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Attitude Verbs

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Abstract

Attitude verbs give rise to a number of puzzles concerning the interpretation of sentences in their scope; so-called ‘opacity effects’. We introduce two of these puzzles, taking them as a window onto the proper semantic analysis of attitude predicates, based on a proposal from Hintikka (1969). The core case is *believe*, but we show that the basic approach can be applied to other verbs, such as *say* and (with some modification) *want*. One challenge to the view developed comes from reports of attitudes ‘de se’, which suggests that attitude verbs should receive a more fine-grained analysis than that proposed by Hintikka. We close by considering two current research directions that inform and are informed by the study of attitude verbs: perspective-sensitive expressions such as predicates of personal taste and epistemic modals, and the acquisition of attitude verbs, with focus on *think*.

Keywords

Attitude reports; Frege’s puzzle; possible worlds; de se; centred worlds; predicates of personal taste; epistemic modals; child language acquisition; *believe*; *want*

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1. Introduction

One of the things speakers can use language for is to report on the mental state or a communicative act of some individual – what she believes, wants, hopes, says, etc. Here are some examples:

- (1)
 - a. Burt believes that it is raining in New York.
 - b. Joan wants to go to the movies.
 - c. Peggy hopes that she will get a raise.
- (2)
 - a. Pete said that the bagel was tasty.
 - b. Don promised that he would be home for dinner.
 - c. Roger claimed that his car had broken down.

Believe, *want* and *hope* are verbs of mental attitude, and *say*, *promise* and *claim* are communication verbs. We shall employ a cover term for these two classes: *attitude verbs*. We will see in section 4 that verbs of mental attitude and communication verbs have enough in common to justify categorizing them under the same heading.

Attitude verbs typically take a clausal complement, along with one or two nominal arguments. We will refer to the nominal argument that denotes the bearer of the attitude or the agent of the reported speech act as the *attitude holder*. A sentence whose main verb is an attitude verb is called an *attitude report*.

This chapter is structured as follows. Section 2 introduces two puzzles concerning the interpretation of clausal complements of attitude verbs. Section 3 presents the standard semantics for *believe* (Hintikka 1969), and shows how it provides solutions to the puzzles discussed in the previous section. The semantics of attitude verbs beyond *believe* is the topic of section 4. A theme of this section is that while there are interesting differences in the behavior of particular attitude verbs, these can generally be accommodated within Hintikka's approach. An arguably more fundamental challenge is presented by so-called attitudes 'de se', discussed in section 5. In section 6, we survey two topics that interact in interesting ways with the semantics of attitude verbs – perspective-sensitivity, and the acquisition of attitude verbs, with particular attention to *think*. Section 7 concludes.

2. Puzzles about attitude verbs

In what ways are attitude verbs different from other expressions? There are several well-known puzzles that are peculiarly associated with attitude reports. In this section, we present two of them.

2.1 Substitution failures with co-referring terms

First, Frege's puzzle (Frege 1892; cf Kripke 1980): suppose we are living at a time at which the President of the USA is Barack Obama, and I tell you that right now, the President of the USA is eating a sandwich. Armed with these two pieces of information, you will conclude that (3) is true.

- (3) Barack Obama is eating a sandwich.

Given a true, present tense sentence S containing the expression *the President of the USA*, replacing this phrase with one that refers to whoever is President of the USA right now yields a sentence S' that is also true. The reverse also holds: if S contains the expression *Barack Obama* and S is true, then a sentence S' obtained by replacing *Barack Obama* with *the President of the USA* is also true. In general, for any sentence S containing a referring expression E, E can be replaced with a co-referring term E' without alteration of truth value.

The generalization breaks down when the sentences of interest are clausal complements of attitude verbs. Consider the following.

- (4) a. Jack believes that the President of the USA is eating a sandwich.
b. Jack believes that Barack Obama is eating a sandwich.

Could there be a situation where (4a) is true but (4b) is false? Of course. All it would take is for Jack not to know that the US President is Barack Obama. He might be watching a news report, say, that reports on what the President is doing right now, but neglects to refer to the President by name.¹ It thus seems that substitution of co-referring terms may fail to be truth-preserving if the terms occur in the complement of an attitude verb.

2.2 Contingency with empty predicates

The first puzzle illustrated how the interpretation of sentences in the scope of attitude verbs may differ from their interpretation when they stand alone – the so-called ‘opacity’ of attitude reports. Here is another example: consider an empty predicate P, such as *unicorn*. Let S be any sentence of form ‘A P Q’, where Q is any predicate. No empirical investigation is required in order to establish that S is false (5a), or that ‘not S’ is true (5b).

- (5) a. A unicorn is in the garden.
b. A unicorn isn't in the garden.

Matters change if the sentence is embedded below an attitude verb:

- (6) Sally believes that a unicorn is in the garden.

This time, our knowledge about unicorns is not enough to judge whether the sentence is true. In order to do that, we would have to find out something about Sally's mental state. In general, the truth of a report of form ‘x believes that S’ is independent of the truth of S. Thus the fact that *A unicorn is in the garden* is false is not grounds for rejection of *Sally believes that a unicorn is in the garden*. An adequate semantics for attitude verbs should accommodate this observation. The development of such a semantics is the goal of section 3.

3. Hintikka semantics for attitude verbs

In this section, we present the classical formal semantics of attitude verbs, developed by Hintikka (1969).

Take the verb *believe*. It takes as its arguments a sentence meaning (a proposition) and an individual (the attitude holder); the resulting belief report itself expresses a proposition. We thus need a semantics for this verb that illuminates how the proposition expressed by the embedded clause is related to the proposition expressed by the report as a whole. Propositions are (characteristic functions of) sets of possible worlds.² The truth of the proposition expressed by a belief report must somehow depend on the proposition expressed by the embedded clause; otherwise, we couldn't explain why replacing the embedded clause in *Michelle believes that the President of the USA is Barack Obama* with ...*that Paris is in Germany* could change the truth value of the report. Yet we have seen that the truth of a belief report is independent of the truth of the embedded sentence that it contains. The question then, is: if not truth, then what property must the embedded sentence have in order for the report to be true? Our answer should provide solutions to the puzzles in the previous section; more generally, it should capture how the truth of a belief report depends upon the mental state of the attitude holder.

What then are beliefs? Intuitively, my beliefs represent ways that things are, according to me. Agents do a lot of reasoning about how things are, or how they might be. Possible worlds can be pressed into service to model such reasoning. For example, there are plenty of questions that are not settled by my belief state. Right now I do not know, for instance, where my brother David is. He could be in his office, or he could be at a café, or he could have left work early and gone home. As far as I'm concerned, then, there is at least one possible world w where David is in his office, at least one where he is in a café, and at least one where he is at home. This state of affairs looks something like this:

- (7) w_1 : David is in his office in w_1
 w_2 : David is in a cafe in w_2
 w_3 : David is at home in w_3

For all that I believe, w_1 , w_2 or w_3 could be the actual world, but I am in no position to judge which of these worlds is in fact actual. Indeed none of us have belief states that identify a single world as actual; our beliefs simply leave too many questions unsettled. The best we can do is have a set of *candidates* for the actual world. Our beliefs determine which worlds we take to be in the running to be the actual world, and which worlds we rule out.

Suppose for example that Michelle believes that Barack Obama is the President of the USA. It follows that if Barack Obama is not the US President in w_7 , then Michelle does not consider w_7 a candidate for the actual world. We can model Michelle's candidates for the actual world as a set, called her *doxastic alternatives*, and write $\text{Dox}_{\text{Michelle},w}$. We define this set as follows.

- (8) $\text{Dox}_{\text{Michelle},w} = \{w' : \text{in } w, \text{ Michelle considers } w' \text{ a candidate for } w\}$

What Michelle believes is itself a contingent matter – there are worlds where Michelle does not believe that Barack Obama is the US President, it just so happens that (in our scenario) none of those is the actual world. We capture this by relativizing a set of doxastic alternatives not only to the individual whose belief state the set models, but also to a world. (8) defines Michelle's doxastic alternatives in w as those worlds w' that Michelle takes to be a candidate for w .

Michelle will consider w' to be a candidate for the actual world only if everything that she believes to be true is true in w' . In our toy example, w_7 is not a candidate for the actual world for Michelle, given that Barack Obama is not the US President in w_7 . We will say that it is not *compatible* with what Michelle believes for w_7 to be the actual world, since there is something that Michelle believes to be true that is false in w_7 . Let's reformulate our definition of Michelle's doxastic alternatives in these terms. In addition, we generalize the definition to any arbitrary attitude holder, by replacing *Michelle* with a variable over individuals x .

- (9) *Doxastic alternatives*
 $\text{Dox}_{x,w} = \{w' : \text{it is compatible with what } x \text{ believes in } w' \text{ for } w \text{ to be } w'\}$

Recall that our goal is to explicate the relationship between the proposition expressed by the embedded sentence in a belief report, and the proposition expressed by the report itself. Doxastic alternatives will help us achieve this. Consider the sentence *Michelle believes that Barack Obama is the President of the USA*. Intuitively, it makes a claim about Michelle's candidate worlds – namely, that they are all worlds where Barack Obama is the US President. That must be, since if Michelle believes that Barack Obama is the President of the USA, then any world in which he is *not* the US President must be excluded from Michelle's set of candidate worlds. The truth conditions of a belief report can thus be stated as a universal quantification over elements of the attitude holder's set of doxastic alternatives, or equivalently, in terms of a subset relation between the attitude holder's doxastic alternatives, and the set of worlds characterized by the embedded clause.^{3 4}

- (10) $\llbracket \text{Michelle believes that Barack Obama is the President of the USA} \rrbracket^{g,w} = 1$ iff
 $\text{Dox}_{\text{Michelle},w} \subseteq \{w' : \text{Barack Obama is the President of the USA in } w'\}$

We are almost ready to give the truth conditions of an arbitrary belief report. We shall treat DPs as individual-denoting expressions, ignoring quantificational expressions to keep things simple. We also distinguish between the *extension* of an expression in a world w , and its *intension*.⁵ The extension of a sentence S in w is its truth value in w . An intension is a function from worlds w' to extensions in w' . Thus the intension of S (a proposition) is a function from worlds to truth values. *DP believes that S* is true just in case the attitude holder's doxastic alternatives are a subset of the proposition expressed by S :

- (11) $\llbracket \text{DP believes that } S \rrbracket^{g,w} = 1$ iff $\text{Dox}_{x,w} \subseteq p$
 Where x is the denotation of *DP* in w and p is the proposition expressed by S .

(11) answers the question of what property the embedded clause S must have in order for the belief report to be true: the report is true just in case the proposition expressed by S is a superset of the attitude holder's doxastic alternatives. Since it is the attitude holder's psychological state that determines which worlds belong among her doxastic alternatives, this captures the fact that the truth of belief reports depends on facts about the attitude holder's mental state.

So much for the semantics of belief reports; what about the lexical entry of *believe* itself? We assume that the structure of *Michelle believes that Barack Obama is the President of the USA* is as in (12):

(12) $[_{CP} [_{IP} \text{Michelle} [_{VP} \text{believes} [_{CP} \text{that} [_{IP} \text{Barack Obama is the President of the USA.}]]]]]$

Believe takes as its first argument the intension of its clausal complement (a proposition), and as its second argument the denotation of the subject (an individual). It returns the value ‘true’ under the conditions in (11). The lexical entry is given in (13).

(13) *Hintikka-semantics for believe*
 $[[\text{believe}]^{\mathfrak{g}, w} = \lambda p \in D_{\langle s, t \rangle} \cdot \lambda x \in D_e \cdot \text{Dox}_{x, w} \subseteq p$
 Where $\text{Dox}_{x, w} = \{w' : \text{it is compatible with what } x \text{ believes in } w \text{ for } w \text{ to be } w'\}$

This semantics requires *believe* to be fed a sentence intension as an argument. We therefore need a composition rule that enables the attitude verb to compose with intensions of linguistic expressions. We shall use *Intensional Functional Application* for this purpose:⁶

(14) *Intensional Functional Application (IFA)*
 If α is a branching node and $\{\beta, \gamma\}$ the set of its daughters, then, for any possible world w and any assignment g , if $[[\beta]]^{\mathfrak{g}, w}$ is a function whose domain contains $\lambda w'$. $[[\gamma]]^{\mathfrak{g}, w'}$ then $[[\alpha]]^{\mathfrak{g}, w} = [[\beta]]^{\mathfrak{g}, w}(\lambda w'. [[\gamma]]^{\mathfrak{g}, w'})$
 [Based on Heim & Kratzer 1998: ex 9, p. 308]

The denotation of a sentence S in a world w , written $[[S]]^w$, is the truth value of S in w . The intension of S is obtained by abstracting over the world parameter, to give the lambda term $\lambda w'. [[S]]^{\mathfrak{g}, w'}$. IFA supplies this meaning as the argument of a function whose domain contains such meanings, such as an attitude verb.

Let’s now calculate the meaning of (12). (We assume that the complementizer *that* is semantically vacuous. An alternative approach would be to follow Montague 1970 in assuming that it expresses abstraction over the world parameter.)

(15) a. $[_{CP1} \text{Michelle} [_{VP} \text{believes} [_{CP2} \text{that Barack Obama is the President of the USA.}]]]$
 b. $[[CP2]]^{\mathfrak{g}, w} = 1$ iff Barack Obama is the President of the USA in w
 c. $[[VP1]]^{\mathfrak{g}, w} =$ (by IFA)
 $[[\text{believe}]^{\mathfrak{g}, w}(\lambda w'. [[CP2]]^{\mathfrak{g}, w'}) =$
 $\lambda x \cdot \text{Dox}_{x, w} \subseteq \{w' : \text{Barack Obama is the President of the USA in } w'\}$
 d. $[[CP1]]^{\mathfrak{g}, w} =$
 $\text{Dox}_{\text{Michelle}, w} \subseteq \{w' : \text{Barack Obama is the President of the USA in } w'\}$

Alternatively, we can get by without IFA if we assume the presence of abstractors over world variables in the syntax (Enc 1981, Groenendijk & Stokhof 1984, Farkas 1993, Percus 2000). It is beyond the scope of this chapter to provide a comparison of these two

approaches (though see ARTICLE [*Index-dependence and Scope*] for discussion of data bearing further on these issues). For our purposes, we can think of them simply as different implementations of the same insight: a belief report characterizes that set of worlds w such that the attitude holder's doxastic alternatives in w is a subset of the set of worlds characterized by the embedded clause. The truth of the belief report therefore depends not on the truth of the embedded clause in the actual world, but rather on its truth in the attitude holder's doxastic alternatives. This insight provides solutions to the two puzzles discussed in section 2: substitution failures with coreferring terms (16), and contingency with empty predicates (17):

- (16) a. Jack believes that the President of the USA is eating a ham sandwich.
b. Jack believes that Barack Obama is eating a ham sandwich.

- (17) John believes that a unicorn is in the garden.

We noticed that in a situation where Jack does not believe that the President of the USA is Barack Obama, it could be that (16a) is true, but (16b) is false. According to our semantics, (16a) is true just in case Jack's doxastic alternatives are a subset of the set A of worlds in which the President of the USA is eating a ham sandwich, while (16b) is true if and only if his doxastic alternatives are a subset of the set B of worlds in which Barack Obama is eating a ham sandwich. For the first to be true, and the second false, then, A and B had better not be the same set. And indeed they're not: A might include not only worlds in which Barack Obama is President and he is eating a ham sandwich, but also worlds in which the President is Hilary Clinton and Hilary Clinton is eating a ham sandwich, and worlds in which the President is Donald Trump and Donald Trump is eating a ham sandwich, and so on. By contrast, the only worlds that may be members of B are worlds where Barack Obama is eating a ham sandwich. Consequently a situation where the President of the USA is not Barack Obama throughout Jack's doxastic alternatives can potentially support the truth of (16a) without it following that (16b) is true.

The approach can also explain the contingency of (17): the sentence requires that John's belief worlds be a subset of the set of worlds where a unicorn is in the garden. That our common knowledge excludes such worlds is irrelevant; we can only know whether the sentence is true by inspection of those worlds compatible with what John believes. In general, since all that is relevant for the truth of a belief report is that the attitude holder's doxastic alternatives are a subset of the set of worlds characterized by the embedded clause, the truth of the report is correctly predicted to be independent of the truth of the embedded clause.

4. Beyond *believe*

Our lexical entry for *believe* provides a template for the semantics of attitude verbs as a class. Following Hintikka (1969), attitude verbs have traditionally been treated as universal quantifiers over worlds; variation in the meaning of particular predicates is attributed to the type of modal alternative that is quantified over. We have seen that *believe* is a universal quantifier over doxastic alternatives – worlds that the attitude holder considers candidates for the actual world. Consider now a speech act verb such as *say* or *claim*. These should not

quantify over doxastic alternatives, since saying something is no guarantee of believing it. We will define a set of *say*-alternatives as follows.

- (18) *Say*-alternatives
 $Say_{x,w} = \{w': \text{it is compatible with what } x \text{ says in } w \text{ for } w \text{ to be } w'\}$

This definition differs from that of doxastic alternatives in that ‘believes’ on the right hand side of the colon is replaced with ‘says’. We can gloss the notion of worlds compatible with what *x* says as worlds in which what *x* says is true. The semantics of *say* is in (19).

- (19) *Lexical entry of say*
 $[[\text{say}]]^{s,w} = \lambda p \in D_{\langle s,t \rangle} . \lambda x \in D_e . Say_{x,w} \subseteq p$
 Where $Say_{x,w} = \{w': \text{it is compatible with what } x \text{ says in } w \text{ for } w \text{ to be } w'\}$

The semantics predicts that *Michelle says that Barack Obama is the President of the USA* is true just in case for every world *w'* such that what Michelle says in *w* is true in *w'*, Barack Obama is the President of the USA in *w'*. The opacity puzzles from section 2 are replicated with *say*: (20a) and (20b) have readings on which they are not equivalent.

- (20) a. Jack said that the President of the USA was eating a sandwich.
 b. Jack said that Barack Obama was eating a sandwich.

This suggests that the treatment of attitude verbs as quantifiers over particular types of alternatives is along the right lines: in each case, opacity effects are explained by treating attitude verbs as operators that shift world variables in their scope.

For some verbs, however, a more nuanced picture is needed. Consider *want*. This verb quantifies over *buletic* alternatives:

- (21) *Buletic alternatives*
 $Bul_{x,w} = \{w': \text{it is compatible with the fulfillment of } x\text{'s desires in } w \text{ for } w \text{ to be } w'\}$

It seems reasonable to treat *want* as a universal quantifier over worlds where the attitude holder’s desires are fulfilled:

- (22) *Lexical entry of want – first version*
 $[[\text{want}]]^{s,w} = \lambda p \in D_{\langle s,t \rangle} . \lambda x \in D_e . Bul_{x,w} \subseteq p$
 $Bul_{x,w} = \{w': \text{it is compatible with the fulfillment of } x\text{'s desires in } w \text{ for } w \text{ to be } w'\}$

As expected, replacement of *say* with *want* in (20) yields non-equivalent sentences. Yet the following puzzle suggests that this cannot be all there is to it (Asher 1987). Suppose that Nicholas would love to fly in the Concorde for free, but is unwilling to pay the high price for a ticket. Intuitively, in this situation (23a) is false, but (23b) is true.

- (23) a. Nicholas wants to have a trip on the Concorde.
 b. Nicholas wants to have a free trip on the Concorde.

These judgments are unexpected given the semantics in (22). If (23b) is true, then at each of Nicholas's belief alternatives, Nicholas has a free trip on the Concorde. Since any world where Nicholas has a free trip on Concorde is a world where Nicholas has a trip on Concorde, it follows that if (23b) is true, then the predicted truth conditions for (23a) are also fulfilled. So (23b) is predicted to entail (23a), yet in Asher's example the former is true and the latter is false.

Nonetheless, work by Stalnaker (1984) and Heim (1992) suggests that *want* can be treated as a universal quantifier over worlds without deriving these unwelcome predictions. Building on a suggestion from Stalnaker, Heim treats a sentence of form *DP wants S* as meaning that the attitude holder believes that a world in which S is true is more desirable than a world in which S is false. Thus *want* is interpreted with respect to a doxastic modal base:

- (24) *Lexical entry of want - second version*

$$\llbracket \text{want} \rrbracket^{s,w} = \lambda p \in D_{\langle s,t \rangle} \cdot \lambda x \in D_e \cdot \text{Dox}_{x,w} \subseteq \{w' : \text{any world } w' \text{ maximally similar to } w' \text{ such that } w' \in p \text{ is more desirable to } x \text{ in } w \text{ than any world } w'' \text{ maximally similar to } w' \text{ such that } w'' \notin p\}$$

[Based on Heim 1992: ex 31, p. 193]

This semantics makes correct predictions regarding (23) given the plausible assumption that it is true in most of Nicholas's belief worlds that if he flies on Concorde, he will have to pay a high price for the privilege. For any world w' included in this majority, then, any world w'' that is maximally similar to w' in which Nicholas gets a trip on the Concorde is one in which Nicholas is obliged to pay for the ticket. (23a) is false in virtue of the fact that Nicholas does not prefer such a world to one where he does not fly on Concorde. (23b) can nonetheless be true, because the comparison is now between worlds where Nicholas has a free trip on Concorde and worlds where he does not fly on Concorde, and he prefers the former to the latter.

In this section, we sketched how Hintikka's semantics for *believe* provides a template that is applicable to other attitude verbs, including speech act verbs like *say*. The case of *want* illustrates that for certain verbs, a more nuanced account may be required. Nonetheless, the problematic example discussed can be reconciled with the core idea that attitude verbs are universal quantifiers over modal bases of a certain sort. Other issues concerning the semantics of particular attitude verbs have been discussed in connection with their presupposition projection behavior (Karttunen 1973, 1974, Heim 1992), NPI licensing with adversative attitude verbs such as *be sorry* and *regret* (von Stechow 1999), and the distribution of epistemic modals in their scope (Anand & Hacquard 2009, 2013; see ARTICLE [Epistemic Modality]).

In the next section, we turn to a puzzle that appears to present a fundamental challenge for Hintikka's semantics for attitude verbs.

5. Attitudes de se

Perry (1979) discussed the following case.

- (25) I once followed a trail of sugar on a supermarket floor, pushing my cart down the aisle on one side of a tall counter and back the aisle on the other, seeking the shopper with the torn sack to tell him he was making a mess. With each trip around the counter, the trail became thicker. But I seemed unable to catch up. Finally it dawned on me. I was the shopper I was trying to catch. [Perry 1979]

Until Perry realizes that he is the shopper with the torn sack of sugar, his belief state is such that he would be disposed to assent to the following two sentences.

- (26) a. The shopper with the torn sack of sugar is making a mess.
b. I am not making a mess.

What we know, but Perry has not yet discovered, is that the shopper with the torn bag of sugar is none other than Perry himself. Perry thus has a belief about himself that he is not aware is about himself – namely, that which he would be disposed to express by uttering (26a). At the same moment, he has many beliefs about himself that he is aware are about himself. Perry would be disposed to express these beliefs using sentences containing the first person pronoun, including (26b). Hintikka's semantics predicts that attitude reports should be insensitive to this distinction between 'first-personal' beliefs about the self, and beliefs about oneself that one does not realize are about oneself. Consider the details.

Perry believes that the shopper with the torn sack of sugar is making a mess, and the shopper with the torn sack of sugar is Perry himself. (27) is therefore true.

- (27) Perry_i believes that he_i is making a mess.

Yet since Perry is disposed to assent to (26b), the following sentence is also true.

- (28) Perry_i believes that he_i is not making a mess.

(27) and (28) contain sentences expressing incompatible contents: that Perry is making a mess, and that Perry is not making a mess. Hintikka's semantics for *believe* predicts that both sentences are true only if Perry is irrational: if in every world compatible with what Perry believes Perry is making a mess and not making a mess, then there are no worlds compatible with what Perry believes. Yet Perry is of perfectly sound mind; he simply happens to lack the crucial information that he is the shopper with the torn sack of sugar.

To address this problem, let's posit two distinct readings for the pronouns in (27) and (28). On the *de se* reading, the belief report containing the pronoun is only true if the attitude holder is aware that the content of her attitude is about herself. (28) is true on this reading, but (27) is false, since Perry does not think, 'I am making a mess'. Call the reading on which it does not matter whether the attitude holder is aware that the content of her belief is about herself the *de re* reading. (27) and (28) are both true on this reading.

Some readers may find the *de re* reading of (27) difficult to detect, in which case they will judge the sentence to be false. There seems to be a general preference for the *de se* reading over the *de re* reading. That does not matter much for our purposes, since the very existence

of the de se reading is unexpected given Hintikka’s semantics for *believe*. According to this semantics, (27) is true just in case Perry is making a mess in all worlds compatible with what Perry believes, and (28) is true just in case Perry is not making a mess at any of Perry’s doxastic alternatives.⁷ The particular way in which Perry is thinking about himself – with or without awareness that his belief is about himself – is predicted to be irrelevant to the truth of the reports. Yet the facts that (27) and (28) have readings on which they do not jointly entail that Perry is irrational, and that (27) has a reading on which it is false, demonstrates that this prediction is incorrect: the grammar cares about whether reports of beliefs about the self are first personal or not.

Moreover, it seems that the grammar goes so far as to provide a dedicated means of encoding first personal attitudes. A classic example is controlled PRO, which is obligatorily interpreted de se (Morgan 1970, Chierchia 1990). Many English attitude predicates are control verbs (eg *want*, *claim*, *hope*), although *believe* is not one of them. However, *believe* can take a control complement in many other languages, including German, Italian and French. In those languages, *Perry believes that he is making a mess* can be expressed as (29).

(29) Perry believes [PRO to be making a mess].

However, the subject of the infinitive, ‘PRO’, can only be read de se. We have seen that *he* in *Perry believes that he is making a mess* has both a de re reading and a de se reading, with respect to which the sentence is judged true and false respectively. By contrast, (29) in the relevant languages can only be judged false.

How can we enrich the semantics of attitude verbs in order to make the attitude holder’s cognitive access to the self count? When we introduced Hintikka’s semantics, we observed that we are never certain about which world we are in; the best we can do is to have candidates for the actual world. Perry’s scenario teaches us that we also live with uncertainty about who we are, in the sense that we can have certain properties (such as carrying a torn bag of sugar) without being aware of it. So our belief states furnish us with candidates for ourselves, as well as candidates for the actual world. Furthermore, the linguistic data show that attitude reports are sensitive to this uncertainty about who we are. Let us therefore treat doxastic alternatives not as sets of worlds, but as sets of world-individual pairs (so-called *centred worlds*; cf Lewis 1979⁸).

(30) *Doxastic alternatives – centred worlds version*
 $\text{Dox}_{x,w} = \{ \langle w', y \rangle : \text{it is compatible with what } x \text{ believes in } w \text{ for } x \text{ to be } y \text{ in } w' \}$

We will continue to assume that a belief report is true just in case the meaning expressed by the embedded clause returns truth when applied to each doxastic alternative. But if doxastic alternatives are world-individual pairs, then the intension of an embedded clause cannot be a set of worlds as before, but it must instead be a set of world-individual pairs – a property, type $\langle s, \langle e, t \rangle \rangle$. The revised lexical entry for *believe* is as follows.

(31) *Lexical entry of believe – centred worlds version*
 $\llbracket \text{believe} \rrbracket^{s,w} = \lambda P \in D_{\langle s, \langle e, t \rangle \rangle} \cdot \lambda x \in D_e \cdot \text{Dox}_{x,w} \subseteq P$

Where $\text{Dox}_{x,w} \{ \langle w', y \rangle : \text{it is compatible with what } x \text{ believes in } w \text{ for } x \text{ to be } y \text{ in } w' \}$

How can we ensure that the embedded clause has property-type meaning? A straightforward method is to postulate an individual abstractor that binds a pronoun in its scope. We assume that PRO and *he* (on its de se construal) are bound by an individual abstractor in embedded C (Chierchia 1990):

- (32) a. $[_{CP1} \text{ Perry } [_{VP} \text{ believes } [_{CP2} \lambda x_1 [\text{he}_1 \text{ is making a mess}]]]]$
 b. $[_{CP1} \text{ Perry } [_{VP} \text{ believes } [_{CP2} \lambda x_1 [\text{PRO}_1 \text{ to be making a mess}]]]]$

The embedded clauses in both examples receive the same interpretation:

- (33) $[[CP2]]^{g,w} = \lambda x. x \text{ is making a mess in } w$

The truth conditions are calculated as follows.

- (34) a. $[[VP]]^{g,w} =$ (by IFA)
 $[[\text{believe}]]^{g,w}(\lambda w'. [[CP2]]^{g,w'}) =$
 $[[\text{believe}]]^{g,w}(\lambda w' \lambda x. x \text{ is making a mess in } w') =$
 $\lambda x. \text{Dox}_{x,w} \subseteq \{ \langle w', y \rangle : y \text{ is making a mess in } w' \}$
 b. $[[CP1]]^{g,w} = \text{Dox}_{\text{Perry},w} \subseteq \{ \langle w', y \rangle : y \text{ is making a mess in } w' \}$

This semantics correctly predicts that (32a) and (32b) are judged false (on the de se reading of *he*). The sentences are true only if for every centred world $\langle w', y \rangle$ such that Perry considers *y* a candidate for himself and w' a candidate for the actual world, *y* is making a mess in w' . Since Perry does not ascribe to any of his candidates for himself the property of making a mess, the sentence is false. The view that the meaning of the embedded clause is of property-type implements an insight due to Lewis – namely, that attitudes de se are self-ascriptions of properties (Lewis 1979).

We have argued that Hintikka's semantics cannot handle cases where the verb embeds a de se pronoun, and enriched the semantics accordingly. What about when there is no de se pronoun? Consider the following example, repeated from the introduction.

- (35) Burt believes that it is raining in New York.

Here, treating *believe* as a quantifier over world-individual pairs results in vacuous quantification: there is no pronoun for the individual coordinate of the centred worlds ranged over by the verb to bind. It is therefore usually assumed that there are (at least) two lexical entries for *believe* – one that is a quantifier over centred worlds, and another that is an ordinary modal quantifier. Conceptually, however, there is no problem with treating all attitudes as self-ascriptions of properties. Lewis (1979) pointed out that for every proposition that is the content of some attitude, there is a corresponding property. When Burt believes that it is raining in New York, he locates himself in a world where it is raining in New York; that is, he self-ascribes the property of inhabiting a world where it is raining in

New York. Lewis’s insight that all attitudes are reducible to attitudes de se has usually been set aside by linguists in favor of an ambiguity approach, presumably to avoid the vacuous binding problem.

The move to centred worlds can be generalized to attitude verbs beyond *believe*, which also give rise to de se readings. For example, an updated lexical entry for *say* is shown below.

- (36) *Lexical entry of say - centred worlds version*

$$\llbracket \text{say} \rrbracket^{g,w} = \lambda P \in D_{\langle s, \langle e, t \rangle \rangle} \cdot \lambda x \in D_e \cdot \text{Say}_{x,w} \subseteq P$$
 Where $\text{Say}_{x,w} \{ \langle w', y \rangle : \text{it is compatible with what } x \text{ says in } w \text{ for } x \text{ to be } y \text{ in } w' \}$

In this section, we have argued that Hintikka’s semantics for attitude verbs is too coarse-grained to account for de se reports. We have described one response to this challenge, which maintains the idea that attitude verbs are universal quantifiers, with the elements quantified over being world-individual pairs. A prominent competitor to this view treats de se as a special case of de re construal; we describe this alternative view below.

On the de re construal of the pronoun in *Perry, believes that he, is making a mess*, the sentence is true in virtue of the facts that (i) Perry believes that the shopper with the torn bag of sugar is making a mess and (ii) the shopper with the torn bag of sugar is Perry himself. There is likewise a reading of *Jack believes that Barack Obama is eating a sandwich* on which it is true in the scenario from section 2 where Jack believes that the President of the USA is eating a sandwich, but is unaware that the President of the USA is Barack Obama. On this reading, the sentence is true because (i) Jack believes that the President of the USA is eating a sandwich and (ii) the President of the USA is Barack Obama. A rough general procedure for deriving the truth conditions of a de re belief report S is to calculate the truth conditions of a counterpart of S which is obtained by replacing the individual-denoting expression in the embedded clause with a definite description that denotes the individual in question in the actual world. The task of giving a complete compositional semantics for de re belief reports is notoriously difficult, and we will not attempt it here (see for example Charlow and Sharvit (2014) for a recent attempt). For our purposes it suffices to note that de se can be treated as a special case of de re if one posits a special definite description corresponding to the individual that the attitude holder identifies as herself in her belief worlds. As argued in Reinhart (1990), Anand (2006) and Maier (2006, 2010, 2011), this is equivalent to letting the value of the de se pronoun range over those individuals whom the attitude holder considers candidates for herself. Regardless of whether one adopts the centred worlds approach or the de se-as-de re approach to attitudes de se, there is consensus that Hintikka’s semantics must be enriched in order to account for the distinguished role of first personal cognitive access to the self in certain reports.

6. New horizons

In this section, we discuss two recent directions in research on attitude reports. The first concerns how embedding below an attitude verb affects the interpretation of certain perspective-sensitive expressions such as predicates of personal taste (PPTs) and epistemic modals. The second investigates the acquisition profile of attitude verbs, with focus on *think*.

6.1 Perspective sensitive expressions

Consider (37).

(37) John: This cauliflower cheese is tasty.

Intuitively, *tasty* expresses a judgment concerning a certain subjective experience – here, eating this cauliflower cheese. Whose judgment is expressed, and what role is played by that individual the truth of the sentence, are vexed questions. In (37), it seems that John expresses his own judgment. If Mary has a different judgment, she may reply as follows:

(38) No, this cauliflower cheese is not tasty.

Why it should be that Mary can contradict John's utterance of (37) by replying with (38) is the puzzle of so-called 'faultless disagreement', discussed in ARTICLE [*Evaluative Predicates*]. One disagrees with a sentence expressing content *p* by expressing a sentence with content *not p*. But if (37) expresses John's judgment ('This cauliflower cheese is tasty to John'), and (38) expresses Mary's judgment ('This cauliflower cheese is not tasty to Mary'), then we have compatible, not contradictory propositions. We will not discuss in detail the various solutions to this puzzle that have been proposed in the literature (see ARTICLE [*Evaluative Predicates*]). Instead, we will show that predicates of personal taste (PPTs) display a distinctive behavior in the scope of attitude verbs, which helps to shed light on how they should be analyzed.

Consider (39).

(39) John thinks that this cauliflower cheese is tasty.

Here, the judgment reported is not the speaker's, but rather the attitude holder's. Indeed, it would be felicitous to follow (39) with ...*but I find it disgusting*. This observation is discussed in (Stephenson 2007a,b), who also observes that when the PPT is embedded below multiple attitude verbs, it is the most immediately dominating attitude holder whose opinion is relevant.

(40) Mary thinks that John thinks that this cauliflower cheese is tasty (but she thinks that she/#he finds it disgusting).

Stephenson observed that this 'Immediateness Requirement' also holds for epistemic modals. According to the classical treatment of these, (41a) says that it is compatible with what is known that it is raining, and (41b) says that what is known entails that it is raining.

(41) a. It might be raining.
b. It must be raining.

But whose knowledge is relevant? Intuitively, it seems to be the speaker's knowledge – in (41a) and (41b), the speaker reports on a judgment about the possibility or necessity of rain, given the evidence available to her. As with PPTs, matters change when epistemic modals are embedded below an attitude verb:

- (42) a. Bill thinks it might be raining (but I know that it isn't).
 b. Bill thinks that it must be raining (but I know that it isn't).

Here too, the Immediateness Requirement applies:

- (43) a. Sally thinks that Bill thinks that it might be raining (but she thinks that she/#he knows that it isn't).
 b. Sally thinks that Bill thinks that it must be raining (but she thinks that she/#he knows that it isn't).

Why should embedding below an attitude verb affect the perspective with respect to which a PPT or epistemic modal is evaluated? Several authors have concluded that the perspective-sensitivity of these expressions is affected by structural factors; we cannot simply say that the individual whose perspective is relevant is semantically underspecified, and supplied by context. In this respect, PPTs and epistemic modals are different from spatial predicates such as *left*. (44a) can report that the vase is to the left of the couch as viewed from the position of the speaker, or from that of some other salient individual, such as the addressee. This flexibility remains when *left* is embedded below *think*: in (44b) the perspective holder can but need not be John, and in (44c) it can but does not have to be either Mary or John.

- (44) a. The vase is to the left of the couch.
 b. John thinks that the vase is to the left of the couch.
 c. Mary thinks that John thinks that the vase is to the left of the couch.

Various authors have responded to Stephenson's observations about the behavior of PPTs and epistemic modals by treating the individual whose taste or information state is relevant as a variable that ranges over the individual coordinate of the centred worlds quantified over by the attitude verb (Stephenson 2007a,b, Moltmann 2010, Pearson 2013a,b). With *tasty*, for example, this can be implemented by positing a null pronominal as a covert Experiencer argument of *tasty*, which is bound by the individual coordinate of the centred worlds quantified over by the attitude verb, in a manner akin to the binding of PRO discussed in section 5. This predicts that when embedded below an attitude verb, PPTs and epistemic modals are obligatorily construed de se: the attitude holder must be aware that it is her own taste or knowledge state that is relevant to the reported judgment. For data suggesting that this prediction is borne out see Stephenson (2007a,b, citing personal communication from Pranav Anand) for epistemic modals, and Pearson (2013a) for PPTs.

To the extent that the analyses just sketched are successful, they support the fine-grained semantics for attitude verbs laid out in section 5. Conversely, the discussion illustrates how studying embedding behavior below attitude verbs sheds light on other linguistic expressions, particularly those that are sensitive to perspective.

6.2 The acquisition of attitude verbs

A robust finding in language acquisition research is that some attitude verbs – particularly *think* - are acquired relatively late. Although children begin to use *think* around the age of 2-3, experiments testing comprehension suggest that it is not interpreted correctly until around

four (Moore, Bryant & Furrow 1989, Johnson and Maratsos 1977, de Villiers & Pyers 2002). The tools for modeling attitude verb semantics described in this chapter are useful for identifying the challenges that these verbs present for acquisition.

According to both Hintikka's semantics, and its descendant based on centred worlds, the truth of a belief report depends not on whether the embedded clause is true in the actual world, but whether it yields truth when applied to the attitude holder's doxastic alternatives. To know the meaning of *think* is to know that *DP thinks that S* can be true even if S is in fact false. Such a situation can be employed to test whether a child has adult-like competence with the verb: if she judges a belief report true in a situation where the embedded sentence happens to be true, it will not be possible to exclude the possibility that she interprets the embedded sentence with respect to the actual world rather than the attitude holder's doxastic alternatives.

In a series of papers, Jill de Villiers and colleagues report experiments where children heard a story involving a character with a false belief, and answered a question about what they heard (de Villiers 1998, de Villiers and de Villiers 2000, de Villiers and Pyers 2002). Here is an example:

- (45) This girl saw something funny at a tag sale and paid a dollar for it. She thought it was a toy bird but it was really a funny hat.

Question: What did she think she bought?

In a longitudinal study testing 3 and 4 year olds on three occasions over seven months, de Villiers and Pyers (2002) found that children did not begin to give adult-like responses in this set-up until around the age of 4.

Intriguingly, this acquisition path mirrors the developmental trajectory of reasoning about false belief. The classic method of investigating the ability to understand that an individual may believe something that is false is the false belief task (Wimmer and Perner 1983). Children hear a story about a character, Maxi, who puts some chocolate in a blue cupboard before leaving the room. While he is out of the room, his mother puts the chocolate in a green cupboard. Maxi comes back, and the child is asked where he will look for the chocolate. 3 year olds give the answer corresponding to where the chocolate actually is – the green cupboard; the ability to recognize that Maxi will look in the blue cupboard because he does not know the chocolate has been moved does not emerge until the age of 4. The discovery that 4 year olds pass false belief tasks but 3 year olds do not has been replicated in many studies since Wimmer and Perner's seminal work; see Wellman, Cross and Watson (2001) for an overview and a meta-analysis confirming the robustness of the finding.

Note that what is tested in the classic false belief task is not linguistic competence with the meaning of belief reports: in this version, the child is asked where Maxi will look for the chocolate, not where he thinks it is. Rather, the task provides a measure of the child's ability to reason about the mental states of others, known as *theory of mind*. It is striking, then, that the age at which children start to comprehend verbs like *think* corresponds to when children pass false belief tasks. This has led a number of researchers to propose that the conceptual

development of false belief reasoning is a precondition for the acquisition of the meaning of verbs like *think* and *believe*.

On the other hand, the false belief task is subject to certain criticisms that raise the possibility that theory of mind develops earlier than is traditionally assumed. If so, then some other explanation would be needed for why *think* is acquired relatively late. It may be that children's initial 'failures' with false belief tasks is due to the relative complexity of the scenarios employed and of the language used to probe children's understanding of what happened. When children's gaze direction is measured instead of explicitly asking where the character will look, three year olds look to the place where he believes that the object is, rather than where it actually is (Clements and Perner 1994).

It is therefore worth considering other explanations for children's difficulty with *think*. One possibility is that the challenge lies in the kind of situations where belief reports are used, rather than in the conceptual underpinnings of the semantics. Papafragou, Cassidy and Gleitman (2007) discuss the possibility that the meaning of *think* may be difficult to infer, due to the fact that mental states of individuals are not immediately visible to inspection.

If situational cues to the meaning of belief verbs are relatively weak in the environment in which children acquire language, then perhaps linguistic cues provide evidence for the meanings of these verbs. We have seen that attitude verbs canonically occur as the main predicate of a clausal embedding structure. Papafragou et al. hypothesize that this syntactic frame provides a cue to the attitudinal nature of belief verbs, in the absence of evidence in the situations in which belief reports are used that the verb describes a mental state. (For further evidence that syntactic evidence provides information about attitude verb meaning, see Fisher, Gleitman and Gleitman 1991, Gleitman, Cassidy, Nappa, Papafragou and Trueswell 2005, White, Dudley, Hacquard and Lidz 2012 and Hacquard to appear). If so, then acquisition of clausal embedding would be a precondition for learning the meanings of belief verbs, thereby causing a delay. Papafragou et al. investigated this hypothesis using the Human Simulation Paradigm (Gillette et al. 1999, Snedeker and Gleitman 2004). This paradigm simulates language-learning situations with adult participants in order to probe the conditions under which the meanings of expressions are learnable. In Papafragou et al.'s study, participants watched scenes of mother-child interactions, and had to guess what the mother was saying to the child. Sentences with English syntax were constructed using nonsense words whose meaning participants had to infer. Success with identifying the presence of a belief verb increased when the situation involved an individual with a false belief, and when the verb had a clausal complement. Participants were most successful when both of these factors were present at once. These results suggest that while many situations are not robust cues to the use of a belief verb, the meaning of a belief verb can be more reliably inferred in situations involving a false belief. Papafragou et al. conclude that children's difficulty with belief verbs is due not to the time course of theory of mind development, but rather to difficulties in inferring the meanings of these verbs, and the need to first master clausal complements.

Finally, Lewis, Hacquard & Lidz (2012, submitted) propose that children's difficulty with belief verbs is due to them underestimating the relevance of a character's mental state. They observe that in some contexts, the complement of an attitude verb carries the main point of the sentence, as in (46).

- (46) Sally: Where's Rob?
Ann: Dave thinks he's at the beach.

Lewis et al. designed a series of experiments involving a hide and seek game, played by the characters Dora and Swiper. Four year-old children heard statements about Dora's beliefs concerning the location of Swiper, such as 'Dora thinks that Swiper is behind the toy box'. In one experiment a second character was added whose beliefs about the location of Swiper differed from Dora's. This conflict increased the relevance of belief, and resulted in an increase in adult-like responses to truth value judgment questions about the target sentences. The authors conclude that children's apparently delayed development of competence with belief verbs is due to pragmatic difficulty with understanding the relevance of belief in a context, rather than reflecting non-adult-like competence.

In this sub-section, we have discussed evidence suggesting that children show competence with belief verbs relatively late. Explanations for this delay proposed in the literature appeal variously to factors relating to conceptual development, inherent properties of attitude verbs that make their semantics difficult to infer, and pragmatics. Each of these proposals finds support in experiments reported in the acquisition literature. This is an area where formal semantics, psycholinguistics and developmental psychology can fruitfully interact, since a technical understanding of the meanings encoded by attitude verbs has an important role to play in the ongoing debate.

7. Conclusion

We have considered puzzles concerning referential opacity with expressions in the scope of attitude verbs, and presented a semantics which provides a framework for understanding why embedding below an attitude verb has distinctive consequences for interpretation. While *believe* was taken as the paradigmatic case, we also showed how Hintikka's semantics can be extended to other attitude verbs like *say*, while acknowledging cases where the basic template may be insufficient to account for the data, as with *want*. We then considered evidence from de se construal that Hintikka's semantics may be too coarse-grained, and developed an enriched analysis employing centred worlds. Finally, we presented two case studies that demonstrate how the study of attitude reports can open up new research avenues. On the theoretical side, this was illustrated by the case of perspective-sensitive expressions such as predicates of personal taste and epistemic modals. On the experimental side, we discussed the distinctive acquisition profile of attitude verbs, with particular attention to *think*.

SEE ALSO: The parameters of indirect speech; Evaluative predicates.

Biographical note

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¹ In fact, there is a reading of (5b) on which it is true under these circumstances. On this reading, the following discourse is coherent.

(i) Jack believes that the President of the USA is eating a sandwich. The President of the USA is Barack Obama. Therefore, Jack believes that Barack Obama is eating a sandwich, even though he doesn't realize that the person he believes is eating a sandwich is Barack Obama.

Call this reading the 'de re' reading. In this section we are concerned with de dicto readings, on which the belief report is only true if the attitude holder is disposed to assent to the embedded sentence.

² A possible world is simply a way that the world could be. The actual world is a specification of everything that is in fact the case; the other possible worlds are also complete in terms of specifying everything that is the case in those worlds. Note that this is different from what we might think of as the worlds of fiction, which typically are concerned only with a particular place and set of inhabitants, and thus leave many questions unsettled.

³ We assume that the interpretation function is relativized to a variable assignment *g*, and a world of evaluation *w*.

⁴ Our semantics glosses over the question of how referring expressions in the scope of attitude predicates are interpreted; this is a topic in its own right. Following Kaplan (1968),

the interpretation of nominals construed ‘de re’ in attitude reports is generally assumed to be mediated by an acquaintance-based guise – roughly, a definite description providing information about the cognitive access of the attitude holder to the individual that her belief is about (Barack Obama in this case).

⁵ Throughout this chapter, we ignore considerations relating to time and tense. If we wished to incorporate those, we would speak of the extension of an expression in a world w , at a time t . Arguments of intensions would be world-time pairs.

⁶ See also ARTICLE [*Representing Intensionality: Variables vs. Parameters*] where Intensional Functional Application is treated as part of the very strategy for defining extensions and intensions.

⁷ Actually, matters are a little more complicated than this, given that, as noted in footnote 4, Hintikka’s semantics for attitude reports must be adjusted to accommodate the mediation of beliefs about individuals (Perry in this case) by definite descriptions or ‘guises’. One might then wonder if it is possible to pick a definite description in such a way as to sidestep the issue highlighted here. We shall return to this question in a moment.

⁸ Note however that since Lewis assumed that no individual can inhabit more than one world, for him a set of centred worlds reduces to a set of individuals. I thank Ede Zimmermann for reminding me of this.