

Attitude Verbs

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1. Introduction

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

- 1a. Burt believes that it is raining.
- 1b. Joan wants to go to the movies.
- 1c. Peggy hopes that she will get a raise.

- 2a. Pete said that the bagel was tasty.
- 2b. Don promised that he would be home for dinner.
- 2c. 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 (sometimes called *verba dicendi*). We shall employ a cover term for these two types of verbs – namely, *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.

Typically, an attitude verb takes 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* argument. 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 referring expressions in the scope of attitude verbs. Section 3 presents the standard semantics for *believe*, due to Jaako Hintikka, 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 subtle and interesting differences in the behavior of particular attitude verbs, in general these can be accommodated within Hintikka's approach. An arguably more fundamental challenge is presented by so-called attitudes 'de se', which are 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 linguistic 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

Suppose we are living at a time at which the President of the USA is Barack Obama. Suppose also that I tell you that right now, the President of the USA is eating a sandwich. Armed with these two pieces of information, you cannot fail to conclude that (3) is true.

3. Barack Obama is eating a sandwich.

Now suppose that I tell you that Barack Obama is in Paris at the moment. Furthermore, nothing has changed in the interim – Obama is still President. You will conclude that (4) is true.

4. The President of the USA is in Paris.

(3) and (4) teach us that given a true sentence *S* containing the expression *The President of the USA*, replacing *The President of the USA* with an expression that refers to whoever is President of the USA right now (namely, *Barack Obama*) yields a sentence *S'* that is also true. (4) just reverses things: if *S* contains the expression *Barack Obama* and *S* is true, then a sentence *S'* that is obtained by replacing *Barack Obama* with *the President of the USA* is also true. In general, it seems that for any sentence *S* containing a referring expression *E*, *E* can be replaced with a coreferring term *E'* *salva veritate* – without alteration of truth value.

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

5a. Jack believes that the President of the USA is eating a sandwich.

5b. Jack believes that Barack Obama is eating a sandwich.

Could there be a situation where (5a) is true but (5b) is false? Of course. All it would take is for Jack not to know that the President of the USA 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 Similarly, we can imagine a situation where we judge (6a) true and (6b) false:

6a. Sophie thinks that Barack Obama is in Paris.

6b. Sophie thinks that the President of the USA is in Paris.

Like Jack, Sophie is not very well informed on current affairs. She meets Barack Obama in a café in Paris, and he introduces himself by name but neglects to mention his current job title.

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. See chapter xxx for discussion of the de re/de dicto distinction.

Sophie would then quite reasonably form the belief that Barack Obama is in Paris, which we could report on with (6a). Nonetheless, there is a reading of (6b) on which it is judged false in this situation.

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 Truth with non-referring terms

Consider a predicate that lacks an extension, such as *unicorn*. We can construct sentences containing this predicate that we immediately know are false, without empirical investigation.

7a. A unicorn is in the garden.

7b. Burt saw a unicorn.

So long as we know that there are no unicorns, we know that the restrictor of the existential quantifier *a unicorn* is empty, and hence that (7a) and (7b) are false. But matters change if these sentences are embedded below an attitude verb:

8a. Sally thinks that a unicorn is in the garden.

8b. Burt_i believes that he_i saw a unicorn.

This time, our knowledge about unicorns is an insufficient basis on which to judge whether the sentences are true. In order to do that, we would have to find out something about Sally and Burt's mental states. In general, the truth of a belief 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 no grounds for rejection of *Sally thinks that a unicorn is in the garden*. It works the other way too: the truth of *The President of the USA is Barack Obama* is no guarantee of the truth of *Michelle thinks that the President of the USA is Barack Obama*. An adequate semantics for attitude verbs must be able to accommodate these observations. The development of such a semantics is the goal of section 3.

3. Hintikka semantics for attitude verbs

In this section, we shall present the classical formal semantic treatment for attitude verbs, developed by Hintikka (1969).

Take the verb *believe*. We use this verb to report on the beliefs of some individual (ourselves, perhaps, or a third party). But what 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, or how they could have turned out differently. 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 getting a cup of coffee, 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:

9. David is in his office in w_1
 David is in a cafe in w_2
 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 is in fact the actual world. In general, none of us have belief states that identify a single world as the actual world. Our mental states simply leave too many questions unsettled. The best that we can do is to 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 one of the things that Michelle believes is that Barack Obama is the President of the USA. It follows that if w_7 is such that Barack Obama is not the President of the USA 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, which we shall call her *doxastic alternatives*, and write $\text{Dox}_{\text{Michelle},w}$. We can define this set as follows.

10. $\text{Dox}_{\text{Michelle},w} = \{w': \text{in } w, \text{ Michelle considers } w' \text{ a candidate for } w\}$

What Michelle believes is itself a contingent matter – there are worlds in which Michelle does not believe that Barack Obama is the US President, it just so happens that none of those is the actual world. We capture this by relativizing any given set of doxastic alternatives not only to the individual whose belief state the set models, but also to a world, which it will be convenient to refer to as the actual world. (10) just defines Michelle's doxastic alternatives in w as those worlds w' such that according to Michelle, w' is a candidate for w .

Under what conditions will Michelle consider w' to be a candidate for the actual world? For Michelle to consider w' to be a candidate for the actual world, exactly those things that Michelle believes to be true must be true in w' . In our toy example, w_7 is not considered by Michelle to be a candidate for the actual world, in virtue of the fact that Michelle believes it to be true that Barack Obama is President of the USA, and yet Barack Obama is not President of the USA in w_7 . A notion of 'compatibility' is often invoked in order to capture this idea: it is not *compatible* with what Michelle believes for w_7 to be the actual world, given that there is something that Michelle believes to be true that is false in w_7 . We will reformulate our definition of Michelle's doxastic alternatives in these terms. In addition, we will generalize the definition to any arbitrary attitude holder, by replacing *Michelle* with a variable over individuals x .

11. *Doxastic alternatives*

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

Doxastic alternatives are a useful tool for modeling the semantics of belief reports such as *Michelle believes that Barack Obama is the President of the USA*. Intuitively, the sentence makes a claim about Michelle's candidate worlds – namely, that they are all worlds in which 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 Barack Obama is *not* the President of the USA 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.²

12. $\llbracket \text{Michelle believes that Barack Obama is the President of the USA} \rrbracket^{g,w} = 1$ iff $\forall w': w' \in \text{Dox}_{\text{Michelle},w}^x$, Barack Obama is the President of the USA in w'

We are almost ready to give the truth conditions of an arbitrary belief report of form 'DP believes that S'. 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*.³ The extension of a sentence S in w is its truth value in w . As usual, an intension is a function from worlds w' to extensions in w' . Thus the intension of S is a function from worlds to truth values, also known as a proposition. 'DP believes that S' is true just in case for every world w' that is among the doxastic alternatives of the attitude holder, the proposition p expressed by S gives back the value 'true' when applied to w' :

13. $\llbracket \text{DP believes that S} \rrbracket^{g,w} = 1$ iff $\forall w': w' \in \text{Dox}_{x,w}^x$, $p(w') = 1$

Where x is the denotation of DP and p is the proposition expressed by S .

So much for the semantics of belief reports; what about the lexical entry of *believe* itself? We assume that the surface structure of *Michelle believes that Barack Obama is the President of the USA* is roughly as shown in (14):

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

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 stated in (13). The lexical entry is given in (15).

15. *Hintikka-semantics for believe*

$\llbracket \text{believe} \rrbracket^{g,w} = \lambda p \in D_{\langle s,t \rangle} \cdot \lambda x \in D_e \cdot \forall w': w' \in \text{Dox}_{x,w}^x$, $p(w') = 1$

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

This semantics requires *believe* to be fed a sentence intension as its first 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 (Heim & Kratzer 1998):

16. *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 $\llbracket \beta \rrbracket^{g,w}$ is a function whose domain contains $\lambda w'$. $\llbracket \gamma \rrbracket^{g,w'}$ then $\llbracket \alpha \rrbracket^{g,w} = \llbracket \beta \rrbracket^{g,w}(\lambda w'. \llbracket \gamma \rrbracket^{g,w'})$

² We assume that the interpretation function is relativized to a variable assignment g , and a world of evaluation w .

³ 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.

[Based on Heim & Kratzer 1998: ex 9, p. 308]

The denotation of a sentence S in a world w , written $\llbracket S \rrbracket^w$, 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 $\lambda w'. \llbracket S \rrbracket^{s, w'}$. IFA lets this propositional meaning be supplied as the argument of a function whose domain contains such meanings, such as an attitude verb. We can now calculate the meaning of (14). (We assume that the complementizer *that* is semantically vacuous.)

17a. $[_{CP1} [_{IP1} \text{Michelle} [_{VP} \text{believes} [_{CP2} \text{that} [_{IP2} \text{Barack Obama is the President of the USA.}]]]]]$

17b. $\llbracket IP2 \rrbracket^{s, w} = 1$ iff Barack Obama is the President of the USA in w

17c. $\llbracket CP2 \rrbracket^{s, w} = 1$ iff Barack Obama is the President of the USA in w

17d. $\llbracket VP1 \rrbracket^{s, w} =$ (by Intensional Functional Application)
 $\llbracket \text{believe} \rrbracket^{s, w}(\lambda w'. \llbracket CP2 \rrbracket^{s, w'}) =$ (by Lexical Entry of *believe* & (17c))
 $\lambda p \lambda x . [\forall w'': w'' \in \text{Dox}_{x, w}, p(w'') = 1](\lambda w'. \text{Barack Obama is the President of the USA in } w')$
 $w') =$

(by Lambda Conversion)

$\lambda x . \forall w'': w'' \in \text{Dox}_{x, w}, \lambda w'. [\text{Barack Obama is the President of the USA in } w'](w'') =$

(by Lambda Conversion)

$\lambda x . \forall w'': w'' \in \text{Dox}_{x, w}, \text{Barack Obama is the President of the USA in } w''$

17e. $\llbracket IP1 \rrbracket^{s, w} =$ (by Functional Application)
 $\llbracket VP1 \rrbracket^{s, w}(\llbracket \text{Michelle} \rrbracket^{s, w}) =$ (by (17d) & meaning of proper name)
 $\lambda x . [\forall w'': w'' \in \text{Dox}_{x, w}, \text{Barack Obama is the President of the USA in } w''](\text{Michelle}) =$
 (by Lambda Conversion)

$\forall w'': w'' \in \text{Dox}_{\text{Michelle}, w}, \text{Barack Obama is the President of the USA in } w''$

17f. $\llbracket CP1 \rrbracket^{s, w} = \forall w'': w'' \in \text{Dox}_{\text{Michelle}, w}, \text{Barack Obama is the President of the USA in } w''$

Alternatively, we can get by without IFA if we assume the presence of intensional abstraction operators in the syntax. (Enc 1981, Groenendijk & Stokhof 1984, Farkas 1993, Percus 2000) On this view, a CP meaning is propositional, and therefore of appropriate type to serve as the first argument of *believe* via Functional Application. To illustrate this idea, we will assume that world abstractors are represented on certain C^0 heads. These bind coindexed world variables in their scope, which are represented as unpronounced pronouns. World variables are the final arguments of predicates; for example the type of *is the President of the USA* is $\langle e, \langle s, t \rangle \rangle$. As a consequence of world variables being represented in the syntax, there is no longer a need for the interpretation function to be relativized to a world parameter. (18a) displays a sample LF under this view, and (18b) is the modified lexical entry for *believe*. (18f)-(18h) calculates the truth conditions.

18a. $[_{CP1} \lambda w_1 [_{IP1} w_1 \text{Michelle} [_{VP} \text{believes} [_{CP2} \lambda w_2 [_{IP2} w_2 \text{Barack Obama is the President of the USA.}]]]]]$

18b. *Hintikka-semantics for believe (extensional variant)*

$\llbracket \text{believe} \rrbracket^g = \lambda p \in D_{\langle s,t \rangle} . \lambda x \in D_e . \lambda w \in D_s \forall w': w' \in \text{Dox}_{x,w} , p(w') = 1$
 Where $\text{Dox}_{x,w} = \{w' : \text{it is compatible with what } x \text{ believes in } w \text{ for } w \text{ to be } w'\}$

18c. $\llbracket \text{IP2} \rrbracket^g = 1$ iff Barack Obama is the President of the USA in $g(1)$

18d. $\llbracket \text{CP2} \rrbracket^g = \lambda w . \text{Barack Obama is the President of the USA in } w$

18e. $\llbracket \text{VP1} \rrbracket^g =$ (by Functional Application)
 $\llbracket \text{believe} \rrbracket^g(\lambda w . \text{Barack Obama is the President of the USA in } w) =$
 (by Lexical Entry of *believe* & (18c))

$\lambda p \lambda x \lambda w . [\forall w' : w' \in \text{Dox}_{x,w} , p(w')](\lambda w' . \text{Barack Obama is the President of the USA in } w')$
 = (by Lambda Conversion)

$\lambda x \lambda w . \forall w' : w' \in \text{Dox}_{x,w} , \lambda w' . [\text{Barack Obama is the President of the USA in } w'](w') =$
 (by Lambda Conversion)

$\lambda x \lambda w . \forall w' : w' \in \text{Dox}_{x,w} , \text{Barack Obama is the President of the USA in } w''$

18f. $\llbracket [\text{Michelle} [\text{VP believes} [\text{CP2} \lambda w_2 [\text{IP2 } w_2 \text{ Barack Obama is the President of the USA.}]]]] \rrbracket^g =$
 (by Functional Application)

$\llbracket \text{VP1} \rrbracket^g (\llbracket \text{Michelle} \rrbracket^g) =$ (by (18d) & meaning of proper name)

$\lambda x \lambda w . [\forall w' : w' \in \text{Dox}_{x,w} , \text{Barack Obama is the President of the USA in } w'](\text{Michelle}) =$
 (by Lambda Conversion)

$\lambda w . \forall w' : w' \in \text{Dox}_{\text{Michelle},w} , \text{Barack Obama is the President of the USA in } w''$

18g. $\llbracket \text{IP1} \rrbracket^g =$ (by Functional Application)

$\llbracket \lambda w . \forall w' : w' \in \text{Dox}_{\text{Michelle},w} , \text{Barack Obama is the President of the USA in } w'' \rrbracket(g(1)) =$
 (by Lambda Conversion)

$\forall w' : w' \in \text{Dox}_{\text{Michelle},g(1)} , \text{Barack Obama is the President of the USA in } w''$

18h. $\llbracket \text{CP1} \rrbracket^g = \lambda w . \forall w' : w' \in \text{Dox}_{\text{Michelle},w} , \text{Barack Obama is the President of the USA in } w''$

It is beyond the scope of this survey to evaluate these two approaches to the compositional semantics of attitude reports. (For evidence in favor of the extensional approach, see Percus 2000). We will simply note that either procedure for calculating the truth conditions predicts the referential opacity effects encountered in section 2. We saw, for example, that the sentences in (19) have readings on which they are not truth conditionally equivalent.

19a. Jack believes that the President of the USA is eating a sandwich.

19b. Jack believes that Barack Obama is eating a sandwich.

This is expected if *the President of the USA* expresses an individual concept – a function from a world w to the unique individual satisfying the description in w . Suppose that Jack believes that Hillary Clinton is the President of the USA. Consider the intensional approach, where the interpretation function is relativized to a world parameter. On the reading of interest, the world parameter with respect to which the denotation of *the President of the USA* is calculated is shifted by *believe*, so that it ranges over elements of Jack's doxastic alternatives. The sentence means, 'for each of John's doxastic alternatives w' , the individual who is the

President of the USA in w' is eating a sandwich in w' . If we suppose that Jack believes that Hillary Clinton is the President of the USA, then the following holds.

19. $\forall w': w' \in \text{Dox}_{\text{Jack},w}$, $\llbracket \text{The President of the USA} \rrbracket^{\text{g},w} = \text{Hillary Clinton}$.

Consequently, *Jack believes that the President of the USA is eating a sandwich* is predicted to be true on this reading just in case for each of John's doxastic alternatives w' , Hillary Clinton is eating a sandwich in w' . If this is the case, and in addition John does not have the belief, 'Barack Obama is eating a sandwich', then (19a) is predicted to be judged true, and (19b) false.

The main difference between the intensional and the extensional account of the non-equivalence of (19a) and (19b) concerns how the denotation of *the President of the USA* is obtained. On the extensional view, the DP contains a world variable, which on the reading under consideration is coindexed with the abstractor in embedded C.

20. $[\dots [_{\text{CP}_2} \lambda w_1 [_{\text{IP}_1} w_1 [_{\text{DP}} w_1 \text{ the President of the USA}] \text{ is eating a sandwich}]]]$

The embedded CP expresses the proposition ' λw . the President of the USA in w is eating a sandwich in w' '. This proposition is applied to each of Jack's belief worlds, so that in a situation where Jack believes that that the President of the USA is Hillary Clinton, the sentence is true just in case at each of Jack's doxastic alternatives w' , Hillary Clinton is eating a sandwich in w' . The non-equivalence of (19a) and (19b) follows in the same way as under the intensional approach. We leave it as an exercise to the reader to verify that both approaches also predict that *Sally thinks that a unicorn is in the garden* and *Burt believes that he saw a unicorn* can be true even though there are in fact no unicorns.

4. Beyond *believe*

Our lexical entry for *believe* serves as a template for the semantics of attitude verbs as a class. In general, attitude verbs are traditionally treated as universal quantifiers over worlds; the 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 to be true. We will define a set of *say*-alternatives as follows.

21. *Say*-alternatives

$\text{Say}_{x,w} = \{w': \text{it is compatible with what } x \text{ says in } w \text{ for } w \text{ to be } w'\}$

The definition of *say*-alternatives is derived from the definition of doxastic alternatives by replacing 'believe' on the right hand side of the colon with 'say'. 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 given in (22).⁴

⁴ For reasons of space, we omit the extensional variants of the attitude verbs discussed in this section. As usual, these have an additional argument of type s .

22. *Lexical entry of say (intensional variant)*

$$\llbracket \text{say} \rrbracket^{g,w} = \lambda p \in D_{\langle s,t \rangle} \cdot \lambda x \in D_e \cdot \forall w': w' \in \text{Say}_{x,w}, p(w') = 1$$

Where $\text{Say}_{x,w} = \{w': \text{it is compatible with what } x \text{ says in } w \text{ for } w \text{ to be } w'\}$

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 described in section 2 are replicated with *say*: (23a) and (23b) have readings on which they are not equivalent.

23a. Jack said that the President of the USA was eating a sandwich.

23b. Jack said that Barack Obama was eating a sandwich.

This is a good result, and suggests that the treatment of attitude verbs as a class as quantifiers over particular types of attitudinal 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, there is reason to think that a more nuanced picture is needed. Consider *want*. The alternatives quantified over by this verb are usually referred to as *buletic* alternatives, which can be defined as follows.

24. Buletic alternatives

$$\text{Bul}_{x,w} = \{w': \text{it is compatible with the fulfillment of } x\text{'s desires in } w \text{ for } w \text{ to be } w'\}$$

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

25. *Lexical entry of want – first version (intensional variant)*

$$\llbracket \text{want} \rrbracket^{g,w} = \lambda p \in D_{\langle s,t \rangle} \cdot \lambda x \in D_e \cdot \forall w': w' \in \text{Bul}_{x,w}, p(w') = 1$$

$$\text{Bul}_{x,w} = \{w': \text{it is compatible with the fulfillment of } x\text{'s desires in } w \text{ for } w \text{ to be } w'\}$$

As expected, replacement of *say* with *want* in the pair in (23) yields non-equivalent sentences. Yet the following puzzle, noticed by Asher (1987), suggests that this cannot be all there is to it. Suppose that Nicholas would jump at the chance to fly on the Concorde for free, but he is unwilling to pay the high price for a ticket. Intuitively, in this situation (26a) is false, but (26b) is true.

26a. Nicholas wants to have a trip on the Concorde.

26b. Nicholas wants to have a free trip on the Concorde.

These judgments are unexpected given the semantics in (25). If (26b) is true, then at each of Nicholas's buletic alternatives, Nicholas has a free trip on the Concorde. Since any world in which Nicholas has a free trip on Concorde is a world in which Nicholas has a trip on Concorde, it follows that if (26b) is true, then the predicted truth conditions for (26a) are also fulfilled. So (26b) is predicted to entail (26a), yet Asher's example shows that there could be a situation in which the former is true and the latter is false. For more examples

illustrating the problem with a simple-minded Hintikka-semantics for *want*, see Asher (1987), Heim (1992).

Nonetheless, work by Stalnaker (1984) and Heim (1992) suggests that it is possible to treat *want* as a universal quantifier over worlds without deriving the unwelcome predictions illustrated above. 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. In effect, *want* is interpreted with respect to a doxastic modal base:

27. *Lexical entry of want - second version (intensional variant)*

$\llbracket \text{want} \rrbracket^{s,w} = \lambda p \in D_{\langle s,t \rangle} \cdot \lambda x \in D_e \cdot \forall w': w' \in \text{Dox}_{x,w}$, any world w'' maximally similar to w' such that $p(w'') = 1$ is more desirable to x in w than any world w''' maximally similar to w' such that $p(w''') = 0$

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

This semantics makes correct predictions regarding (26) given the (intuitively plausible) assumption that in the relevant scenario, 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. (26a) is false in virtue of the fact that Nicholas does not consider such a world preferable to one in which he does not fly on Concorde. (26b) can nonetheless be true, because the comparison is this time between worlds in which Nicholas has a free trip on Concorde and worlds in which he does not fly on Concorde, and we know that he prefers the former to the latter.

In this section, we sketched how the Hintikka semantics for *believe* provides a template that can be applied to other attitude verbs, including speech act verbs such as *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, such as doxastic alternatives and *say*-alternatives. 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).

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

5. Attitudes de se

John Perry (1979) discussed the following case.

28. 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 the moment that 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.

- 29a. The shopper with the torn sack of sugar is making a mess.
- 29b. I am not making a mess.

What we know, but Perry has not yet found out, 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 (29a). At the same moment, he has many beliefs about himself that he is aware is about himself. Perry would be disposed to express these beliefs using sentences containing the first person pronoun, including (29b). The Hintikka-semantics for attitude verbs 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. (30) is therefore true.

- 30. Perry_i believes that he_i is making a mess.

Yet since Perry is disposed to assent to (29b), it seems that the following sentence is also true.

- 31. Perry_i believes that he_i is not making a mess.

(30) and (31) contain sentences expressing incompatible propositions: that Perry is making a mess, and that Perry is not making a mess. The Hintikka-semantics for *believe* predicts that both sentences are true only if Perry is irrational: if every world compatible with what Perry believes is one in which Perry is making a mess, and one in which Perry is not making a mess, then there are no worlds compatible with what Perry believes. Yet in the situation at hand, Perry is of perfectly sound mind; he simply happens to lack some crucial information (namely, that he is the shopper with the torn sack of sugar).

To address this problem, a starting point is to posit two distinct readings for the pronouns in (30) and (31). 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. (31) is true on this reading, but (30) is false on this reading, 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. (30) and (31) are both true on this reading.

Some readers may find the *de re* reading of (30) difficult to detect, in which case they will judge the sentence to be false. In general, there seems to be a 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 the Hintikka-semantics for *believe*. According to this semantics, (30) is true just in case Perry is making a mess in all worlds compatible with what Perry believes, and (31) is true just in case Perry is not making a mess at any of Perry's doxastic alternatives. The particular way in which Perry has a belief about himself – with or without awareness that his belief is about himself – is predicted to be irrelevant to the truth of the sentences in question. Yet the facts that (30) and (31) have readings on which they do not jointly entail that Perry is irrational, and that (30) 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.

In fact, there is evidence that the grammar goes so far as to provide a dedicated means of encoding attitudes that have a distinctly first personal nature. A classic example is controlled PRO, which is obligatorily interpreted de se (Morgan 1970, Chierchia 1990). Many English control predicates are attitude 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 in (32).

32. Perry believes [PRO to be making a mess].

However, the subject of the infinitive, 'PRO', cannot be assigned a de re reading. 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 in the scenario at hand. By contrast, (32) 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 the Hintikka-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 – so-called doxastic alternatives. 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. In that sense, our belief states furnish us with candidates for ourselves, as well as candidates for the actual world. Furthermore, the linguistic data show that this uncertainty about who we are is an aspect of mental states that attitude reports are sensitive to. Let us therefore treat doxastic alternatives not as sets of worlds, but rather as sets of world-individual pairs (so-called *centred worlds*).

33. *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 embedded clause cannot express a function from worlds to truth values as before (a proposition), but it must instead express a function from world-individual pairs to truth values – a property. More precisely, let us say for now that the embedded clause expresses a function from individuals to functions from worlds to

truth values; its meaning is of type $\langle e, \langle s, t \rangle \rangle$. The revised lexical entry for *believe* is as follows.

34. *Lexical entry of believe – centred worlds version (extensional variant)*

$\llbracket \text{believe} \rrbracket^g = \lambda P \in D_{\langle e, \langle s, t \rangle \rangle} . \lambda x \in D_e . \lambda w \in D_s . \forall \langle w', y \rangle : \langle w', y \rangle \in \text{Dox}_{x,w} , P(y)(w') = 1$

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 is of property-type meaning? Recall the extensional approach, where a constituent of type $\langle s, t \rangle$ is obtained from a constituent of type t by positing a world abstractor in embedded C . To obtain a constituent of type $\langle e, \langle s, t \rangle \rangle$ from a constituent of type $\langle s, t \rangle$, we simply posit an individual abstractor in addition to the world binder. We have at hand elements that can be bound by individual binders – namely, individual-denoting pronouns such as *he* and PRO. Let us then assume that PRO and *he* (on its de se construal) are bound by an individual abstractor in embedded C . The relevant LFs are as follows.

35a. Perry_i believes that he_i is making a mess.

35b. $[_{CP1} \lambda w_1 [_{IP1} w_1 \text{ Perry } [_{VP} \text{ believes } [_{CP2} \lambda x_2 \lambda w_3 [_{IP2} w_3 \text{ he}_2 \text{ is making a mess}]]]]]]$

36a. Perry believes PRO to be making a mess.

36b. $[_{CP1} \lambda w_1 [_{IP1} w_1 \text{ Perry } [_{VP} \text{ believes } [_{CP2} \lambda x_2 \lambda w_3 [_{IP2} w_3 \text{ PRO}_2 \text{ to be making a mess}]]]]]]$

The embedded clauses in both examples receive the same interpretation, displayed below.

37. $\llbracket [CP2] \rrbracket^g = \lambda x \lambda w . x \text{ is making a mess in } w$

We can calculate the truth conditions as follows.

38a. $\llbracket [CP2] \rrbracket^g = \lambda x \lambda w . x \text{ is making a mess in } w$

38b. $\llbracket [VP1] \rrbracket^g = \lambda x \lambda w . \forall \langle w', y \rangle : \langle w', y \rangle \in \text{Dox}_{x,w} , y \text{ is making a mess in } w'$

38c. $\llbracket [CP1] \rrbracket^g = \lambda w . \forall \langle w', y \rangle : \langle w', y \rangle \in \text{Dox}_{\text{Perry},w} , y \text{ is making a mess in } w'$

This semantics correctly predicts that (35a) and (36a) are judged false (on the de se reading of *he*). The sentence is 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' . As a matter of fact, Perry is disposed to assent to the sentence, 'I am not making a mess' (and furthermore Perry is rational). Thus Perry does not ascribe to any of his candidates for himself the property of making a mess, so the sentence must be false. In general, the view that the meaning of the embedded clause is of property-type provides an implementation of an insight due to Lewis – namely, that attitudes de se are self-ascriptions of properties (Lewis 1979).

The more fine-grained semantics for *believe* is successful in accommodating the fact that there are reports of beliefs about the attitude holder that are sensitive to the attitude holder's

awareness of the belief being about herself. These de se reports are judged false in situations involving ‘mistaken identity’ such as Perry’s sugar example. The account was implemented in an extensional framework, with abstraction over worlds represented in the syntax. However the centred worlds approach can also be implemented in an intensional set up. Recall that intensional systems posit a world parameter w on the interpretation function, as an alternative to world-denoting pronouns in the syntax. We can likewise posit an individual parameter x , so that the circumstances of evaluation with respect to which the denotation of a sentence is calculated is a world-individual pair. Consequently, sentence intensions (propositions) are no longer sets of worlds, but rather sets of world-individual pairs – so-called *centred propositions*. As is usual in an intensional framework, the attitude verb is interpreted as a quantifier that shifts the circumstances of evaluation, as shown in (39).⁵

39. *Lexical entry of believe – centred worlds version (intensional variant)*

$\llbracket \text{believe} \rrbracket^{g, w, x} = \lambda p \in D_{\langle s, \langle e, t \rangle \rangle} . \lambda x \in D_e . \forall \langle w', y \rangle : \langle w', y \rangle \in \text{Dox}_{x, w}, p(w')(y) = 1$
 Where $\text{Dox}_{x, w} = \{ \langle w', y \rangle : \text{it is compatible with what } x \text{ believes in } w \text{ for } x \text{ to be } y \text{ in } w' \}$

In the extensional approach, de se pronouns are in effect bound by the individual coordinate of the centred worlds quantified over by the attitude verb, in virtue of the fact that they are bound by the individual abstractor inserted below this verb. This effect can be mimicked in the intensional set up by stipulating that a de se pronoun is assigned the value of the individual parameter as its semantic value. We exemplify this with obligatorily controlled PRO (Anand & Nevins 2004, Stephenson 2007, 2010).

40. $\llbracket \text{PRO} \rrbracket^{g, w, x} = x$

We leave it as an exercise for the reader to confirm that the predicted truth conditions for *Perry believes PRO to be making a mess* are identical to those derived in the extensional approach. We shall not attempt to adjudicate between these two approaches in this survey; for discussion, see Pearson (to appear).

We have seen that the Hintikka-semantics for *believe* is inadequate to account for 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.

41. Burt believes that it is raining.

In this case, 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. For this reason, it is 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 seems to be 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, he locates himself in a world in which it is raining. We might then say that he self-ascribes the property of inhabiting a world in which it is raining. This

⁵ The intension of an expression E is now $\lambda w \lambda x . \llbracket E \rrbracket^{g, w, x}$. Intensional Functional Application must be modified accordingly. See Stephenson (2007a, 2007b) for details.

insight of Lewis's, that all attitudes are reducible to attitudes de se, has typically been set aside by linguists in favor of an ambiguity approach to attitude verb meaning, presumably in order to avoid the problem of vacuous binding.

The strategy of moving from worlds to centred worlds as the objects quantified over by the verb can be generalized to attitude verbs other than *believe*, which also give rise to de se readings with attitude holder-denoting pronouns in their scope.⁶ For example, an updated lexical entry for *say* is shown below.

42a. *Lexical entry of say - centred worlds version (extensional variant)*

$\llbracket \text{say} \rrbracket^s = \lambda p \in D_{\langle e, \langle s, t \rangle \rangle} . \lambda x \in D_e . \lambda w \in D_s . \forall \langle w', y \rangle : \langle w', y \rangle \in \text{Say}_{x,w} , P(y)(w') = 1$
Where $\text{Say}_{x,w} \{ \langle w', y \rangle : \text{it is compatible with what } x \text{ says in } w \text{ for } x \text{ to be } y \text{ in } w' \}$

42b. *Lexical entry of say centred worlds version (intensional variant)*

$\llbracket \text{say} \rrbracket^{s, w, x} = \lambda p \in D_{\langle s, \langle e, t \rangle \rangle} . \lambda x \in D_e . \forall \langle w', y \rangle : \langle w', y \rangle \in \text{Say}_{x,w} , p(w')(y) = 1$
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 shown that the Hintikka semantics for attitude verbs is too coarse-grained to account for reports of attitudes de se. We have described one response to this challenge, which maintains the idea that attitude verbs are universal quantifiers, but treats the elements quantified over as world-individual pairs rather than simply worlds. Space constraints prohibit a detailed comparison of this approach with a prominent competitor, which treats de se construal as a special case of de re construal.

On the de re construal of the pronoun in *Perry*, *believes that he_i 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 happens to be 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 discussed in 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 in virtue of the facts that (i) Jack believes that the President of the USA is eating a sandwich and (ii) the President of the USA is Barack Obama. In general, a rough procedure for deriving the truth conditions of a de re belief report S is to calculate the truth conditions of some 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.⁷ The task of giving a complete compositional semantics for de re belief reports is notoriously difficult, and we will not attempt it here (see chapter xxx for discussion). For our purposes it suffices to note that de se belief reports can be treated as a special case of de re reports 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, 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

⁶ Strictly speaking, on this view de se pronouns are not attitude holder denoting. Rather, they are interpreted as variables ranging over the attitude holder's candidates for herself.

⁷ This glosses over several important details, including that the definite description must provide a concept that is based on an acquaintance relation in the sense of Kaplan 1968. See chapter xxx for discussion.

approach or the de se-as-de re approach to attitudes de se, there is general consensus that the Hintikka-semantics needs to be enriched in order to account for the distinguished role of first personal cognitive access to the self in certain attitude reports.

6. New horizons

In this section, we discuss two recent directions that have been adopted in research on attitude reports. The first concerns the consequences of embedding below an attitude verb for the interpretation of certain perspective-sensitive expressions such as predicates of personal taste and epistemic modals. The second investigates the acquisition profile of attitude verbs, with particular attention to *believe* and *want*.

6.1 Perspective sensitive expressions

Consider the following sentences.

43a. This cauliflower cheese is tasty.

43b. This computer game is fun.

Intuitively, *fun* and *tasty* are used to express a judgment concerning a certain subjective experience – in this case, eating this cauliflower cheese and playing this computer game. Whose judgment is expressed, and what role is played by that individual in the calculation of the meaning of the sentences are vexed questions. In the examples above, it seems that the speaker expresses her own judgment. If her interlocutor has a different judgment, she may reply as follows:

44a. No, this cauliflower cheese is not tasty.

44b. No, this computer game is not fun.

Just why it should be that Mary can contradict John's utterance of (43a) by replying with (44a) is the puzzle of so-called 'faultless disagreement', discussed in chapter xxx. Usually, the only felicitous way to disagree with a sentence expressing content *p* is by expressing a sentence with content *not p*. But if (43a) expresses John's judgment ("This cauliflower cheese is tasty to John"), and (44a) expresses Mary's judgment ("This cauliflower cheese is not tasty to Mary"), then we should have compatible rather than contradictory propositions. In this sub-section, we will not discuss in detail the various solutions to this puzzle that have been proposed in the literature (see chapter xxx). Instead, we will show that predicates of personal taste display a distinctive behavior in the scope of attitude verbs, which helps to shed light on the question of how these expressions should be analyzed.

Consider sentence (45).

45. John thinks that this cauliflower cheese is tasty.

This, time, the judgment that is reported is not the speaker's, but rather the attitude holder's. Indeed, it would be felicitous to follow up this sentence by saying, '...but I find it disgusting'. This observation is discussed at length in (Stephenson 2007a, 2007b), who in

addition observes that when the taste predicate is embedded below multiple attitude verbs, it is the most immediately dominating attitude holder whose opinion is relevant.

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

Stephenson observed that this ‘Immediateness Requirement’ also holds for the epistemic modals *might* and *must*. According to the classical treatment of epistemic modals, (47a) says that it is compatible with what is known that it is raining, and (47b) says that what is known entails that it is raining.

47a. It might be raining.

47b. It must be raining.

But whose knowledge is relevant? Intuitively, it seems to be the speaker’s knowledge – in (47a) and (47b), the speaker reports on a judgment about the possibility or necessity of it raining, given the evidence available to her. As with predicates of personal taste, matters look different when epistemic modals are embedded below an attitude verb:

48a. Bill thinks it might be raining (but I know that it isn’t).

48b. Bill thinks that it must be raining (but I know that it isn’t).

Here too, the Immediateness Requirement applies:

49a. Sally thinks that Bill thinks that it might be raining (but she/#he knows that it isn’t).

49b. Sally thinks that Bill thinks that it must be raining (but she/#he knows that it isn’t).

Why should embedding below an attitude verb make a difference to the perspective with respect to which a predicate of personal taste or an epistemic modal is evaluated? Several authors have taken from this observation that the perspective-sensitivity of these expressions is affected by structural factors. It seems that we cannot simply say that the individual whose perspective is relevant is semantically underspecified, and supplied by context. In this respect, taste predicates and epistemic modals appear to be quite different from a spatial predicate such as *left*. (50a) 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 does not diminish when *left* is embedded below *think*: in (50b) the perspective holder can but need not be John, and in (50c) it can but does not have to be either Mary or John.

50a. The vase is to the left of the couch.

50b. John thinks that the vase is to the left of the couch.

50c. 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 taste predicates 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, 2007b, Moltmann 2010, Pearson 2013a, 2013b). With *tasty*, for example, this can be implemented in an intensional setting by

positing a null pronominal as a covert Experiencer argument of *tasty*, whose semantic value is supplied by the individual parameter of the circumstances of evaluation discussed in section 5. Alternatively, an individual abstractor can be posited in the left periphery of the embedded clause, which binds the null pronominal. In either case, the covert Experiencer argument is effectively given a parallel analysis to that developed for obligatorily controlled PRO in the last section. This predicts that when embedded below an attitude verb, taste predicates and epistemic modals are obligatorily construed *de se* with respect to the individual whose judgment or information state is relevant: the attitude holder must be aware that it is her own taste or knowledge state that is relevant for the reported judgment. For data suggesting that this prediction is borne out for epistemic modals, see Stephenson (2007a and 2007b, citing personal communication from Pranav Anand). For data making the same point concerning predicates of personal taste, see (Pearson 2013a). On the other hand Anand (under revision) discusses examples suggesting that this prediction is not borne out for taste predicates after all.

To the extent that the analyses just sketched are along the right lines, they lend support to the more 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 child language acquisition research is that some attitude verbs – particularly *think* - are acquired relatively late. Children begin to use *think* around the age of 2-3, but initially uses are limited to formulaic locutions, particularly ‘I don’t know’, parenthetical uses, expressions of degrees of certainty, and first person uses (Shatz, Wellman and Silber 1983, Bloom, Rispoli, Gartner and Hafitz 1989, Diessel and Tomasello 2001). Experiments testing children’s comprehension of *think* suggest that this verb is not interpreted correctly until the age of four (Moore, Bryant and Furrow 1989, Johnson and Maratsos 1977, de Villiers and Pyers 2002). The tools for modeling the meaning of attitude verbs described in this chapter are useful for identifying the particular challenges that these verbs present for acquisition.

According to both the Hintikka-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 rather whether it yields truth when applied to the attitude holder’s doxastic alternatives. So to know the meaning of a verb like *think* is to know that a sentence of form ‘DP think that S’ can be true even if S is as a matter of fact false. Indeed, such a situation can be employed in order to test whether a participant in an experiment has adult-like competence with the verb: if the child judges the belief report true in a situation where the embedded sentence happens to be true, it will not be possible to exclude the possibility that the child interprets the embedded sentence with respect to the actual world rather than the attitude holder’s doxastic alternatives.

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

51. 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 a seven-month period, de Villiers and Pyers (2002) found that children did not begin to give adult-like responses in this sort of set-up until around the age of 4.

Intriguingly, this acquisition path seems to mirror 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 is not aware that the chocolate has been moved does not start to emerge until the age of 4. However, certain contextual manipulations can affect whether or not the child answers correctly: both 3 and 4 year olds are more likely to answer correctly if the mother uses all the chocolate to make a cake rather than putting it in a different drawer. The overall 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 of the literature and a meta-analysis confirming the robustness of the finding).

Note that what is tested in the classic version of the 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, also 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 the plausible hypothesis 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 point to the possibility that theory of mind develops earlier than is traditionally assumed. If so, then some other explanation would be needed for why belief verbs are acquired relatively late. It may be that children's initial 'failures' with false belief tasks is due to the relative complexity of the scenarios in question and of the language used to probe children's understanding of what took place. 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 casting around for other explanations for children's difficulty with the verb *believe*. One possibility is that the challenge lies in the kind of situations in which belief reports are used, rather than in the conceptual underpinnings of the semantics of belief

verbs. Papafragou, Cassidy and Gleitman (2007) discuss the possibility that the meaning of verbs like *believe* and *think* may be inherently 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 the canonical configuration in which an attitude verb occurs is 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 linguistic expressions are learnable. In Papafragou et al.'s study, participants watched scenes of interactions between mothers and children, and had to guess what the mother might be 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 in the same item. 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 not due to the time course of the development of theory of mind, but rather to difficulties in inferring the meanings of these verbs, and the need to first master clausal complements.

Finally, Lewis, Hacquard and 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 may carry the main point of the sentence, as in the exchange in (52).

52. 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 were different 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 given context, rather than reflecting non-adult-like competence with the verbs in question.

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 have variously appealed to factors relating to conceptual development, inherent properties of attitude verbs that make their semantics difficult to infer, and development of 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 classical Hintikka-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 of an attitude verb, we also showed how the Hintikka-semantics can be extended to other attitude verbs, such as *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 construals of pronouns that the Hintikka-semantics may be insufficiently fine-grained, and developed an enriched analysis that treated attitudinal alternatives as centred worlds. Finally, we presented two case studies that demonstrate quite distinct ways in which 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*.

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