

# Representing *De Re* and *De Dicto* Belief Reports in Discourse and Narrative

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*Belief reports can be interpreted de re or de dicto, and we investigate the disambiguation of belief reports as they appear in discourse and narrative. In earlier work, representations for de re and de dicto belief reports were presented, and the distinction between de re and de dicto belief reports was made solely on the basis of their representations. This analysis is sufficient only when belief reports are considered in isolation. We need to consider more complicated belief structures, in addition to those presented earlier, in order to sufficiently represent de re and de dicto belief reports as they appear in discourse and narrative. Further, we cannot meaningfully apply one, but not the other, of the concepts de re and de dicto to these more complicated belief structures. We argue that the concepts de re and de dicto do not apply to an agent's conceptual representation of her beliefs, but that they apply to the utterance of a belief report on a specific occasion. A cognitive agent interprets a belief report such as "S believes that N is F," or "S said, 'N is F'" (where S and N are names or descriptions, and F is an adjective) de dicto if she interprets it from N's perspective, and she interprets it de re if she interprets it from her own perspective.*

## 1. INTRODUCTION

The branch of artificial intelligence (AI) and computer science known as "knowledge representation" is concerned with how to represent "knowledge of the application environment . . . and knowledge of the intended audience" in a computer system (cf. [5, p. 12]). In this paper, we report on current research that we are doing on the logical foundations of belief representation. The ultimate goal is the construction of an AI system that can reason about the cognitive states of intelligent agents. These agents include people (e.g., the system's users), other AI systems (e.g., interacting ones), and itself (cf. [7, p. 9]). The cognitive states include goals, desires, hopes, and knowledge, in addition to beliefs. Currently, we are concerned only with beliefs, partly because belief plays a central logical and psychological role in the network of cognitive states, partly because it is in many ways simpler to analyze than other cognitive states, and partly to be able to build on the large philosophical and computational literature about belief.

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## A. The Nature of Belief Representation

The sort of AI system that is of concern here is to be a reasoning system whose database contains information about the world and about various cognitive agents. In order for the system to learn more about these agents (and the world)—to expand its "knowledge" base—it should contain information about their beliefs and be able to reason about them. Such a database constitutes the beliefs of the system about these agents and about their beliefs.

Since each of the agents is in fact such a system itself, each has beliefs about the beliefs of the others. Thus our system must be able to represent (i.e., have beliefs about) beliefs about beliefs and to reason about these. Such beliefs are called *nested beliefs*.

A belief-representation system must also be sensitive to the *intensionality of belief* and to the associated phenomenon of *referential opacity*. The intensionality of belief puts constraints on the system's deduction mechanism. For instance, given the system's beliefs that an agent *A* believes some proposition *p* and that *p* is logically equivalent to another proposition *q*, the system should not infer that *A* believes *q*, in the absence of further information.

Moreover, an agent can have inconsistent beliefs about an object. For instance, *A* might believe both that the Evening Star is a planet and that the Morning Star is not a planet, even though the Morning Star *is* the Evening Star. This can happen as long as *A* does not believe that the Morning Star is the Evening Star. In this case, *A*'s "knowledge base" contains two items, one for the Morning Star, one for the Evening Star. Such items are *intensional objects*, and our AI system must be able to deal with them.

Finally, if the system is to be considered as a cognitive agent, and especially if it is to be used as a tool in understanding *our* belief-representation mechanisms, it ought to interpret ordinary statements about belief, expressed in (grammatical) natural language, the way humans do. Thus we would want the system to make reasonable or plausible interpretations of users' belief reports—based on such things as subject matter and prior beliefs (including beliefs about the user and the user's beliefs)—and to modify its initial representation as more information is received.

It is important to represent beliefs in a knowledge representation and reasoning system for several reasons. First,



beliefs, as well as other cognitive attitudes (such as knowledge), can play an evidentiary role. That is, one's own beliefs, as well as the beliefs of others, can be used as evidence or premises for coming to believe propositions. As an example, to decide whether I should believe  $p$ , I might reason as follows:

John believes  $q$ .  
 I believe what John believes.  
 I believe that  $p$  is logically equivalent to  $q$ .  
 Therefore, I should believe  $p$ .

Thus if an AI system is going to be able to increase and refine its database—its "beliefs"—it ought to be able to represent and reason about its own beliefs as well as those of its users.

Second, actions that are the results of conscious planning are the end results of chains of reasoning that include beliefs. An AI system (perhaps an intelligent robot) that would be capable of performing actions, or even a system that would be capable of recommending actions to its users, would thus need to be able to represent and reason about beliefs.

When a belief is a cause of a person's actions, we are not only interested in *what* the person believes, but also in *how* the person believes it. That is, we are not only interested in a third-person characterization of the agent's beliefs, but also in the agent's *own* characterization of those beliefs. The distinction between these two ways of reporting beliefs is captured by means of a distinction between *de re* and *de dicto* belief representations. Thus an AI system that is capable of explaining or recommending behavior must be able to distinguish between these two kinds of belief reports by having two distinct means of representing them. We describe these two kinds of belief reports in more detail, below.

### B. SNePS

As our knowledge representation and reasoning system, we use SNePS, the Semantic Network Processing System [10], [11]. A semantic network consists of labeled nodes and labeled directed arcs. SNePS networks are propositional semantic networks in which the following conditions hold:

- 1) each node represents a unique concept;
- 2) each concept represented in the network is represented by a node;
- 3) each concept represented in the network is represented by a unique node;
- 4) arcs represent nonconceptual, binary, structural relations between nodes;
- 5) the knowledge represented about each concept is represented by the structure of the entire network connected to the node representing the concept.

As an example of a SNePS network, consider the network depicted in Fig. 1. Node  $m2$  represents the proposition that  $m3$  is named 'John'; node  $m6$  represents the proposition that  $m7$  is named 'Lucy'; and node  $m10$  represents the proposition that the person named 'John' believes that the person named 'Lucy' is rich. Nodes with a LEX arc to a node labeled with an English expression indicate that they are expressed in English by that label (for more details, see Maida and Shapiro [6] and Shapiro and Rapaport [11]).

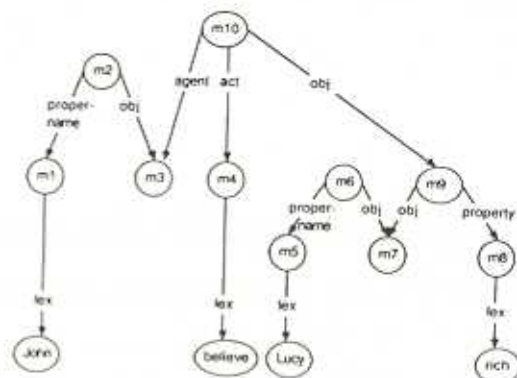


Fig. 1. SNePS network for the isolated *de re* belief report "John believes of Lucy that she is rich."

Following Maida and Shapiro [6], nodes represent only intentions and not extensions. That is, they represent mental entities, and not "objects in the world." Further, if we view SNePS as a system for modeling the mind of a cognitive agent, then all represented concepts are in the mind of the cognitive agent. For the sake of clarity, we have named this cognitive agent, 'Cassie' (for Cognitive Agent of the SNePS System—an Intelligent Entity). Thus when Cassie represents the beliefs of someone else, what is represented is Cassie's representation of the beliefs of the other person, not the other person's actual beliefs.

### C. Belief Spaces

The concept of *belief spaces* is central to the work presented here. A cognitive agent's belief space consists of the propositions the agent believes and the concepts that these propositions are about. For example, if Cassie believes that John believes that Lucy is rich, then that John believes that Lucy is rich is a belief that appears in Cassie's belief space, and that Lucy is rich is a belief that appears in Cassie's model of John's belief space. Since we represent the mind of a single agent—in our case Cassie—any other belief space that we represent includes those beliefs that Cassie believes are held by the other agent; it does not represent the other agent's *actual* beliefs. We will sometimes call Cassie's belief space the 'top-level belief space,' and we will call the belief space of an agent who appears in Cassie's belief space a 'nested belief space.'

We represent belief spaces as follows: Cassie's belief space includes all beliefs represented by nodes that are either non-dominated (i.e., no arcs point to them) or that are tagged by an explicit 'asserted' flag. The belief space of an agent  $S$  who appears in Cassie's belief space includes the beliefs that are OBJECT cases of AGENT-ACT-OBJECT propositions with  $S$  as the AGENT case and Cassie's concept of 'believe' as the ACT case. Thus, in Fig. 2, Cassie's belief space includes the beliefs represented by nodes  $m2$  (that  $m3$  is named 'John'),  $m8$  (that  $m3$  believes that  $m7$  is named 'Lucy'), and  $m11$  (that  $m3$  believes that  $m7$  is rich). The belief space of the agent represented by node  $m3$  includes both of the beliefs represented by nodes  $m6$  (that  $m7$  is named 'Lucy') and  $m10$  (that  $m7$  is rich). In Fig. 1, Cassie's belief space includes the beliefs represented by nodes  $m2$  (that  $m3$  is named 'John'),  $m6$  (that  $m7$  is named 'Lucy'), and  $m10$  (that  $m3$  believes that  $m7$  is rich). The belief space of the



agent represented by node  $m3$  only includes the belief represented by  $m9$  (that  $m7$  is rich).

As mentioned above, an individual's belief space also includes the concepts about which the individual has beliefs. It will be useful to identify those concepts that an individual has "direct" beliefs about. If node  $m$  is pointed to by an arc emanating from a node representing a belief in  $S$ 's belief space, then we say that  $S$  has a direct belief about the concept represented by node  $m$ . In Fig. 2, for example, Cassie has direct beliefs about the concepts represented by nodes  $m1$  ('John'),  $m3$  (John),  $m4$  (the act of believing),  $m6$  (that  $m7$  is named 'Lucy'), and  $m10$  (that  $m7$  is rich), since they are pointed to by nodes  $m2$ ,  $m8$ , or  $m11$ , nodes that represent beliefs. We will say that an agent's beliefs and the concepts that the agent has direct beliefs about appear directly in the agent's belief space. Thus in Fig. 2, Cassie's beliefs, represented by nodes  $m2$ ,  $m8$ , and  $m11$ , and the concepts Cassie has direct beliefs about, represented by nodes  $m1$ ,  $m3$ ,  $m4$ ,  $m6$ , and  $m10$ , appear directly in Cassie's belief space. Note that a node can appear directly in more than one belief space. For example, if Cassie believes that John believes that Lucy is rich (as in Fig. 2, node  $m11$ ), then that Lucy is rich ( $m10$ ) is a belief that appears directly in a nested belief space, and it is an object of a belief that appears directly in the top-level belief space.

#### D. Names and Descriptions

Names and descriptions of individuals are central to our analysis of belief reports. We are aware of important differences between names and descriptions, but for our present purposes, they can be treated alike, as characterizations of individuals. Let  $N$ ,  $S$ , and  $W$  be characterizations (i.e., names or descriptions) of individuals. We represent the concept of the individual who Cassie believes is named ' $S$ ,' if there is one, by: ( $S$  Cassie). Similarly, ( $N$   $S$  Cassie) is the concept of the individual who Cassie believes that ( $S$  Cassie) believes is named ' $N$ ,' and ( $W$   $N$   $S$  Cassie) is the concept of the individual who Cassie believes that ( $S$  Cassie) believes that ( $N$   $S$  Cassie) believes is named ' $W$ ,' and so on, recursively. If ( $N$   $S$  Cassie) exists in the network, then ( $S$  Cassie) believes that ( $N$   $S$  Cassie) is named ' $N$ ,' hence, ( $N$   $S$  Cassie) appears directly in ( $S$  Cassie)'s belief

space. Similarly, if ( $S$  Cassie) exists in the network, then Cassie believes that ( $S$  Cassie) is named ' $S$ ,' and so ( $S$  Cassie) appears directly in Cassie's belief space. Thus for an individual to appear directly in  $S$ 's belief space, it is sufficient for there to be some characterization ' $N$ ' such that the belief that the individual is named (or described by) ' $N$ ' appears in  $S$ 's belief space.

If ( $S$  Cassie) exists in the network, then both, one, or neither of ( $N$   $S$  Cassie) and ( $N$  Cassie) may exist in the network, and, if both of them do, they may or may not represent concepts of the same individual. However, to simplify matters, we will assume that at most one individual named or described by ' $N$ ' can appear in any single belief space. Further, we restrict our attention to belief reports such as " $S$  believes that  $N$  is  $F$ " or " $S$  said, ' $N$  is  $F$ '" in which ' $N$ ' refers to a concept that appears directly in ( $S$  Cassie)'s and/or Cassie's belief spaces, but not in some other nested belief space.

#### E. The De Re/De Dicto Distinction

We are now ready to explain the distinction between *de re* and *de dicto* belief reports. Let us begin with an example: Suppose that Ralph sees the person whom he knows to be the janitor stealing some government documents, and suppose that, unknown to Ralph, the janitor has just won the lottery. Then we can express Ralph's belief through the *de dicto* report, "Ralph believes that the janitor is a spy," and through the *de re* report "Ralph believes of the lottery winner that he is a spy." If asked, Ralph would assent to the proposition 'The janitor is a spy'; but he merely believes of the man who we know to be the lottery winner that he is a spy—Ralph would not assent to 'The lottery winner is a spy.' The difference between the *de re* and *de dicto* reports of Ralph's belief is the characterization we choose in order to refer to the janitor.

In general, the difference between a *de dicto* and a *de re* report of  $S$ 's belief that  $N$  is  $F$  lies in the characterization of  $N$  that appears in the report. If the characterization is one with which we agree, then the report is *de re*. If it is one with which  $S$  agrees, then the report is *de dicto*.  $S$  would not necessarily agree with the characterization of  $N$  that appears in a *de re* report, and we would not necessarily agree with the characterization of  $N$  that appears in a *de dicto* report. In Figs. 1 and 2, this is captured by the absence or presence of node  $m6$  in ( $S$  Cassie)'s belief space.

*De dicto* belief reports contain "referentially opaque" but "propositionally transparent" contexts, while *de re* belief reports contain "referentially transparent" but "propositionally opaque" contexts [3]. A context is *referentially opaque* if substitution of co-referential expressions into the context does not preserve truth value, and it is *referentially transparent*, otherwise. Consider the example just given: even though 'the janitor' and 'the lottery winner' are co-referential expressions, the second cannot be substituted for the first in the *de dicto* report "Ralph believes that the janitor is a spy," to yield the *de dicto* report "Ralph believes that the lottery winner is a spy," since Ralph does not know that the janitor won the lottery. Therefore, the *de dicto* report is referentially opaque. However, if the lottery winner is named 'Fred,' then 'Fred' can be substituted for 'the lottery winner' in the *de re* report "Ralph believes of the lottery

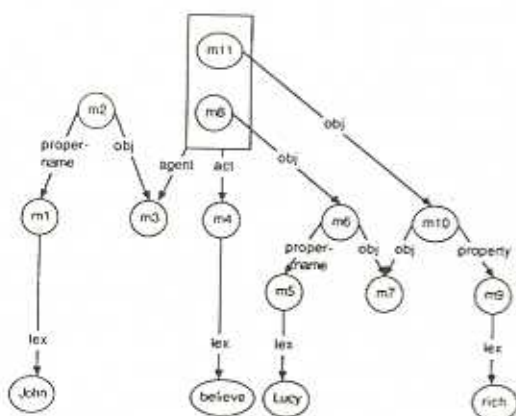


Fig. 2. SNePS network for the isolated *de dicto* belief report "John believes that Lucy is rich." The box indicates that  $m11$  and  $m8$  have AGENT arcs to  $m3$  and ACT arcs to  $m4$ .



winner that he is a spy," to yield the *de re* report "Ralph believes of Fred that he is a spy." Therefore, the *de re* report is referentially transparent.

On the other hand, a belief context is *propositionally transparent* if it conveys the propositional content of the belief of which it is a report, and if the believer would assent to the report. It is *propositionally opaque*, otherwise. Returning to our example, "Ralph believes that the janitor is a spy," is propositionally transparent, but the *de re* report involving the characterization 'the lottery winner' is propositionally opaque.

#### F. Belief Reports and the Representation of Belief

In this paper, we are specifically concerned with the representation of beliefs that Cassie acquires through her understanding of belief reports, and with the expression of her beliefs through belief reports. Such reports are expressed in sentences. However, our representations of Cassie's understanding of belief reports are, following Maida and Shapiro [6], representations of *beliefs*, rather than of *sentences*. In this, we are closer in spirit to Schank and Rieger [12], who represent "conceptualizations," than we are to Woods [13], who is concerned with representing the meaning of sentences.

Moreover, we consider belief reports that appear within the context of narrative and discourse, and not simply in isolation. In Section II, we show that an agent's understanding of a belief report depends upon her prior beliefs, and that her expression of a belief depends not only on the belief she is expressing, but on other beliefs as well. Thus in order to represent the beliefs that an agent acquires or expresses through a belief report, we cannot consider just the belief that is being acquired or expressed; we must also consider some of the agent's other beliefs. These other beliefs, in turn, were formed or brought into focus as the agent understood the previous utterances of the narrative or discourse.

#### G. Earlier Research

In earlier work, Rapaport and Shapiro presented computational analyses of *de re* and *de dicto* belief reports [8], [9]. A belief report canonically expressed in the form "S believes that N is F" (where 'N' is a characterization, and 'F' is an adjective) was interpreted *de dicto*, i.e., 'N' referred to (N S Cassie), and was represented by the network in Fig. 2. A belief report canonically expressed in the form "S believes of N that s/he is F" was interpreted *de re*, i.e., 'N' referred to (N Cassie), and was represented by the network in Fig. 1.<sup>1</sup> The difference between Figs. 1 and 2 is that in Fig. 2, it is (S Cassie) who believes that the person s/he believes is F is named (or described by) 'N,' and in Fig. 1, it is Cassie herself who believes this.

The networks depicted in Figs. 1 and 2 were the only representations presented in the earlier analysis, and a belief report could be identified as *de re* or *de dicto* on the basis of which of these representations the report was generated

<sup>1</sup>Rapaport and Shapiro used canonical language so that their analysis of the *representation* of belief reports was clear; they recognized that belief reports appearing in ordinary language need to be disambiguated on other grounds. We address the disambiguation of belief reports in Section IV, below.

from or into which the report was parsed. Thus unambiguous representations were provided for the two possible interpretations of belief reports. In this paper, we argue that this analysis of *de re* and *de dicto* belief reports is sufficient only in the artificial case when belief reports are considered in isolation. When they are considered within the context of narrative and discourse, and not just in isolation, we need to consider more complicated belief structures, in addition to those depicted in Figs. 1 and 2. Further, we cannot meaningfully apply one but not the other of the concepts *de re* and *de dicto* to these more complicated networks. We do not suggest that the concepts *de re* and *de dicto* lose their meaning when belief reports are considered within the context of narrative or discourse. Rather, we shall argue that *de re* and *de dicto* are not attributes of *representations*, as they were understood to be in the earlier analysis, but are ways of *understanding* and *expressing* belief reports on specific occasions.

## II. CHOOSING CHARACTERIZATIONS

In this section, we show that it is possible for an agent to express a *de re* belief report from a belief that she acquired through a *de dicto* belief report, and *vice versa*, even though the representation of the belief itself remains unchanged. As we shall see, this can occur because an agent's understanding or expression of a belief report depends not only on the belief acquired or expressed, but upon other beliefs as well.

As mentioned above, we represent Cassie's beliefs about other's beliefs; we do not represent the actual beliefs of any other agent. Within this framework, a *de dicto* belief report of Cassie's belief that (John Cassie) believes that Lucy is rich contains a characterization of Lucy that Cassie believes (John Cassie) would agree with, but not that Cassie herself necessarily agrees with. A *de re* report of such a belief contains a characterization of Lucy that Cassie agrees with, but not that Cassie necessarily believes (John Cassie) would agree with.

Thus the difference between a *de re* and a *de dicto* belief report is to be found in Cassie's characterizations of individuals, and her representations of others' characterizations of individuals.

A belief is represented in a propositional semantic network such as SNePS by a node with certain kinds of arcs pointing to other nodes. Typically, some of these nodes existed in the network prior to the acquisition of the belief. For example, if Cassie acquires a belief that John believes that Lucy is rich, Cassie's belief is represented by a node which relates the nodes representing John, the act of believing, and the proposition that Lucy is rich; the node representing this proposition itself relates the nodes representing Lucy and the property of being rich. There is a constraint in SNePS that new concepts are formed only if they were not previously represented in the network (this follows from SNePS principle 3). Thus any of the concepts in Cassie's belief space may have existed in the network prior to the acquisition of the belief, or they may have been formed as a result of the acquisition of the belief.

A concept is represented in SNePS by a single node (this follows from SNePS principles 1, 2, and 3). However, there is no limit to the number of beliefs Cassie can acquire about a concept. For many of the uses Cassie makes of a concept,



she must access some knowledge or belief she has about that concept; i.e., she must think something about it. Consider Cassie's belief that John believes that Lucy is rich. When Cassie accesses this belief (for use in generation or inference, for example), she might think about John and Lucy in some way, apart from their roles in this belief. For example, on one occasion, she may think of John as someone named 'John,' and on another occasion she may think of John as her favorite user. In other words, when Cassie accesses this belief, she may access other beliefs about John and Lucy than the belief itself. Among these could be a belief that Lucy is named 'Lucy,' or a belief that John believes that Lucy is named 'Lucy.'

The comprehension and use of language forces an agent to think of individuals in specific ways. Suppose Cassie hears an utterance of

(1) John believes that Lucy is rich

and her understanding of it is such that 'John' and 'Lucy' refer to concepts that are already represented in the network. Then, through the characterization 'Lucy' in the report, Cassie identifies the concept of Lucy, call it concept1: she accesses some proposition that concept1 is named 'Lucy.' If she believes this proposition, then she has accessed her own belief about concept1. On the other hand, if she believes that this proposition is believed by John, then she has accessed a belief of John's about concept1: she thinks about concept1 in a way that (she believes) John would think of concept1. Thus it is important that the concept of an individual be distinct from the individual's name—hence our use of the PROPER-NAME-OBJECT case frame.

Suppose, on the other hand, that Cassie's understanding of (1) is such that 'Lucy' does *not* refer to a concept that is already represented in the network. Then she forms a *new* concept to which 'Lucy' refers, along with the proposition that this concept is named 'Lucy.' Cassie may believe this proposition, or she may believe that John believes this proposition. In any case, she has acquired a concept of an individual, and a belief (perhaps a belief about a belief) about that individual, through her understanding of the utterance of (1).

Now consider the generation of a report of Cassie's belief that John believes that Lucy is rich. Among other things, Cassie must choose a name or description to express her concept of Lucy. Suppose she chooses the name 'Lucy.' In order to do this, she must access a proposition that Lucy is named 'Lucy.' If she believes this proposition, then she accesses one of her own beliefs about how Lucy can be characterized. If she believes that John believes this proposition, then she accesses one of her beliefs about how John believes Lucy can be characterized.

Thus when Cassie hears an utterance of (1), the proper name 'Lucy' not only enables her to identify or form a concept, but also forces her to access or form a belief (or a belief of a belief) about the concept: she is forced to think of the concept in some way, apart from the information asserted by the utterance. Further, when Cassie generates a report such as (1), in order to generate the proper name 'Lucy,' she must access a belief (or a belief of a belief) that someone can be characterized as 'Lucy': she is forced to think of that individual in some way, apart from the information she is asserting by making the utterance.

How does this relate to the *de re/de dicto* distinction? If the characterization of Lucy in an utterance is the name 'Lucy,' then Cassie agrees with this characterization of Lucy if she herself believes that Lucy has the name 'Lucy.' Cassie believes that John would agree with this characterization if she believes that John believes that Lucy has the name 'Lucy.' Thus Cassie interprets or expresses an utterance of (1) *de re* if she accesses or forms her *own* belief that Lucy is named 'Lucy,' in order to interpret or express the utterance, and she interprets or expresses it *de dicto* if she accesses or forms her belief that *John* believes that Lucy is named 'Lucy,' in order to interpret or express the utterance.

The fact that we cannot identify two distinct, unambiguous representations for *de re* and *de dicto* belief reports can be understood within the following framework. Suppose that Cassie hears an utterance of (1), and then on a later occasion, she decides to express a report of her understanding of (1).<sup>2</sup> Depending upon many factors, including her purpose in making the report, Cassie may choose any of her beliefs that characterize Lucy (including beliefs about beliefs about Lucy) in order to generate a noun phrase to express her concept of Lucy. This belief may be quite different from the belief she accessed or formed in order to identify Lucy in *understanding* (1). She may have accessed her *own* belief that Lucy can be characterized by 'Lucy' when she understood (1), and she may choose one of her beliefs about how John characterizes Lucy when she later generates a report of the belief.

In fact, in the interim between hearing (1) and expressing a report of her understanding of (1), Cassie may have acquired additional beliefs or may have revised her beliefs about Lucy. In the next section, we turn to a consideration of these issues.

### III. REPRESENTING BELIEF REPORTS IN CONTEXT

Consider the following example. Suppose that Cassie is reading a story that contains the sentence "John said, 'Lucy is rich,'" and that Cassie does not know who 'Lucy' refers to (perhaps no individual named 'Lucy' has been introduced into the narrative thus far). Cassie decides that 'Lucy' refers to an individual who John believes is named 'Lucy,' and she interprets the belief report *de dicto* (see Fig. 2). Note that the representation involves (Lucy John Cassie). Later in the story, a person named 'Lucy' is directly introduced and Cassie believes that she is (Lucy John Cassie). Further, Cassie finds out that this individual is the town beggar, and does not believe that (John Cassie) knows this. The representation of the original belief (*m11*) together with these new beliefs (*m6* asserted, and *m13*) is depicted in Fig. 3.

But at this stage, we can no longer apply just one of the concepts *de re* and *de dicto* to the representation of Cassie's belief that John believes that Lucy is rich (*m11*, in Fig. 3). Cassie can now express that belief in three different ways: "John believes [*de dicto*] that Lucy is rich," "John believes [*de re*] of Lucy that she is rich," and "John believes [*de re*] of the town beggar that she is rich." The first is *de dicto* because (John Cassie) would agree with the characteriza-

<sup>2</sup>We assume for now that Cassie automatically believes everything she is told.



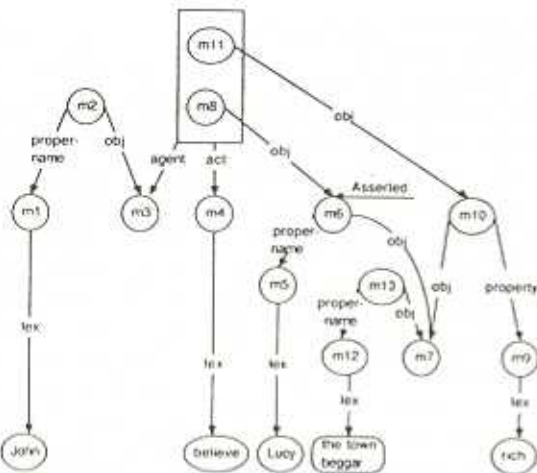


Fig. 3. The belief represented by node  $m_{11}$  can be expressed through a *de re* report or through a *de dicto* report.

tion of  $m_7$  it contains, and the other two are *de re* because Cassie would agree with both of the characterizations of  $m_7$  that appear in these sentences. Further,  $m_{11}$  could be the representation of a belief report that was interpreted *de re*, such as "John believes of the town beggar that she is rich," or the representation of a belief report that was interpreted *de dicto*, as is the case in our example.

Further, although the original belief report was referentially opaque, "John believes that Lucy is rich" can be referentially transparent, even though it involves exactly the same characterization of (Lucy John Cassie) as the one that appeared in the original belief report: 'The town beggar' can be substituted for 'Lucy' to yield the *de re* report "John believes of the town beggar that she is rich."

Propositions  $m_{11}$ ,  $m_2$ , and  $m_{13}$  of Fig. 3 comprise a representation that is just like Fig. 1, except that the characterization of  $m_7$  is 'the town beggar' rather than 'Lucy.' Propositions  $m_{11}$ ,  $m_2$ , and  $m_6$  of Fig. 3 also comprise a representation that is the same as Fig. 1, and propositions  $m_{11}$ ,  $m_2$ , and  $m_8$  of Fig. 3 comprise a representation that is the same as Fig. 2. Within Fig. 3, we can find instances of the *de re* and *de dicto* representations that were identified in the original analysis.

The next important point is that a belief report of  $m_{11}$  cannot be expressed from  $m_{11}$  alone, but must be expressed from a combination of  $m_{11}$ ,  $m_2$ , and one of  $m_6$ ,  $m_8$ , or  $m_{13}$ . Similarly, Cassie's interpretation was not represented by  $m_{11}$  alone, but by  $m_{11}$ ,  $m_2$ , and  $m_8$ . We must distinguish between structural (or definitional) information and assertional information [13]. Proposition  $m_{11}$  is *structurally* defined by the nodes it dominates, i.e., nodes  $m_3$ ,  $m_4$ ,  $m_{10}$ ,  $m_7$ , and  $m_9$ . Node  $m_{11}$ , by itself, simply represents the proposition that some individual,  $m_3$ , believes that some other individual,  $m_7$ , is rich. In order to express the proposition representing  $m_{11}$ , part of the *assertional* information represented by nodes  $m_2$ ,  $m_6$ ,  $m_{13}$ , and  $m_8$  must be accessed; i.e., characterizations for  $m_3$  and  $m_7$  must be chosen. Similarly, in order to represent Cassie's interpretation of the report "John said, 'Lucy is rich,'" it was necessary to build  $m_{11}$ , and to build (or access)  $m_2$  and  $m_8$ , propositions that represent assertional information about  $m_3$  and  $m_7$ .

The *structural* definition of  $m_{11}$  does not change as Cassie

acquires additional beliefs about  $m_7$  and about (John Cassie)'s beliefs about  $m_7$ . Node  $m_{11}$ , by itself, has nothing to do with whether Fig. 3 is the representation of Cassie's interpretation of a *de re* or a *de dicto* belief report. This depends upon whether the characterization of  $m_7$  that appears in the belief report is Cassie's or (John Cassie)'s. Nor does node  $m_{11}$ , by itself, have anything to do with whether Cassie expresses the belief *de re* or *de dicto*. This depends upon whether the characterization for  $m_7$  is chosen from Cassie's or (John Cassie)'s belief space.

In the earlier analysis of *isolated* belief reports, two distinct, unambiguous representations for *de re* and *de dicto* belief reports could be identified because the only cases that were considered were those in which only one of Cassie and (John Cassie) has a characterization for the individual who (John Cassie) believes is rich. In each case, there was only one candidate for the characterization of this individual: in Fig. 2, the characterization appears only in (John Cassie)'s belief space; in Fig. 1, it appears only in Cassie's belief space.

Using intensional representations, the set of nodes that exist in the network depends not only upon what beliefs Cassie has, but also on the order in which she acquires them. This property is called *order dependency* [6, p. 299]. In the above example, Cassie came to believe directly of (Lucy John Cassie) that she is named 'Lucy,' and that she is the town beggar. Suppose, however, that Cassie already had a concept of a person named 'Lucy' who was the town beggar, and suppose that upon reading "John said, 'Lucy is rich,'" she decides that 'Lucy' refers to an individual who John believes is named 'Lucy,' who is a different individual from (Lucy Cassie) (perhaps she reasons that John would not think that the town beggar is rich). Thus Cassie forms a new concept, (Lucy John Cassie), as the individual to whom 'Lucy' refers, and about whom Cassie believes only that (John Cassie) believes that she is rich and is named 'Lucy.' The network representing this belief structure is depicted in Fig. 4. Notice that only a *de dicto* belief report can be generated from this representation.

Now suppose that Cassie later comes to believe that (Lucy John Cassie) and (Lucy Cassie) are concepts of the same

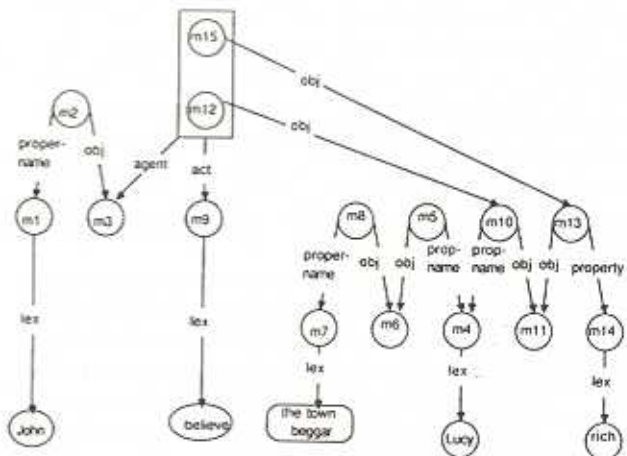


Fig. 4. The belief represented by node  $m_{15}$  can be expressed through a *de dicto* report only. The box indicates that  $m_{12}$  and  $m_{15}$  have AGENT arcs to  $m_3$  and ACT arcs to  $m_9$ .











cur within Eumaios's direct speech should be interpreted *de dicto*, and, at this point in the narrative, their representations should involve (the-beggar Odysseus reader). Third-person belief reports are reports from the author to the reader about Eumaios's beliefs, and first-person belief reports are intended to be interpreted as direct statements of Eumaios's beliefs. This is consistent with our revised analysis of *de re* and *de dicto* belief reports.

## VI. CONCLUSION

We presented an analysis of the representation of *de re* and *de dicto* belief reports that appear within the context of narrative and discourse, and not simply in isolation. We argued that there were not two distinct, unambiguous representations of *de re* and *de dicto* belief reports when belief reports are considered in context. Under our analysis, *de re* and *de dicto* are ways of interpreting and expressing belief reports on particular occasions: a *de re* belief report is a report from the agent's perspective, and a *de dicto* belief report is a report from (S agent)'s perspective.

We discussed the factors that influence an agent's disambiguation of belief reports that occur in ordinary language, and included an example that illustrates the disambiguation of belief reports based on the writer's intentions. We also illustrated through this example that characterizations that do not appear within a belief report are subject to the same ambiguity as characterizations that appear within belief reports.

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