: Lingens can believe that he is a spy without believing that the F is a spy, for some property F that he alone possesses.

How do *de re* attitudes and ascriptions fit into this picture? Here Lewis adapts the descriptivist proposal into the centred worlds setting. Descriptive concepts can now be identified with *relations* of a certain sort, or functions from centred worlds to individuals. Lewis takes the relations in question to be *acquaintance relations*, relations of causal dependence "of a sort apt for the reliable transmission of information" (Lewis 1979, 155). The proposed truth condition for (3) is as follows:

> $[\![\text{Lingens believes that someone is a spy}]\!]^{c,i} = 1$ iff there is a individual y and an acquaintance relation R such that:
>
> (i) $R(w_i, t_i, \text{Lingens}) = y$, and
>
> (ii) every centred world $\langle w, t, x\rangle$ compatible with what Lingens believes at t_i in w_i is such that $R(w, t, x)$ is a spy at t in w.

To see how this deals with the Lingens case, note that Lewis treats the relation of *identity* – the function that maps a centred world to its centre – as a relation of acquaintance. On the centred worlds theory, Lingens has a *de se* belief in w_i to the effect that he is a spy iff:

(A) all the centred worlds $\langle w, t, x\rangle$ compatible with what Lingens believes in w_i are such that x is a spy at t in w.

Note that if ID is the function that maps a centred world to its centre, then (A) holds just in case (i) and (ii) both hold:

(i) $\textsc{id}(w_i, t_i, \text{Lingens}) = \text{Lingens}$,

(ii) all the centred worlds $\langle w, t, x \rangle$ compatible with what Lingens believes in w_i are such that $\textsc{id}(w, t, x)$ is a spy at t in w.

Claim (ii) entails (i), and (A) and (ii) entail each other because $\textsc{id}(w, t, x)$ just is x, and so (A) and (ii) just say the same thing.

This means that if Lingens believes *de se* in w_i that he is a spy, the above truth condition of (3) will be satisfied: just take as a witness for the first existential quantifier ("there is an individual y...") Lingens himself, and for the second ("[there is] an acquaintance relation R..."), ID, the relation of identity.

That's the account of the truth conditions of *de re* ascriptions which will serve as our target in what follows. Although I have only been talking about belief reports so far, I assume, of course, that this proposal is intended as a general account of attitude reports. In particular, I assume parallel accounts for the counterfactual attitude reports (e.g. imagination reports, wish reports). This point about generality will become important later.

There remains the question of how these truth conditions are compositionally generated. One approach holds that the *res* expression is moved out of the complement clause into an argument position of the attitude verb. On this view, in a sentence like (4), *believes* takes three arguments: *Ralph*, *Ortcutt*, and *is a spy*:

4. Ralph believes that Ortcutt is a spy.

   Ralph believes [Ortcutt] [λx x is a spy]

Believes then receives the following lexical entry:[2]

$[\![\text{believes}]\!]^{c,i} = \lambda res_e.\lambda p_{\langle s\langle r,et\rangle\rangle}.\lambda att_e.$ there is an acquaintance relation R such that:

(i) $R(w_i, t_i, att) = res$, and

(ii) every centred world $\langle w, t, x \rangle$ compatible with what att believes at t_i in w_i is such that that $p(w, t, y) = 1$, where $y = R(w, t, x)$.

To handle attitude reports with more than one *res* expression, we would need something more sophisticated, along the lines of Cresswell and von Stechow (1982). On that treatment, the first argument of the verb is not a single individual, but a sequence thereof, and the second argument is not a monadic property but an n-ary relation.

But even with that modification, accounts of this sort are widely disliked on the grounds that *res* movement is though to be syntactically implausible. Schlenker (2004, 190), for example, refers to this process as '*De Re* Magic'. (See Maier (2009, 459) for a round-up of recent complaints about *res* movement.)

[2] Individuals are of type e, worlds of type s, times of type r, truth values of type t.

While there are accounts in the literature which avoid positing such movement,[3] I won't investigate them here. For I wish to raise another problem for this approach, one which targets the *truth conditions* this theory assigns to attitude reports. Any account that predicts the Lewisian truth conditions is thus subject to this objection, even if it manages to avoid the problems associated with *res* movement

3. The problem of counterfactual attitudes

The problem concerns the truth conditions this approach assigns to counterfactual attitude reports. The problem is quite simple and can be made vivid with an example. Let us alter our original Ralph/Ortcutt example as follows. Ralph is only acquainted with Ortcutt in one way, having seen Ortcutt sneaking around on the waterfront. (So in this version of the story, Ralph hasn't heard of the man called "Bernard Ortcutt," town mayor.) But, as before, Ralph believes that this fellow sneaking around on the waterfront is a spy. The relevant acquaintance relation is Q, the relation x bears to y just in case y is the unique individual x sees sneaking around on the waterfront.

The problem is that, once Ralph has a 'cognitive fix' on Ortcutt, he is able to consider scenarios in which he is not acquainted with Ortcutt in this way. For example, Ralph might imagine a scenario in which he sees Ortcutt flying a kite in an alpine meadow, rather than sneaking around on the waterfront. In such a scenario, the following sentence would appear to be true:

5. Ralph imagined that he did not see Ortcutt sneaking around on the waterfront.

On the standard approach to *de re* ascription, however, this sentence is true at world w and time t iff there is an acquaintance relation R meeting two conditions:

- $R(w, t, \text{Ralph}) = \text{Ortcutt}$, and
- every centred world $\langle w', t', x' \rangle$ compatible with what Ralph imagines at t in w is such that x' does not see $R(w', t', x')$ sneaking around on the waterfront at t' in w'.

But *ex hypothesi* the only acquaintance relation Ralph bears to Orctutt is Q, a function which maps a centred world to the individual the centre see sneaking around on the waterfront. This means that (5) is true in the envisioned scenario iff:

- $Q(w, t, \text{Ralph}) = \text{Ortcutt}$, and
- every centred world $\langle w', t', x' \rangle$ compatible with what Ralph imagines at t in w is such that x' does not see $Q(w', t', x')$ sneaking around on the waterfront at t' in w'.

[3] Percus and Sauerland (2003); Anand (2006); Maier (2009).

And while the first condition is met, the second isn't: none of the centred worlds compatible with what Ralph imagines meets this condition, since no centred world whatsoever meets it. No centred world $\langle w', t', x' \rangle$ is such that the x' does not see $Q(w', t', x')$ sneaking around on the waterfront at t' in w', since $Q(w', t', x')$ just is the individual that x' sees sneaking around on the waterfront at t' in w'. So, given the assumption that at least one centred world is compatible with what Ralph imagines, we have the result that the standard theory incorrectly predicts that (5) is false in the above scenario.[4]

Note that this problem also arises for other counterfactual attitudes: Ralph could equally well *dream*, *wish*, or *hope* that he did not see Ortcutt sneaking around on the waterfront.

But is this a genuine problem? Perhaps we have simply mis-identified the acquaintance relation under which Ralph thinks of Ortcutt. Perhaps the acquaintance relation is tied to Ralph's visual perception of Ortcutt and so is not easily put into words ("the man who looks thus-and-so"). While this suggestion may help to evade the present counterexample, others are easy to find. Consider a slightly different scenario: as above, except that Ralph imagines that Ortcutt died as infant (cf. Kripke 1980). In this case, there may be no interesting similarities between the physical appearance of the man Ralph sees on the waterfront and the unfortunate infant of Ralph's imagining. In such a case, (6) would be true, but it's unclear how it's truth could be accounted for by the standard approach.

6. Ralph imagined that Ortcutt died as infant.

A natural thought about the earlier example is that the kite-flier in the imaginary scenario isn't the individual the centre sees sneaking around on the waterfront *in that scenario*, but the individual that Ralph *actually* sees sneaking around on the waterfront. I take it the suggestion is that (5) is true at a world w and time t iff there is an acquaintance relation R meeting the following conditions

- $R(w, t, \text{Ralph}) = \text{Ortcutt}$, and
- every centred world $\langle w', t', x' \rangle$ compatible with what Ralph imagines at t in w is such that x' does not see $R(w, t, \text{Ralph})$ sneaking around on the waterfront at t' in w'.

Note that $R(w, t, \text{Ralph})$ is the person Ralph actually sees sneaking around the docks, viz. Ortcutt. So on this proposal, in all of Ralph's centred imagination worlds, the centre does not see *Ortcutt* sneaking around on the waterfront.

But of course this is just a centred worlds version of the account of *de re* attitudes that we considered at the beginning of §2, the account we rejected

[4] If no centred worlds are compatible with what Ralph imagines, then the sentence is true, since the second clause of the truth condition is vacuously true. But if no centred worlds are compatible with what Ralph imagines, Ralph counts as imagining *every* centred proposition, a result which is at least as bad.

because of the problem of double vision. Go back now to the *original* Ralph and Ortcutt scenario, in which Ralph is acquainted with Ortcutt in two ways but doesn't realise it. And suppose that Ralph imagines a scenario in which the following two conditions hold: (i) that guy [we point at a shadowy figure on the waterfront] works for MI6, and (ii) Ortcutt doesn't work for MI6. This account predicts that the content of Ralph's imagining is the set of centred worlds in which Ortcutt both works and doesn't work for MI6. Since there is no centred world that meets that condition, we predict that Ralph has imagined a contradiction—a bad result.

4. Sequenced worlds

In seeking a solution to this problem, I want to begin with the following observation. The problem of counterfactual attitudes does not arise for the centred worlds theorist's treatment of ***de se*** attitudes. To see what I mean by this, recall the possible worlds version of descriptivism which we discussed in §2, the theory offered the following account of sentence (4):

> $[\![$Ralph believes that Ortcutt is a spy$]\!]^{c,i} = 1$ iff there is a suitable descriptive concept f such that:
>
> (i) $f(w_i) =$ Ortcutt, and
>
> (ii) every world w compatible with what Ralph believes in w_i is such that there is such that $f(w)$ is a spy in w.

Recall that this view gave the same treatment to both *de se* and *de re* attitudes reports, and that we rejected it on the grounds that the descriptive account of the *de se* was untenable.

But note also that the problem of counterfactual attitudes arises just as well for this theory as it does for the centred worlds account. In fact, things are worse in one respect for the possible worlds descriptivist: that theorist has a ***de se*** problem of counterfactual attitudes in addition to a *de re* one. To see this, note that, on the possible worlds version of descriptivism, for Lingens to imagine *de se* that he is G, there would have to be some descriptive concept f such that Lingens is the f, and such that Lingens imagines that the f is G. Suppose the only descriptive concept that Lingens possesses for himself is *the tallest philosopher in Palo Alto.* Then according to this theory, for Lingens to imagine *de se* that he is G is for him to imagine that the tallest philosopher in Palo Alto is G. Then we immediately have the result that G cannot be a property incompatible with the property of being the tallest philosopher in Palo Alto. We have the result that Lingens cannot imagine anything incompatible with his being the tallest philosopher in Palo Alto. But even if the the only descriptive concept that Lingens possesses for himself is *the tallest philosopher in Palo Alto*, it seems possible for Lingens to imagine things that are incompatible with his being the tallest philosopher in Palo Alto. So the possible worlds version of descriptvism faces a *de se* problem of counterfactual attitudes, in addition to a *de re* one.

The centred worlds theorist avoids that particular problem. Even if the only descriptive concept Lingens possesses for himself is *the tallest philosopher in Palo Alto*, this descriptive concept is irrelevant to the characterisation of Lingens's imagination alternatives. For Lingens to imagine that he is not the tallest philosopher in Palo Alto is simply for all his centred imagination worlds to be centred on someone who is not the tallest philosopher in Palo Alto. And there certainly are centred worlds that meet this condition. The reason the centred worlds theorist avoids the *de se* problem of counterfactual attitudes is that she does not offer a descriptivist account of *de se* attitudes.

The fact that the ***de se*** problem of counterfactual attitudes arises for the possible worlds account, but not for the centred worlds account, is suggestive. Perhaps we can solve the ***de re*** problem of counterfactual attitudes if we can find a way of avoiding descriptivism about *de re* attitudes. This is the strategy I shall pursue in what follows.[5]

In thinking about how to execute this strategy, consider the contrasting answers the possible worlds descriptivist and the centred worlds theorist give to the following **question of *de se* identification**:

> Let s be an arbitrary one of Lingens's imagination alternatives. Who in s represents Lingens there?

The possible worlds theorist says: Lingens must possess some descriptive concept for himself (e.g. *the tallest philosopher in Palo Alto*), and the individual in s who represents Lingens is the one who satisfies that descriptive concept there (e.g. the tallest philosopher in Palo Alto in s). Giving that answer is what leads to the *de se* problem of counterfactual attitudes: i the problematic cases, there is a clash between the method we use to identify Lingens's representative in one of his imagination alternatives and what Lingens imagines about himself. The centred worlds theorist, on the other hand, says this: s is a centred world, and the individual who represents Lingens in s is the centre of s. Since there is no requirement that the centre of one of Lingens's centred imagination worlds be qualitatively similar to Lingens in any respect, the centred worlds theorist avoids the *de se* problem of counterfactual attitudes.

Here's a way of picturing the contrast between these two approaches: On the descriptivist approach, we take one of Lingens's imagination alternatives and *scan* it for the individual there who satisfies the relevant descriptive concept—e.g. we search that world for the tallest philosopher in Palo Alto. Once we find that individual, we've thereby found the individual in that alternative who represents Lingens there. On the centred worlds approach, in contrast, no scanning is needed, since the imagination alternative comes with Lingens's representative already picked out in advance, so to speak.

[5]Other strategies are possible. For example, one might try to solve the problem by pursing the idea that a state of imagining is 'anaphorically related' to the agent's state of belief; see Ninan (2008, Ch. 2) for my attempt to work out this idea. Asher (1987), Kamp (1990), and Heim (1992) may also be relevant in this connection.

Now consider a **question of *de re* identification**:

> Let s be one of Ralph's imagination alternatives. Who in s represents Ortcutt there?

The centred worlds theorist answers as follows: Ralph must bear some acquaintance relation R to Ortcutt (e.g. the relation x bears to y just in case y is the unique man x sees sneaking around on the docks), and the individual who represents Ortcutt in s is the one to whom the centre bears R (e.g. the individual who the centre of s sees sneaking around on the waterfront in s). That leads to the problem of counterfactual attitudes because it means that Ralph cannot imagine anything incompatible with his bearing R to Ortcutt (e.g. he cannot imagine that he does not see Ortcutt sneaking around on the waterfront). As before, the problem arises because the individual who represents Ortcutt in s must bear a certain type of descriptive similarity to Ortcutt himself. Or to put it another way: Let $\langle w', t', x' \rangle$ be one of Ralph's imagination alternatives, and let y' be the individual who represents Ortcutt in $\langle w', t', x' \rangle$. Then the centred worlds approach requires the pair $\langle x', y' \rangle$ to be descriptively similar to the pair $\langle$Ralph, Ortcutt$\rangle$. In particular, there must be some relation of acquaintance R that Ralph bears to Ortcutt and that x' bears to y'. This requirement then means that Ralph can't imagine anything incompatible with his bearing R to Ortcutt.

To avoid this problem, we need an approach which doesn't require there to be such an R, i.e. that doesn't require $\langle x', y' \rangle$ and $\langle$Ralph, Ortcutt$\rangle$ to be similar in this way. Taking our cue from the centred worlds approach, the obvious thing to do is to construct Ralph's imagination alternatives so that that they come with both Ralph's *and* Ortcutt's representatives picked out in advance. The idea would be to represent Ralph's imagination alternatives using *pair-centred worlds*, triples of a world, a time, and an *ordered pair* of individuals. Suppose $\langle w', t', \langle x'_1, x'_2 \rangle \rangle$ is one Ralph's imagination alternatives, where x'_1 represents Ralph, and x'_2 represents Ortcutt. Such an approach would avoid the problem of counterfactual attitudes, since it will not be a constraint that $\langle x'_1, x'_2 \rangle$ be descriptively similar to the pair $\langle$Ralph, Ortcutt$\rangle$ in any way. In particular, we do not require there to be an acquaintance relation that both pairs stand in. Acquaintance relations no longer play a role in finding Ortcutt's representatives in Ralph's imagination alternatives.[6]

For Ralph to imagine that he does not see Ortcutt sneaking around on the waterfront will be for all the pair-centred worlds $\langle w', t', \langle x'_1, x'_2 \rangle \rangle$ compatible with what he imagines to be such x'_1 does not see x'_2 sneaking around on the waterfront at t' in w'. Since there are pair-centred worlds that meet this condition, the account has no trouble accommodating Ralph's imagining. Just as the centred worlds account avoids the *de se* problem of counterfactual attitudes, the pair-centred account avoids the *de re* problem of counterfactual attitudes.

Moving to pair-centred worlds requires one piece of additional machinery not required by either the centred worlds or the possible worlds theory. When

[6] As we shall see, this does not mean acquaintance relations play no role at all in the theory.

assessing a pair-centred world for compatibility with what an agent imagines, we need a mechanism for indicating who each element of the pair represents. This wasn't a problem on the centred worlds picture because we had a background stipulation in place: the centre always represents the agent. But now we don't really know what is being said if we are simply told, for example, that a given pair-centred world $\langle w', t', \langle x'_1, x'_2 \rangle\rangle$ is compatible with what Ralph imagines (at t in w). To know what this means we need to know who x'_1 and x'_2 are supposed to represent; we need to know, for example, that x'_1 represents Ralph and x'_2 represents Ortcutt (or vice-versa).

To make this sort of stipulation explicit, it will help to think of an attitude state as being represented by *two* things: a set S of pair-centred worlds, and a *base world*, which is a pair-centred world that tells you who the centres of the pair-centred worlds in S represent (a base world is something like the key to a map). On this setup, it's wrong to think of Ralph imagining or not imagining a pair-centred proposition (set of pair-centred worlds) p *simpliciter*; rather, he imagines or doesn't imagine p *relative to* a given base world. So when Ralph imagines that he does not see Ortcutt sneaking around on the waterfront, we can characterise his imagining as follows. Given the base world $\langle w, t, \langle$Ralph, Ortcutt$\rangle\rangle$, the content of Ralph's imagining is:

> $\{\langle w', t', \langle x'_1, x'_2 \rangle\rangle : x'_1$ does not see x'_2 sneaking around on the waterfront at t' in $w'\}$

Since Ortcutt is the second member of the base world $\langle w, t, \langle$Ralph, Ortcutt$\rangle\rangle$, the second centre of a pair-centred world counts as representing Ortcutt relative to that base world.

Note that we could equally well represent Ralph's imagining using a base world in which we swap the positions of Ralph and Ortcutt around, i.e. $\langle w, t, \langle$Ortcutt, Ralph$\rangle\rangle$. Relative to *that* base world, we should say that the content of Ralph's imagining is:

> $\{\langle w', t', \langle x'_1, x'_2 \rangle\rangle : x'_2$ does not see x'_1 sneaking around on the waterfront at t' in $w'\}$

This should make it clear that one only bears/doesn't bear an attitude towards a pair-centred proposition relative to a given base world. But note that these are two notationally equivalent ways of representing the content of Ralph's imagining.

Ralph might of course have *de re* attitudes that concern more that just himself and Ortcutt; he might have attitudes that concern any number of individuals. So to generalise our account, we'll need to use *sequenced worlds* – triples of a world w, a time t, and an n-ary *sequence* of individuals g – to represent attitudinal alternatives.[7] Base worlds will likewise now be sequenced worlds: a base world for an agent x at a world w and time t will consist of w, t, and a sequence whose elements are all and only the individuals that x is acquainted

[7] Formally, a sequence of individuals is a partial function from positive integers to individuals.

with at t in w. So when Ralph imagines that he does not see Ortcutt sneaking around on the waterfront, a better representation of Ralph's imagining would be the following. Given a base world $\langle w, t, g\rangle$ for Ralph, there will be an m and an n such that $g(m)$ is Ralph and $g(n)$ is Ortcutt (there will be such an m and n since Ralph is acquainted with both himself and Ortcutt). Then relative to $\langle w, t, g\rangle$, the content of Ralph's imagining is:

> $\{\langle w', t', g'\rangle : g'(m)$ does not see $g'(n)$ sneaking around on the waterfront at t' in $w'\}$

How do we handle the problem of double-vision on this account? In approaching this, I need to rely on our intuitive grasp of the notion of an agent's believing (or imagining, etc.) something about an individual *relative to* an acquaintance relation. Our main grasp on this notion comes from our understanding of cases like the original Ortcutt case, in which Ralph is acquainted with Ortcutt in two different ways. Ralph sees a suspicious figure sneaking around on the docks. Relative to the acquaintance relation R – the relation x bears to y just in case y is the unique individual x sees sneaking around on the docks – Ralph believes that Ortcutt is a spy. Ralph has heard of a person under the name "Bernard J. Ortcutt". Relative to the acquaintance relation Q – the relation x bears to y just in case y is the person x has heard of under the name "Bernard J. Ortcutt" – Ralph does not believe that Ortcutt is a spy. This notion of believing something about someone relative to an acquaintance relation plays an important role in the sequenced worlds solution of the problem of double vision.

Note that any solution to that problem is going to have the following feature. In an arbitrary one of Ralph's doxastic alternatives, there will two distinct individuals, both of whom correspond to Ortcutt. One will, so to speak, correspond to Ortcutt relative to R, the other to Ortcutt relative to Q. In the centred worlds theory, a doxastic alternative is a centred world $\langle w, t, x\rangle$, and the individual who represents Ortcutt relative to R is $R(w, t, x)$, and the individual who represents Ortcutt relative to Q is $Q(w, t, x)$. But how does this work in the sequenced worlds framework?

In order to answer this question, we need revise the present framework slightly. We need to change our definition of a base world, so that a base world now include a sequence of acquaintance relations in addition to a sequence of individuals. So let a base world for x at t in w now be a quadruple $\langle w, t, g, G\rangle$, where G is a sequence of acquaintance relations that meets two conditions: (i) the elements of G are all and only the acquaintance relations that x bears to someone at t in w, and (ii) for all n for which G is defined, the nth element of G is a relation that x bears to $g(n)$ at t in w, i.e. $G(n)(w, t, x) = g(n)$. This means that if $\langle w, t, g, G\rangle$ is a base world for Ralph in the original Ortcutt case, there will be an m such that $G(m) = R$, the relation x bears to y just in case y is the unique individual x sees sneaking around on the docks. And there will be an n such that $G(n) = Q$, the relation x bears to y just in case y is the unique individual x sees sneaking around on the docks. So $G(n)(w, t, \text{Ralph}) = G(m)(w, t, \text{Ralph}) = \text{Ortcutt}$, which means that $g(n) = g(m) = \text{Ortcutt}$.

Now let $\langle w', t', g' \rangle$ be a sequenced world compatible with what Ralph believes relative to $\langle w, t, g, G \rangle$. Then if $G(m) = R$ and $G(n) = Q$, $g'(m)$ represents Ortcutt relative to R in $\langle w', t', g' \rangle$, and $g'(n)$ represents Ortcutt relative to Q in $\langle w', t', g' \rangle$. And we can now represent Ralph's beliefs about Ortcutt as follows. Given a base world $\langle w, t, g, G \rangle$ for Ralph at t in w, let positions m and n be such that $G(m) = R$, and $G(n) = Q$. Since Ralph believes that Ortcutt is a spy relative to R, we can say that he believes the following sequenced proposition relative to $\langle w, t, g, G \rangle$:

$$\{\langle w', t', g' \rangle : g'(m) \text{ is a spy at } t' \text{ in } w'\}$$

And since he believes that Ortcutt is not a spy relative to Q, we can say that he also believes this sequenced proposition relative to $\langle w, t, g, G \rangle$:

$$\{\langle w', t', g' \rangle : g'(n) \text{ is not a spy at } t' \text{ in } w'\}$$

Note that we represent Ralph's beliefs as consistent, since the intersection of these two sequenced propositions is non-empty. Each of Ralph's sequenced belief worlds contains two distinct characters, one of whom corresponds to Ortcutt-relative to R, the other of whom corresponds to Ortcutt relative to Q. The first individual is a spy, the second is not. We correctly represent Ralph's picture of the world as coherent.

How do we represent *de se* attitudes in this framework? Following Lewis, we can suppose that the relation of *identity* – the relation that maps a centred worlds to its centre – is an acquaintance relation. That means that in any base world $\langle w, t, g, G \rangle$ for x at t in w there will be an n such that $g(n) = x$ and $G(n)$ is the relation of identity. Then the nth position in of a sequenced world is the '*de se* position' of $\langle w, t, g, G \rangle$, in the sense that x believes *de se* at t in w that she is F iff x believes:

$$\{\langle w', t', g' \rangle : g'(n) \text{ is } F \text{ at } t' \text{ in } w'\}$$

5. Sequenced worlds truth conditions

Since it will be useful in what follows, let's adopt the following notation:

> Let $Bel_x^{w,t,g,G}$ be the set of sequenced worlds compatible with what x believes relative to the base world $\langle w, t, g, G \rangle$.[8]

I assume similar definitions for other attitudes, e.g. $Imag_x^{w,t,x,G}$ will be the set of sequenced worlds compatible with what x imagines relative to $\langle w, t, g, G \rangle$.

In order to state the truth conditions of a *de re* report, we need to specify a base world for the subject of the sentence. For the moment let us do this by having a fixed but arbitrary function A which takes a centred world $\langle w, t, x \rangle$ and returns a particular base world for that centred world. In our semantics, we can add A as a separate parameter of interpretation. Then we can give the truth conditions for (4) as follows:

[8]This is only well-defined if $\langle w, t, g, G \rangle$ is a base world for x at t in w.

(4) Ralph believes that Ortcutt is a spy.

$[\![(4)]\!]^{A,c,i} = 1$ iff: if $\langle w_i, t_i, g, G\rangle = A(w_i, t_i, \text{Ralph})$, then there is a positive integer n such that:

- $g(n) =$ Ortcutt, and
- every sequenced world $\langle w', t', g'\rangle$ in $Bel^{w_i,t_i,g,G}_{Ralph}$ is such that $g'(n)$ is a spy t' in w'.

Note that this doesn't require Ralph to think of Ortcutt in any particular way. If there is some acquaintance relation R relative to which Ralph believes that Ortcutt is a spy, then (4) will be true on this view. This is one effect of existentially quantifying over positions in the sequences—we effectively existentially quantify over acquaitance relations, just as the centred worlds theorist does.

Recall the sentence and situation that we used to illustrate the problem of counterfactual attitudes. Ralph is acquainted with Ortcutt in one way, by seeing him sneaking around on the the waterfront. Still the following sentence seems like it could be true in that situation:

5. Ralph imagined that he did not see Ortcutt sneaking around on the waterfront.

On the sequenced worlds account, (5) is true at a point of evaluation A, c, i just in case:

if $\langle w_i, t_i, g, G\rangle = A(w_i, t_i, \text{Ralph})$, then there are positive integers m and n such that:

- $g(m) =$ Ralph and $g(n) =$ Ortcutt, and
- every sequenced world $\langle w', t', g'\rangle$ in $Imag^{w_i,t_i,g,G}_{Ralph}$ is such that $g'(m)$ does not see $g'(n)$ sneaking around on the waterfront at t' in w'.

The important thing to note is that there are sequenced worlds meeting that last condition. Thus, the account predicts that (5) has satisfiable truth conditions, truth conditions that are met at some points of evaluation.

Since it will be useful later in the paper, I want to note an equivalent way of stating the truth conditions of a sentence like (4). For any positive integer n, we can state the truth conditions for (4) thus:

$[\![\text{Ralph believes that Ortcutt is a spy}]\!]^{c,i} = 1$ iff there is a base world $\langle w_i, t_i, g, G\rangle$ for Ralph at t_i in w_i such that:[9]

- $g(n) =$ Ortcutt, and

[9] Here, "there is a base world $\langle w_i, t_i, g, G\rangle$..." is short for: "there is a base world $\langle w, t, g, G\rangle$ (where $w = w_i$ and $t = t_i$)...". This sort of abbreviation will be used throughout.

- every sequenced world $\langle w', t', g' \rangle$ in $Bel_{Ralph}^{w_i,t_i,g,G}$ is such that $g'(n)$ is a spy t' in w'.

Here we have done away with the parameter of interpretation A which maps a centred world to one of its base worlds.

To see why these are equivalent, imagine we had two machines, one designed to evaluate whether the first truth condition is met, the other designed to evaluate whether the second truth condition is met. We hand the first machine the A-generated base world $\langle w_i, t_i, g, G \rangle$ for Ralph at t_i in w_i. It then looks at each position in the sequences g and G. In particular, it looks at *each* pair $\langle g(k), G(k) \rangle$ ($g(k)$ an element of g, $G(k)$ an element of G), and checks to see whether $g(k)$ is Ortcutt, and whether Ralph believes that Ortcutt is a spy relative to $G(k)$, i.e. whether every sequenced world $\langle w', t', g' \rangle$ compatible with what Ralph believes relative to $\langle w_i, t_i, g, G \rangle$ is such that $g'(k)$ is a spy at t' in w'. If it finds such a pair, it tells us that the sentence is true; if it finds no such pair, it tells us that the sentence is false.

To the second machine, we hand an arbitrary integer m. The machine then begins looking at each base world for Ralph at t_i in w_i. Given a base world $\langle w_i, t_i, h, H \rangle$, the machine *only* looks at the mth position of the sequences. That is, it *only* looks at the pair $\langle h(m), H(m) \rangle$, and checks to see whether $h(m)$ is Ortcutt, and whether Ralph believes that Ortcutt is a spy relative to $H(m)$, i.e. whether every sequenced world compatible $\langle w', t', h' \rangle$ compatible with what Ralph believes relative to $\langle w_i, t_i, h, H \rangle$ is such that $h'(m)$ is a spy at t' in w'. If it finds a base world that generates such a pair, it tells us the sentence is true; if it fails to find such a pair, it tells us the sentence is false.

Obviously, the two machines are essentially performing the same task. This is because for any pair $\langle y, R \rangle$ such that Ralph is acquainted with y via R, there will be a position n in Ralph's A-generated base world $\langle w_i, t_i, g, G \rangle$ such that $g(n) = y$ and $G(n) = R$. This simply follows from the definition of a base world and the fact that Ralph bears R to y. One can then use this base world to assess what Ralph believes relative to it. And for any such pair $\langle y, R \rangle$ and arbitrary integer m, there will be some base world for Ralph at t_i in w_i such that $g(m) = y$ and $G(m) = R$. Again, this simply follows from the definition of a base world and the fact that Ralph bears R to y. And one can then use this base world to assess what Ralph believes relative to it.

6. Assignment-sensitivity

We now turn to the task of giving a compositional semantics that generates the sequenced worlds truth conditions for *de re* attitude reports. One way of doing this is to use the *res* movement LF:

(4) Ralph believes that Ortcutt is a spy.

Ralph believes [Ortcutt] [λx x is a spy]

If we have this LF, then we can generate the sequenced worlds truth condition for this sentence if we re-write the lexical entry for *believes* as follows:

$[\![\text{believes}]\!]^{A,c,i} = \lambda res_e.\lambda p_{\langle sr,et\rangle}.\lambda att_e.$ if $\langle w_i, t_i, g, G\rangle = A(w_i, t_{,i}\, att)$, then there is an n such that:

(i) $g(n) = res$, and

(ii) every sequenced world $\langle w', t', g'\rangle$ in $Bel_{att}^{w_i,t_i,g,G}$ is such that $p(w', t', g('n)) = 1$.

It's not hard to verify that this entry, combined with the above LF for (4), will generate the correct sequenced worlds truth condition for (4). (Note that this statement of truth conditions makes use of a function A in the point of evaluation; so it corresponds to the first of the two ways of generating sequenced worlds truth conditions discussed in §5.) But as we noted earlier, the *res* movement required by this approach is widely thought to be implausible. Are there any alternatives for the sequenced worlds theorist?

There may be more than one, but the alternative I wish to explore has two central features. First, it treats pronouns and proper names as *assignment-sensitive*, that is, as sensitive to a variable assignment. And second, it treats attitude verbs as *assignment shifters* (unselective quantifiers). I'll start by first working through an example of a *de re* ascription in which the *res* expression is a third-person pronoun, a type of expression which is widely-assumed to be assignment-sensitive. I'll then show how the basic proposal can be extended to first- and second-person pronouns and to proper names. The treatment of definite descriptions and quantifiers is fairly standard; I discuss them at the end of the section.

6.1. Third-person pronouns

According to a familiar picture, the semantics of a third-person pronoun is similar to that of the logician's variable. We begin by supposing that pronouns like *he* always bear a numerical index at LF, and that interpretation occurs relative to a variable assignment. A variable assignment can be identified with a function from positive integers to individuals. I shall assume that the variable assignment g_i is a parameter of the circumstance of evaluation i. I also assume that the other parameters of the circumstance are a world and a time, which means that circumstances are of the same semantic type as sequenced worlds. The meaning of the pronoun is then determined by the variable assignment as follows (Heim and Kratzer 1998, 241):

$$[\![\text{he}_2]\!]^{c,i} = g_i(2)$$

Such a semantics allows us to predict the fact that *he* can occur bound, as it might in *Every boy loves his mother.*

This semantics also allows us to treat deictic occurrences of pronouns, if we assume that the utterance context c determines a variable assignment g_c. Consider the sentence *He is tall.* In accordance with our indexing requirement, this sentence will be represented as He_j *is tall*, for some number j.[10] Consider

[10] I shall harmlessly conflate the difference between numerals and numbers throughout.

this sentence in a context c in which I utter that sentence while intending to refer to Obama by my use of *he*. To represent this, the theorist should say that c determines the variable assignment g_c that maps j to Obama.[11]

Recall the standard definition of truth at a context for two-dimensional systems of the sort we are presupposing (cf. Kaplan 1989):

A sentence ϕ is true at a context c iff $[\![\phi]\!]^{c,i_c} = 1$

Truth at a context *simpliciter* is defined in terms of the recursive notion of truth at a context and circumstance, or truth at a point of evaluation. A sentence is true at a context c just in case it is true at the corresponding *proper* point of evaluation c, i_c, which results from setting all values of the parameters in the circumstance to the corresponding values of the context. Since *He*$_j$ *is tall* is true relative to a point of evaluation c, i just in case $g_i(j)$ is tall at t_i and w_i, that sentence will be true relative to a context c just in case $g_c(j)$ is tall at t_c and w_c. Since I intended in c to refer to Obama, $g_c(j)$ is Obama, and so my utterance is true just in case Obama is tall at t_c in w_c.

Consider now a *de re* report that contains a third-person pronoun:

7. Ralph believes that he$_2$ is a spy.

I want to find a way of compositionally generating the sequenced worlds truth conditions for this sentence. The way of stating the truth conditions that I will seek to capture is the second of the two ways we considered in §5, the one which does *not* use an arbitrary function A from centred worlds to base worlds, but instead involves existentially quantifying over base worlds.

Let me begin by making two observations about (7). First, someone who utters (7) in a context c will typically have in mind a referent for the pronoun *he*. Suppose, for example, that I utter (7) in a context c in which I am pointing at Ortcutt. This means that the contextually determined assignment g_c will map 2 to Ortcutt. So I will have said something that is true just in case Ralph believes that Ortcutt is a spy (relative to some acquaintance relation or other). The second thing I wish to draw your attention to is the fact that the intension of the complement clause of the attitude report is the sequenced proposition π:

$$\begin{aligned} \pi &= \lambda i'.[\![\text{that he}_2 \text{ is a spy}]\!]^{c,i'} \\ &= \lambda i'.\ g_{i'}(2) \text{ is a spy at } t_{i'} \text{ in } w_{i'} \end{aligned}$$

(Recall that circumstances of evaluation are essentially sequenced worlds.)

Since we want to generate the sequenced worlds truth conditions for (7), we want π to represent the content of what Ralph would believe if he were to believe that Ortcutt is a spy (relative to some acquaintance relation or other). Given our setup, π only represents that content relative to a base world $\langle w_i, t_i, g, G\rangle$

[11] Note that the context determines a variable assignment only relative to an assignment of numerical indices to index-bearing expressions. So it might be more accurate to say that the context determines a set of admissible pairs $\langle w, g\rangle$ consisting of a way w of assigning numerical indices to index-bearing expressions and a variable assignment g.

in which $g(2)$ is Ortcutt. Since, as we just noted, $g_c(2)$ is Ortcutt, what this suggests is that we should existentially quantify over base worlds for Ralph that agree with g_c on the value they assign to 2, since Ortcutt will be the second member of the individual sequence of any such base world.

Here is a way to achieve that result. First, let us define the notion of the *domain* of a sequenced proposition p, $dom(p)$. To do this, we first need to define the notion of an *n-sensitive* sequenced proposition:

> For any positive integer n, a sequenced proposition p is *n-sensitive* iff there is a pair of sequenced worlds $\langle w, t, g\rangle$, $\langle w, t, h\rangle$, where h differs from g only at the nth position, such that $p(w, t, g) = 1$ and $p(w, t, h) = 0$.

Intuitively, an n-sensitive sequenced proposition is a sequenced proposition that makes a non-trivial demand on the nth element of a sequenced world. Sequenced proposition π, for example, is 2-sensitive, but not n-sensitive for any other n. With this notion in hand, we can define the *domain* of a sequenced proposition as follows:

> The *domain* of a sequenced proposition p, $dom(p)$, is the set of all positive integers n such that p is n-sensitive.

So the domain of π is simply $\{2\}$ since is only 2-sensitive. In normal cases, one will be able to determine the domain of the sequenced proposition expressed by a sentence ϕ at a context c simply by collecting all the indices on the indexed expressions that occur in ϕ.[12]

For a sentence ϕ, let "$[\![\phi]\!]^c$" stand for $\lambda i'.[\![\phi]\!]^{c,i'}$, the sequenced proposition expressed by ϕ in context c. And let's say that two variable assignments g and g' *agree* on an element n of a set S of positive integers just in case $g(n) = g'(n)$. Here is our preliminary account of attitude reports (to be refined shortly):

> $[\![x \text{ believes } \phi]\!]^{c,i} = 1$ iff there is a base world $\langle w_i, t_i, g, G\rangle$ for x at t_i in w_i such that:
>
> - g and g_i agree on all elements in $dom[\![\phi]\!]^c$, and
> - every sequenced world $\langle w', t', g'\rangle$ in $Bel_x^{w_i,t_i,g,G}$ is such that $[\![\phi]\!]^{c,\langle w',t',g'\rangle} = 1$.

Applying this account to (7) yields the following:

- $[\![\text{Ralph believes he}_2 \text{ is a spy}]\!]^{c,i} = 1$ iff

[12] An alternative would be to define the notion of the domain of a *sentence* (or LF) ϕ as the set of indices that occur on indexed expressions in ϕ. (Daniel Rothshild uses a related idea in unpublished work on the relationship between static and dynamic semantic theories.) The meaning of attitude verbs would then be stated in terms of this notion. This would make the semantics non-compositional in a certain sense, since an attitude verb would need access to information about something more than the meaning of the LF it embeds, but this seems like a relatively innocuous violation of compositionality.

- there is a base world $\langle w_i, t_i, g, G\rangle$ for Ralph at t_i in w_i such that:
  - g and g_i agree on all elements in $dom[\![\text{he}_2 \text{ is a spy}]\!]^c$, and
  - every sequenced world $\langle w', t', g'\rangle$ in $Bel^{w_i,t_i,g,G}_{Ralph}$ is such that $[\![\text{he}_2 \text{ is a spy}]\!]^{c,\langle w',t',g'\rangle} = 1$ iff
- there is a base world $\langle w_i, t_i, g, G\rangle$ for Ralph at t_i in w_i such that:
  - $g(2) = g_i(2)$, and
  - every sequenced world $\langle w', t', g'\rangle$ in $Bel^{w_i,t_i,g,G}_{Ralph}$ is such that $g'(2)$ is a spy at t' in w'.

So (7) will be true at a context c just in case:

there is a base world $\langle w_c, t_c, g, G\rangle$ for Ralph at t_c in w_c such that:

- $g(2) = g_c(2)$, and
- every sequenced world $\langle w', t', g'\rangle$ in $Bel^{w_c,t_c,g,G}_{Ralph}$ is such that $g'(2)$ is a spy at t' in w'.

Suppose c is a context in which I utter (7) while pointing at Ortcutt. Then $g_c(2)$ will be Ortcutt, which means that my utterance is true just in case:

there is a base world $\langle w_c, t_c, g, G\rangle$ for Ralph at t_c in w_c such that:

- $g(2) =$ Ortcutt, and
- every sequenced world $\langle w', t', g'\rangle$ in $Bel^{w_c,t_c,g,G}_{Ralph}$ is such that $g'(2)$ is a spy at t' in w'.

Note that this is equivalent to the second method of stating the sequenced worlds truth conditions that we discussed in §5. So we have the result we want.

6.2. *I* and *you*

What about other pronouns? Although philosophers tend to follow Kaplan (1989) in assuming that the first- and second-person pronouns are indexicals (expressions that receive their semantic value directly from the context parameter), certain examples suggest that these pronouns can be bound:

8. (a) Only I did my homework. (von Stechow 2002, attributed to Heim)
   Bound reading ≈ "I did my homework and for all individuals x ($x \neq$ me $\rightarrow x$ didn't do x's homework)."

   (b) You're the only one who forgot your wallet.
   Bound reading ≈ "You forgot your wallet and for all individuals x ($x \neq$ you $\rightarrow x$ didn't forget x's wallet)."

This suggests that, like their third-person cousins, first- and second-person pronouns should be treated as assignment-sensitive expressions, not as straight indexicals.

A first-pass implementation would simply attach numerical indices to these pronouns, indices whose value is again determined by the variable assignment:

$$[\![\mathrm{I}_3]\!]^{c,i} = g_i(3)$$

$$[\![\mathrm{you}_4]\!]^{c,i} = g_i(4)$$

But this treatment overlooks the most salient feature of the interpretation of these expressions: that when they occur free, *I* refers to the speaker and *you* to the addressee. The standard way to account for this, while still assuming an assignment-sensitive semantics for these terms, is to treat this aspect of pronominal meaning as presuppositional, where presuppositions are understood as conditions on definedness (cf. Cooper 1983; Heim 2008; Kratzer 2009). Glossing over some of the underlying compositional mechanics, this approach yields the following account of *I* and *you*:

$$[\![\mathrm{I}_3]\!]^{c,i} : g_i(3) = x_c.\ g_i(3)$$

$$[\![\mathrm{you}_4]\!]^{c,i} : g_i(4) = a_c.\ g_i(4)$$

Note also that a similar treatment of third-person pronouns can be given in order to capture the semantic contribution of gender features:

$$[\![\mathrm{he}_2]\!]^{c,i} : g_i(2) \text{ is male at } t_i \text{ in } w_i.\ g_i(2)$$

Can we use this analysis to predict the right sequenced worlds truth condition for a sentence like (9)?

9. Ralph believes that I_3 am a spy.

Before we can answer this question, we need to say what happens when a clause with an undefined expression lies in the scope of an attitude verb. I assume that if I_3 is undefined at a point of evaluation c, i, then any sentence containing it – e.g. I_3 *am a spy* – is likewise undefined at c, i. This suggests that the intension of I_3 *am a spy* at a context c should be regarded as a partial function from circumstances to truth values. It is defined at a circumstance i just in case I_3 *am a spy* is defined at c, i:

$$\lambda i.[\![\mathrm{I}_3 \text{ am a spy}]\!]^{c,i} =$$

$$\lambda i : g_i(3) = x_c.\ g_i(3) \text{ is a spy in at } t_i \text{ in } w_i$$

Now assume that attitude verbs 'filter' presuppositions, so that a belief report is defined only if the presuppositions of the complement clause are satisfied at each of the relevant doxastic possibilities (cf. Heim 1992). In our system, this means the following:

> $[\![x \text{ believes } \phi]\!]^{c,i}$ is defined iff there is a base world $\langle w_i, t_i, g, G\rangle$ for x at t_i in w_i such that:
>
> – g and g_i agree on all the elements in $dom[\![\phi]\!]^c$, and
>
> – every sequenced world $\langle w', t', g'\rangle$ in $Bel_x^{w_i,t_i,g,G}$ is such that $[\![\phi]\!]^{c,\langle w',t',g'\rangle}$ is defined.
>
> Where defined, $[\![x \text{ believes } \phi]\!]^{c,i} = 1$ iff there is a base world $\langle w_i, t_i, g, G\rangle$ for x at t_i in w_i such that
>
> – g and g_i agree on all the elements in $dom[\![\phi]\!]^c$, and
>
> – every sequenced world $\langle w', t', g'\rangle$ in $Bel_x^{w_i,t_i,g,G}$ is such that $[\![\phi]\!]^{c,\langle w',t',g'\rangle}$ $= 1$.

This means that (9) will be defined iff I_3 *am a spy* is defined at each of the speaker's sequenced belief worlds. Here are the conditions under which (9) would be defined at a proper point of evaluation c, i_c:

> $[\![\text{Ralph believes that I}_3 \text{ am a spy}]\!]^{c,i_c}$ is defined iff there is a base world $\langle w_c, t_c, g, G\rangle$ for Ralph at t_c in w_c such that:
>
> – g and g_c agree on all the elements in $dom[\![\text{I}_3 \text{ am a spy}]\!]^c$, and
>
> – every sequenced world $\langle w', t', g'\rangle$ in $Bel_{Ralph}^{w_c,t_c,g,G}$ is such that $g'(3) = x_c$.

That is, (9) is defined at a context only if the third member of each of Ralph's sequenced belief worlds is identical to the speaker of the context. There are two problems with this. First, it predicts that (9) is undefined if the speaker's representative in one of Ralph's sequenced belief worlds is distinct from the speaker herself. But that requirement isn't part of the intended sequenced worlds truth conditions for this sentence: we don't generally require that the *res* be represented by the *res* herself in each of the agent's doxastic possibilities.[13] A second problem with this is that it allows the sentence to be be defined even if $g_c(3)$ is not the speaker of c. But if $g_c(3)$ is someone other than the speaker, the sentence will not be saying anything about what Ralph believes about the speaker, contrary to fact.

Both problems stem from the fact that the presupposition is being evaluated with respect to the shifted assignment rather than with respect the original, unshifted one. The belief operator shifts the original circumstance i_c to i', and since I_3 occurs in the scope of that operator, the original circumstance i_c is gone by the time we get around to determining whether I_3's presupposition is satisfied. The solution to this problem begins with the observation that, even within the scope of the belief operator, I_3 still has access to is the context parameter, which includes a variable assignment. And note that, when it comes

[13]Such a requirement essentially collapses the sequenced worlds proposal into the very first approach to *de re* attitudes that we considered in §2.

to saying when this sentence is true at a context, it is relative to *this* assignment that we want to evaluate the presupposition.

So what we need is for the presuppositional aspect of I to be evaluated with respect to the assignment of the context and for the 'asserted' component of I to be determined by the assignment of the shifted circumstance. (This second thing is needed in order for us to generate the right sequenced proposition as the semantic value of the complement clause.) One way to do this is to revise our semantics for pronouns as follows:

- $[\![\text{I}_3]\!]^{c,i} : g_c(3) = x_c.\ g_i(3)$
- $[\![\text{you}_4]\!]^{c,i} : g_c(4) = a_c.\ g_i(4)$
- $[\![\text{she}_5]\!]^{c,i} : g_c(5)$ is female. $g_i(5)$
- etc.

Note that now the assignment relative to which the presupposition is being checked differs from the assignment that determines the semantic value of the numerical index (when that value is defined).[14]

With this semantics, we generate the following intension for I_3 *am a spy*:

$$\lambda i'.[\![\text{I}_3 \text{ am a spy}]\!]^{c,i'} =$$

$$\lambda i' : g_c(3) = x_c.\ g_{i'}(3) \text{ is a spy at } t_{i'} \text{ in } w_{i'}$$

If $g_c(3) = x_c$, the intension is a total function from circumstances to truth values; if not, it is undefined for every circumstance. It's straightforward to verify that this account predicts the following for (9):

- $[\![\text{Ralph believes that I}_3 \text{ am a spy}]\!]^{c,i}$ is defined iff there is a base world $\langle w_i, t_i, g, G\rangle$ for Ralph at t_i in w_i such that
  - g and g_i agree on all elements in $dom[\![\text{I}_3 \text{ am a spy}]\!]^c$, and
  - every sequenced world $\langle w', t', g'\rangle$ in $Bel_{Ralph}^{w_i,t_i,g,G}$ is such that $g_c(3) = x_c$.

  Note that this definedness condition amounts to the following: $g(3) = g_i(3)$, and $g_c(3) = x_c$.
- Where defined, $[\![\text{Ralph believes that I}_3 \text{ am a spy}]\!]^{c,i} = 1$ iff there is a base world $\langle w_i, t_i, g, G\rangle$ for Ralph at t_i in w_i such that:
  - g and g_i agree on all elements in $dom[\![\text{I}_3 \text{ am a spy}]\!]^c$, and
  - every sequenced world $\langle w', t', g'\rangle$ in $Bel_{Ralph}^{w_i,t_i,g,G}$ is such that $g'(3)$ is a spy at t' in w'

[14] Note that this semantics predicts that the presuppositions of pronouns alway project to the global context (unless the pronoun is embedded under a monstrous operator). Given the empirical facts discussed in Heim (2008), this may be a welcome prediction.

If the semantic value of the sentence is defined at a context c, then $g_c(3)$ will be the speaker of the context. Where defined, the sentence will be true at c iff

> there is a base world $\langle w_c, t_c, g, G\rangle$ for Ralph at t_c in w_c such that:
>
> - g and g_c agree on all elements in $dom[\![\text{I}_3 \text{ am a spy}]\!]^c$, and
> - every sequenced world $\langle w', t', g'\rangle$ in $Bel_{Ralph}^{w_c,t_c,g,G}$ is such that $g'(3)$ is a spy at t' in w'

And since 3 is the only element in $dom[\![\text{I}_3 \text{ am a spy}]\!]^c$, this is equivalent to:

> there is a base world $\langle w_c, t_c, g, G\rangle$ for Ralph at t_c in w_i such that:
>
> - $g(3) = g_c(3)$, and
> - every sequenced world $\langle w', t', g'\rangle$ in $Bel_{Ralph}^{w_c,t_c,g,G}$ is such that $g'(3)$ is a spy at t' in w'

Since $g_c(3)$ is the speaker of c, the sentence is true just in case Ralph believes that the speaker of c is a spy (relative to some acquaintance relation or other). Note that the definedness condition essentially imposes two conditions: that Ralph has beliefs about the speaker (i.e. that the speaker appears in Ralph's base world), and that the third member of the context assignment is the speaker.

6.3. Proper names

A number of authors have defended the idea that names are assignment-sensitive (Yagisawa 1984; Geurts 1997; Dever 1998; Cumming 2008). The main motivation for these authors is the observation that names can be bound, as in (10):

10. If a child is christened "Goofy", and the CEO of Disney hears about it, he'll sue Goofy's parents. (Geurts 1997, 322)

Intuitively, (10) has a reading on which it is true just in case:

> For every x, if (x is a child christened "Goofy" and the CEO hears that x is christened "Goofy"), then (the CEO sues x's parents).

If that's right, then it appears that the occurrence of *Goofy* in the consequent of (10) is bound, presumably by material in the antecedent (or perhaps by the conditional operator).

Cumming (2008, 535) gives another example:

11. There is a gentleman in Hertfordshire by the name of "Ernest". Ernest is engaged to two women.

As Cumming notes, this pair of sentences appears to be true just in case:

> There is an x such that (x is a gentleman in Hertfordshire named "Ernest" and x is engaged to two women).

If that's right, then the occurrence of *Ernest* in the second sentence of the discourse in (11) appears to be bound by material found in the first sentence.

Motivated by these examples and the other arguments provided by these authors, I wish to explore an assignment-sensitive semantics for proper names. How would such a theory go? A simple way to do this generalises our earlier treatment of pronouns. On this approach, we assume that each proper name bears a numerical index at LF. We place a definedness condition on the semantic value of the name-plus-index to the effect that it is defined at a point of evaluation c, i only if g_c maps the index to the intuitive referent of of the name. Here is the idea:

$$[\![\text{Ortcutt}_2]\!]^{c,i} : g_c(2) = \text{Ortcutt.}\ \ g_i(2)$$

Given this semantics for names, and our analysis of attitude verbs, it's not hard to see how the resulting account generates the sequenced worlds truth conditions for reports like (12):

12. Ralph believes that Ortcutt$_2$ is a spy.

Since our treatment of this case isn't substantially different from our treatment of reports with pronouns in the scope of the attitude verb, I'll simply record the predicted truth conditions of this sentence:

- $[\![$Ralph believes that Ortcutt$_2$ is a spy$]\!]^{c,i}$ is defined iff there is a base world $\langle w_i, t_i, g, G\rangle$ for Ralph at t_i in w_i such that:
  - g and g_i agree on all elements in $dom[\![$Ortcutt$_2$ is a spy$]\!]^c$, and
  - every sequenced world $\langle w', t', g'\rangle$ in $Bel^{w_i,t_i,g,G}_{Ralph}$ is such that $g_c(2) =$ Ortcutt.
- Where defined, $[\![$Ralph believes that Ortcutt$_2$ is a spy$]\!]^{c,i} = 1$ iff there is a base world $\langle w_i, t_i, g_i, G\rangle$ for Ralph at t_i in w_i such that
  - g and g_i agree on all elements in $dom[\![$Ortcutt$_2$ is a spy$]\!]^c$, and
  - every sequenced world $\langle w', t', g'\rangle$ in $Bel^{w_i,t_i,g,G}_{Ralph}$ is such that $g'(2)$ is a spy at t' in w'.

Let c, i_c be a point of evaluation at which this sentence is defined. When we assess this sentence for truth at c, the assignment of the circumstance will be identical to the assignment of the context g_c, which maps 2 to Ortcutt. So the sentence will be true at c just in case Ralph believes that Ortcutt is a spy (relative to some acquaintance relation or other).

6.4. Definite descriptions and quantifiers

As is well-known, definite descriptions occurring in the scope of an attitude verb often give rise to two readings. Consider (13), for example:

13. Ralph believes that the man who orchestrated the GM bailout is a crook.

Suppose that Ralph doesn't know who orchestrated the GM bailout, but doesn't believe that whoever did is a crook (why would the President ask a crook to fix the auto industry?). Then (13) is false on its *de dicto* reading. But suppose further that Ralph believes that the financier Steve Rattner is a crook, on account of his participation in a kick-back scheme with the New York state pension fund. Since Rattner is in fact the man who orchestrated the GM bailout, (13) could, in the right sort of context, be used to report this second belief of Ralph's, and so would be counted true. This true reading is the *de re* reading of (13); its truth doesn't require Ralph to ascribe crook-hood to the man who orchestrated the bailout under the description *the man who orchestrated the bailout*.

We want an account of (13) that will predict both these readings. Although there is evidence that definite descriptions can be bound, our analysis doesn't actually require us to treat definite descriptions as assignment-sensitive. We can in fact generate both readings given fairly familiar (if not uncontroversial) assumptions about the semantics of definite descriptions. Still, our account of *de re* ascriptions with definites fits in with our general theme of assignment-sensitivity, since the account exploits the assignment-sensitivity of the *trace* left behind by a wide-scoped definition description.

The account has two main parts. First, we treat the definite article à la Frege and Strawson, i.e. as presupposing, rather than asserting, existence and uniqueness. In our system, this means giving the following semantics for the definite article (letting k be the type of a sequenced world):

- $[\![\text{the}]\!]^{c,i} = \lambda f_{\langle k,e\rangle} : \exists! x(f(i)(x) = 1).\ \iota x f(i)(x) = 1$
- $[\![\text{the man who orchestrated the GM bailout}]\!]^{c,i}$ is defined iff $\exists! x$ (x orchestrated the GM bailout at t_i in w_i).

  Where defined, $[\![\text{the man who orchestrated the GM bailout}]\!]^{c,i}$ = the man who orchestrated the GM bailout at t_i in w_i.

Second, we shall suppose that the *de dicto*/*de re* ambiguity is generated by a scope ambiguity: when the description has narrow scope with respect to the attitude verb, the *de dicto* reading results; when it has wide scope, the *de re* reading results.[15]

To illustrate this, begin with the *de dicto* reading. Computing this reading is entirely straightforward, and so I here record only the predicted truth-conditions:

- $[\![\text{Ralph believes that the man who orchestrated the GM bailout is a crook}]\!]^{c,i}$ is defined iff there is a base world $\langle w_i, t_i, g, G\rangle$ such that:

[15] Analysing the *de dicto-de re* ambiguity in terms of scope is controversial, though not wholly unmotivated (see Keshet (2008) for a recent discussion of the issues involved). The broad approach taken in this paper is, I think, compatible with an alternative treatment of the interaction between definites and attitude verbs, one which doesn't involve appeal to scope. But I leave working out the details of this as a matter for future work.

- g and g_i agree on all elements in dom[[the man who orchestrated the GM bailout is a crook]]^c, and
- every sequenced world $\langle w', t', g'\rangle$ in $Bel_{Ralph}^{w_i,t_i,g,G}$ is such that there is a unique man who orchestrated the GM bailout at t' in w'.

- Where defined, [[Ralph believes that the man who orchestrated the GM bailout is a crook]]$^{c,i} = 1$ iff there is a base world $\langle w_i, t_i, g, G\rangle$ for Ralph at t_i in w_i such that:
  - g and g_i agree on all elements in dom[[the man who orchestrated the GM bailout is a crook]]^c, and
  - every sequenced world $\langle w', t', g'\rangle$ in $Bel_{Ralph}^{w_i,t_i,g,G}$ is such that the unique man who orchestrated the GM bailout at t' in w' is a crook in at t' in w'.

Since dom[[the man who orchestrated the GM bailout is a crook]]^c is empty, this boils down to:

> there is a base world $\langle w_i, t_i, g, G\rangle$ for Ralph at t_i in w_i such that every sequenced world $\langle w', t', g'\rangle$ in $Bel_{Ralph}^{w_i,t_i,g,G}$ is such that the unique man who orchestrated the GM bailout at t' in w' is a crook in at t' in w'.

The *de re* reading of (13) is generated when that sentence has something like the following LF:

> The man who orchestrated the GM bailout [λ_2 Ralph believes that x_2 is a spy]

Note that x_2 is a trace left behind by the definite, which has moved above the attitude verb. Importantly, the semantic value of a trace is determined by the variable assignment of the circumstance.

It's easiest to see how the truth-conditions of the *de re* reading are computed if we split the calculation into two parts, the definite (which we've already computed above) and the property-abstract. Note that [[x_2 is a crook]]^c is defined for all circumstances, and so we can ignore the definedness clause. We compute the value of the property abstract thus:

- [[λ_2 Ralph believes that x_2 is a crook]]^{c,i} =
- $\lambda y.$[[Ralph believes that x_2 is a crook]]$^{c,\langle w_i, {g_i}^{y/2}\rangle}$ =
- ($\lambda y.$ there is a base world $\langle w_i, t_i, g, G\rangle$ for Ralph at t_i in w_i such that:
  - g and ${g_i}^{y/2}$ agree on all elements in dom[[x_2 is a crook]]^c, and
  - every sequenced world $\langle w', t', g'\rangle$ in $Bel_{Ralph}^{w_i,t_i,g,G}$ is such that [[x_2 is a crook]]$^{c,\langle w', t', g'\rangle} = 1$) =

- λy. there is a base world $\langle w_i, t_i, g, G\rangle$ for Ralph at t_i in w_i such that
  - $g(2) = {g_i}^{y/2}(2) = y$, and
  - every sequenced world $\langle w', t', g'\rangle$ in $Bel^{w_i,t_i,g,G}_{Ralph}$ is such that $g'(2)$ is a crook at t' in w'

Now suppose that Steve Rattner is the man who organised the GM bailout at t_i in w_i. Then (13) will be true at c, i iff:

> there is a base world $\langle w_i, t_i, g, G\rangle$ for Ralph at t_i in w_i such that
> - $g(2) =$ Rattner, and
> - every sequenced world $\langle w', t', g'\rangle$ in $Bel^{w_i,t_i,g,G}_{Ralph}$ is such that $g'(2)$ is a crook at t' in w'

And this is exactly what we want.

This last calculation shows how *de re* readings of quantificational examples would work, like the sentence with which we began the paper:

2. Ralph believes that someone is a spy.

The *de re* reading can again be generated by scoping out the quantifier:

> Someone [λ_2 Ralph believes that x_2 is a spy]

To calculate the truth conditions of this, one applies the meaning of the quantifier to the meaning of the property-abstract which we computed above. Again, the assignment-sensitivity of the trace left behind by the quantifier plays a crucial role in generating the right reading. The *de dicto* reading results from interpreting the quantifier *in situ*.

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