

# Identity in epistemic semantics

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## abstract

This paper is a contribution to the semantical theory of different types of knowledge ascription, in particular the semantics of ‘knowing who’ and of the interaction between quantifiers and epistemic modal expressions. In possible world semantics, the truth conditions of such sentences depend on the way that identity across possible worlds is modeled. The main argument of this paper is that the context-dependence of such sentences can be modeled as a dependence on the identity relation between objects in possible worlds.

## 1 Introduction

Imagine a small room with two people in it: a butler and a gardener. One of them is called John, the other Mary, but you do not know whether John is the butler or the gardener, and similarly for Mary. The butler has committed a horrible crime; the gardener had nothing to do with it.

Since you know that the butler has done it, it seems that you can be said to know who has done it: the butler. And since you know that the gardener must be innocent, it seems that you believe that it is not the case that everyone in the room might be the murderer.

On the other hand, you do not know if John is the butler or not, and so you don’t know whether he has done it. The same holds for Mary. Since John and Mary are all the people in the room, it holds that everyone in the room might have done it. It seems you do not know who has done it after all: it could be either John or Mary.

We seem to have a situation here in which, in one respect, you know who has done it (namely the butler) and from another viewpoint, you don’t (it could be either John or Mary). Similarly, it seems that given this information, it can be said both that everyone might have done it (both John and Mary) as well as that it is not the case that everyone might have done it (the gardener certainly had nothing to do with it).

This situation is not as exotic as it may seem. As I will argue, it is related to the oft-noted ‘ambiguity’ of wh-knowledge ascriptions and of questions, and also to puzzles about *de re* beliefs that are familiar from the philosophical literature on modal logic. In this paper, I will show how such examples can be accounted for in a standard possible worlds semantics.

## 2 Quantification in Epistemic Contexts.

Possible world semantics has turned out to be a useful tool for the analysis of intensional expressions, e.g. of sentences about necessity, knowledge or belief, and of questions. To interpret a language, possible worlds need to have a certain minimal structure: we need to know in each possible world what the predicates, constants and other lexical items of the language refer to. For the purposes of this paper, in which the object language is that of modal predicate logic, this means that possible worlds should at least contain as much structure as a first-order predicate logical model:

**Definition 2.1** (possibilities, information states and Kripke models)

- A (epistemic) possibility  $w$  for a language  $\mathcal{L}$  is a (first-order) model  $(D_w, I_w)$ , where  $D_w$  is a set (called the domain of  $w$ ), and  $I_w$  is an interpretation function that assigns to each non-logical constant of  $\mathcal{L}$  an interpretation of the appropriate type.
- An information state is a set of possibilities.
- A Kripke model is a pair  $(w, \sigma)$ , where  $w$  is a possibility and  $\sigma$  is an information state.  $\square$

The information (knowledge, beliefs) of an agent are modeled by an information state. An information state contains all and only those possibilities that are compatible with what that agent knows; it consists of those models that, given the information of the agent in question, may picture the world correctly. If  $\sigma$  is the information state of some agent  $a$  that represents the *knowledge* of  $a$ , then we can assume that there is a possibility  $w \in \sigma$  that represents ‘the real world.’

Usually, a Kripke model is defined as a set of possible worlds with an accessibility relation over that set. If the accessibility relation is transitive and euclidean (these properties are usually assumed to hold for relations modeling ‘knowledge’ or ‘belief’) Kripke models can be represented as a pair  $(w, \sigma)$ . I have chosen this relatively simple representation.

One of the issues that need to be addressed before defining a semantics for knowledge ascriptions is what it means for two objects in different possibilities to be ‘the same.’ For example, in the analysis of *wh*-complements of Groenendijk and Stokhof (1984, 1997), a sentence of the form ‘ $a$  knows who VP’ is true just in case the extension of the property expressed by the VP is *the same* in all epistemic alternatives of that agent.

The same question of identity needs to be answered when we want to give a definition of the interaction of quantifiers and epistemic modals, and in particular when we want to account for *de re* knowledge ascriptions. Under the standard analysis, an agent believes about a certain object that it has the property  $P$  just in case in each of her epistemic alternatives, that same object has the property  $P$ .

So, the usual semantics of *wh*-complements and of quantification presupposes a certain notion of identity across possible worlds. Let us postpone the question

as to what this identity relation exactly is, and just assume that we are given some equivalence relation  $R$  over objects that models our notion of transworld identity.

**Definition 2.2** (identity relations)<sup>2</sup>

A relation  $R$  between pairs  $(w, d)$  consisting of a possibility  $w$  and an object  $d$  in the domain of  $w$  is an *identity relation* just in case  $R$  is an equivalence relation.

□

When  $(w_1, d_1)R(w_2, d_2)$ , I will say that  $d_2$  in  $w_2$  is a counterpart of  $d_1$  in  $w_1$ . For easier reading, I will often write  $d_1Rd_2$  instead of  $(w_1, d_1)R(w_2, d_2)$ , where this does not lead to confusion.

Relative to an identity relation  $R$ , we can define a semantics for quantified modal logic as follows:

**Definition 2.3** (semantics)

Let  $(w, \sigma)$  be a Kripke model,  $g$  an assignment of objects in  $w$  to the variables in the language.

$$\begin{aligned}
(w, \sigma) \models_R^g Px_1 \dots x_n & \text{ iff } \langle g(x_1) \dots g(x_n) \rangle \in I_w(P) \\
(w, \sigma) \models_R^g x_1 = x_2 & \text{ iff } g(x_1) = g(x_2) \\
(w, \sigma) \models_R^g \phi \wedge \psi & \text{ iff } (w, \sigma) \models_R^g \phi \text{ and } (w, \sigma) \models_R^g \psi \\
(w, \sigma) \models_R^g \neg \phi & \text{ iff } (w, \sigma) \not\models_R^g \phi \\
(w, \sigma) \models_R^g \exists x \phi & \text{ iff } \exists d \in D_w : (w, \sigma) \models_R^{g[x/d]} \phi \\
(w, \sigma) \models_R^g \Box \phi & \text{ iff } \forall v \in \sigma \text{ and } \forall h \text{ such that } g \mapsto_R^{w,v} h : (v, \sigma) \models_R^h \phi
\end{aligned}$$

In the definition,  $g \mapsto_R^{w,v} h$  iff for all variables  $x$ ,  $(w, g(x))R(v, h(x))$ . □

In this definition, all clauses except the one for the modal operator  $\Box$  are standard. It holds that  $g \mapsto_R^{w,v} h$  just in case  $h$  is an assignment in which all values of  $g$  in  $w$  are replaced by their counterparts in  $v$ . For example, the sentence  $\exists x \Box Px$  is true in a model  $(w, \sigma)$  just in case there is an object  $d$  in the domain of  $\sigma$  such that in all the possibilities in the information state  $\sigma$ , all counterparts of  $d$  have the property  $P$ .

Note that if we assume that every object has exactly one counterpart in each possibility, then the choice of defining the semantics of  $\Box$  with the help of universal quantification over counterparts instead of an existential one is moot: both are equivalent.

### 3 Switching Schemes

In the literature on possible world semantics (cf., for example, the collections Linsky (1971) and Loux (1979)) a lot of attention has been given to the question what the right notion of transworld identity is. Asking what *the* relation

<sup>2</sup>In the following, I will ignore issues related to cases in which certain objects do not have counterparts in other possibilities. These issues are important, but I believe they are not directly relevant to the points I want to make in this paper. In the following, I will assume that an object in any one possibility always has a counterpart in every other possibility.

of transworld identity is presupposes that this relation is unique. Below, I will argue that in epistemic contexts the assumption that there is a single and fixed identity relation cannot be upheld. Instead, the notion of transworld identity that applies to epistemic possibilities should be seen as a context-dependent notion. The assumption that the identity relation depends on the context allows us to account not only for the puzzle sketched in the introduction, but for a wide range of examples which would be mystifying otherwise: the oft-noted ‘ambiguity’ of questions and ‘knowing who’-constructions, certain examples concerning the interaction of quantifiers with epistemic ‘might’, and some old puzzles concerning *de re* belief.

There are different ways one can motivate particular answers to the question of transworld identity. In the philosophical literature on modal logic the discussion has focused for a major part on the question of the ontological status of possible worlds and the objects in these worlds. In this paper, I want to take a more ‘empirical’ approach to the notion of identity across possibilities in epistemic contexts. Given the informal characterization above of what an information state is, the intuitions we have about the truth conditions of sentences (i.e. which sentences are true in which Kripke models) are fairly robust. Coupled with intuitions about logical relations between sentences (which sentences are synonymous, which sentences are logical consequences of each other), such intuitions are sufficiently precise to answer this question. So, in the following, I will avoid ‘ontological’ or ‘philosophical’ questions as much as I possibly can, and will base my arguments on intuitions about truth conditions instead.

Before discussion particular examples, there is one issue that needs to be mentioned. When we take  $R$  to be ‘rigid identity’, the relation that holds between objects in different possible worlds just in case they are identical (i.e.  $(w_1, d_1)R(w_2, d_2)$  iff  $d_1 = d_2$ ), we get a classical interpretation for modal logic as it is defined in Kripke (1963). In later work (Kripke (1980)) Kripke has argued –convincingly, I believe– that this is the relation of transworld identity that corresponds to the way we speak about objects in counterfactual contexts. Kripke himself stresses that his arguments do not apply to epistemic modality. In fact, as I have tried to argue in Gerbrandy (1997) for the analysis of *epistemic* modals rigid identity is not the right way of identifying objects in epistemic possibilities. I will come back to this point at the end of this paper.

## Knowing who.

It has often been observed (Ginzburg (1996), Boër and Lycan (1986), Carlson (1983)) that both the correctness of an answer to a question and the truth of sentences of the form ‘*a* knows who VP’ are highly context dependent: what constitutes a good answer to a question depends on the goals and interests of the questioner; and whether someone can be said to know who VP depends on contextual factors in a similar way. For example, depending on the context, all of the following sentences may express a complete answer to the question ‘Who is Bill Clinton?’, as well as the information that *a* needs so that the sentence ‘*a*

knows who Bill Clinton is' is true.

- (1) Bill Clinton is the president of the United States.
- (2) That is Bill Clinton (pointing to him).
- (3) Bill Clinton was born on 10.13 AM, on august 19, 1946, in Hope, Arkansas.

The first sentence would be a complete answer to the question who Bill Clinton is in the context of, for example, a highschool exam. In another context, say at a fund-raising party at which Bill Clinton is present, the question who Bill Clinton is is not satisfactory answered with (1); pointing him out to the questioner would be a better answer instead. In yet another context, a conference of astrologers for example, his job or looks may be considered completely irrelevant. Instead, his date of birth would be considered much more important. In such a situation, sentence (3) would be considered a good answer to the question who Bill Clinton is, and many an astrologer would agree that he does not know who Bill Clinton is unless he knows time and place of his birth.

In general, it seems that when we ascribe knowledge to people by using a circumlocution of the form '*a* knows who ... is,' there will be different kinds of information that support such a judgment. For some purposes, knowing someone's name will be enough evidence for knowing who that person is (and stating his name a good answer to the question who he is), for other purposes, knowing where he is and what he looks like may be the kind of information needed, in other cases, it may be important what his birthdate is, etcetera.

To model this phenomenon in our semantics, we need an formal analysis of 'knowing who.' The analysis of questions and of 'knowing who' that I will concentrate on is that of Groenendijk and Stokhof (1984, 1997). In their analysis, the meaning of a question is given by the set of its complete answers; answers are identified with propositions, i.e. sets of possibilities. A complete answer to the question 'Who VP?' is represented by the set of all worlds in which the extension of VP is the same. In other words, a complete answer to the question 'Who VP?' is given by a specification of the set of objects that have the property expressed by the VP. A sentence of the form '*a* knows who VP' is true just in case *a* knows what the complete true answer to the question 'Who VP?' is, i.e. *a* knows who VP just in case the set of objects with the property expressed by VP in each of *a*'s epistemic alternatives is the same as the set of those objects that have the property VP in 'the real world.'

Let us use the notation  $?x\phi(x)$  for the statement that our agent knows who  $\phi$ . We can define:<sup>3</sup>

$$(w, \sigma) \models_R ?x\phi \text{ iff } (w, \sigma) \models_R \forall x(\Box\phi \vee \Box\neg\phi)$$

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<sup>3</sup>The observation that the notion of 'knowing who' can be defined in quantified modal logic –the observation is new, I believe– provides us with an axiomatization of the logic of questions and answers defined in Groenendijk and Stokhof (1997). To be more precise: the semantics that Groenendijk and Stokhof assign to interrogatives is of the following definition, in which all possible worlds have their domain in common, and *R* is 'real identity.' There exist axiomatizations for quantified modal logic under these assumptions (cf. Garson (1984)); and the observation that sentences of the form  $?x\phi$  can be defined in this logic provides the wanted axiomatization.

So, our agent knows who  $\phi$  just in case for each object, she either knows it has the property  $\phi$ , or she knows it does not have the property  $\phi$ . Under the assumption that all objects have counterparts in each possibility, it holds that  $(w, \sigma) \models ?xPx$  iff for all  $v$  and  $v' \in \sigma$ ,  $I_v(P)$  is  $R$ -identical to  $I_{v'}(P)$ ; i.e. if  $d$  is in the extension of  $P$  in  $v$ , then all  $R$ -counterparts of  $d$  are in the extension of  $P$  in  $v'$ , and vice versa.

The context-dependence of ‘knowing who’ (and of questions) can be modeled by interpreting the quantifier  $?x$  relative to a different identity relation in each context. Relative to a relation  $R$  that identifies people by their position in society (in particular, if it holds that  $(v, d)R(v', d')$  just in case  $d$  is the president of the United States in  $v$ , and  $d'$  is the president in  $v'$ ), it holds that you know who Bill Clinton is iff you know that he is the president, i.e.<sup>4</sup>

$$(w, \sigma) \models_R ?x(x = \text{Bill Clinton}) \text{ iff } (w, \sigma) \models \Box(1)$$

Relative to an identity relation  $R$  that identifies people just in case they are born at the same time, day and place (and assuming these coordinates identify a unique person in each possibility) it holds that

$$\sigma \models_R ?x(x = \text{Bill Clinton}) \text{ iff } \sigma \models \Box(3)$$

## Might.

If we allow for identity to vary with the context, we can give a formal account of the situation described in the introduction.

If we transpose the analysis of the modal operator ‘might’ of Groenendijk et al. (1996) into a static framework, it is easily seen that ‘might’ is just the dual of the epistemic operator  $\Box$ . In this analysis, it holds that an agent whose information is described by an information state  $\sigma$  believes that ‘everything might be  $\phi$ ’ just in case for each object, it holds that there is a possibility in  $\sigma$  where that object has the property  $\phi$ . More formally, the sentence  $\forall x \Diamond \phi$  is accepted in a state  $\sigma$  just in case for each  $v \in \sigma$ , it holds that  $(v, \sigma) \models_R \forall x \Diamond \phi$ .

We can view the two people in the room under (at least) two different perspectives, and each of these perspectives correspond to a different identity relation. If we view the people under their description as ‘the butler’ and ‘the gardener,’ then we know who has done it, and we do not accept the sentence ‘everyone might have done it.’ Formally, this way of identifying the people in the room corresponds with a relation  $R$  that holds between two objects just in case they have the same profession (in this case, it connects the butler in the different possibilities with each other, and it does the same with the gardener). If  $\sigma$  is the information state of someone who has (only) the information about the butler and the gardener that was given in the introduction of this paper,

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<sup>4</sup>I assume that  $(w, \sigma)$  models the *knowledge* of some person, i.e. that  $w \in \sigma$ .

it holds that  $(w, \sigma) \models_R ?x \text{done it}(x)$  and that the sentence  $\neg \forall x \diamond \text{done it}(x)$  is accepted in  $\sigma$ .

The other case, in which we identify the people in the room as ‘John’ and ‘Mary,’ can be modeled by taking an identity relation  $R$  that identifies objects just in case they carry the same name. Relative to this relation  $R$ , it holds that  $(w, \sigma) \not\models_R ?x \text{done it}(x)$  and that the sentence  $\forall x \diamond \text{done it}(x)$  is accepted in  $\sigma$ .

## De re beliefs.

Consider Quine’s example of Ralph. Ralph believes that reverend Bernard J. Ortcutt, a man he once met at a party, is a man of high moral standing. In particular, he believes of Ortcutt that he is not a spy. In the classical analysis of *de re* belief, this means that the sentence  $\exists x(\text{Ortcutt}(x) \wedge \Box(\neg \text{spy}(x)))$  is true in such a situation.

Ralph has also seen a man behaving suspiciously on the beach. Ralph has concluded that this man must be a spy. This man was in fact Ortcutt, but Ralph does not know this. So, Ralph believes of the man on the beach, i.e. of Ortcutt, who is the tallest Moldavian spy, that he is a spy; the sentence  $\exists x(\text{Ortcutt}(x) \wedge \Box(\text{spy}(x)))$  is true.

So, it seems that Ralph has contradictory beliefs about Ortcutt: Ralph believes him to be both a spy and not a spy. On the other hand, there is no reason to assume that Ralph’s beliefs are inconsistent.

Relative to a single identity relation, both sentences can be true in a model  $(w, \sigma)$  only if  $\sigma$  is the empty set, i.e. if Ralph’s beliefs are inconsistent. But there seems to be no reason to assume this. So it seems that examples such as these provide evidence that there is not one single notion of identifying objects at work here.

A description of this situation in terms of our semantics would run as follows. Suppose  $\sigma$  is an information state that represents Ralph’s beliefs, and  $w$  is ‘the real world.’ Ralph has two ways of identifying Ortcutt: he knows Ortcutt as the man called Ortcutt that he has met at the party, but he also knows Ortcutt as the man the saw behaving suspiciously at the beach. Both ways of identifying Ortcutt correspond to a certain identity relation: the first corresponds to a relation  $R_1$  that connects objects in Ralph’s epistemic alternatives just in case they are the man called Ortcutt that he has met at the party, and connects these objects with the object Ralph in fact met at the party in the ‘real world’  $w$ ; the second way of identifying objects can be modeled by a relation  $R_2$  that connects objects in Ralph’s epistemic alternatives just in case they are the man that Ralph saw behaving suspiciously at the beach, and connects these objects with the object that Ralph saw on the beach in the ‘real world.’

It now holds that  $(w, \sigma) \models_{R_1} \exists x(\text{Ortcutt}(x) \wedge \Box(\neg \text{spy}(x)))$  and that  $(w, \sigma) \models_{R_2} \exists x(\text{Ortcutt}(x) \wedge \Box(\text{spy}(x)))$ .

A related example is Kripke’s Pierre, a somewhat confused bilingual Frenchman who believes that London is not pretty, but that *Londres* is pretty. The

problem we are concerned with here<sup>5</sup> is trying to find an answer to the question what Pierre believes of London, i.e. what does he believe *de re* of the ‘object’ London? The answer is analogous to the way we described Ralph’s beliefs about Ortcutt: under the description of London as ‘London’, Pierre believes that London is ugly; under the description of London as ‘Londres’, Pierre believes that London is pretty.

## 4 Properties of identity.

It should be clear now that examples such as the above can be iterated indefinitely. This implies that the different ways of identifying objects that are at work in epistemic semantics are also, in principle, unlimited. This does not necessarily mean, of course, that there are no general restrictions on the kind of identity relations that are, or may be, used. I will discuss some of these in this section.

A natural restriction on identity relations is that they should identify objects in different models that have exactly the same properties. In more mathematical terms, this means that if  $\pi$  is an isomorphism between two models  $w$  and  $w'$ , then it should hold that if  $\pi(d) = d'$ , then  $d$  and  $d'$  are identified. Let us call an identity relation *blind with respect to isomorphism* if it has this property.

Relative to a relation that is not blind with respect to isomorphism, it may happen that you know all the properties of a certain object, the president of France, say, but may still not know ‘who the president of France is’ because you do not know ‘which object it is.’ I find it very hard to make sense of such a notion of ‘knowing who.’ It seems that for the way we speak about knowledge and belief, you know everything that can possibly be known about an object if you know all the properties of that object. The constraint that identity should be blind with respect to isomorphism reflects this observation.

Note that this constraint excludes rigid identification as a possible way of identifying objects. If the constraint is adopted that an identity relation should always be blind with respect to isomorphism, then a semantics of modal logic in the style of Kripke (1963), which is used for epistemic semantics in the work of Groenendijk et al. cited above, is not only too limited (in the sense that it is presumed that there is one fixed notion of transworld identity), but actually *wrong* for the analysis of epistemic modals.

If we allow quantification only with respect to identity relations that are blind with respect to isomorphism, then the number of isomorphic copies that occurs in a given information state will have no influence on which sentences are accepted in that state. This is a welcome consequence. I have characterized epistemic states as containing those possibilities that are consistent with the information of the agent in question. Under such a characterization, it is hard to see how a certain possibility could be consistent with an agent’s beliefs, while an isomorphic copy of that possibility is not. Considering only identity relations

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<sup>5</sup>Kripke presents this problem as a problem about meaning in relation to belief.

that are blind with respect to isomorphism means that the number of isomorphic copies of a possibility in an information state is inessential for determining what is known in that state; what matters is which isomorphism classes of first-order models are represented in that state.

Another general constraint on identity relations I will only mention; lack of space does not allow me to discuss it in detail. The constraint is that each object has at most one counterpart in any possibility. Any identity relation  $R$  that is ‘real identity’ when restricted to a single possibility (i.e. if  $(w, d_1)R(w, d_2)$ , then  $d_1 = d_2$ ) has this property. Such a constraint does not only seem natural, it is also interesting because it allows us to identify  $R$  with a set of individual concepts.

## 5 Conclusions and further work

In this article, I have argued that the assumption that transworld identity is a non-fixed notion can be used to give a semantical analysis of a fairly wide range of examples and puzzles connected to epistemic modals. The discussion, however, has been far from systematic. If the tools developed in this article survive further scrutiny, an obvious next step in further research is to study the general constraints, and the dynamics of the counterpart relation in more detail.

Due mostly to lack of space, I have omitted many things that should have been in this paper. For one, I have almost completely omitted references to the extensive literature on the subjects discussed here. Particularly relevant are the work of Hintikka (1969a, 1969b), who proposes to distinguish two different notions of transworld identity. Kaplan (1969), suggests that the notion of transworld identity may vary between possible worlds, but does not really address the question of how and why. Robert Kraut (e.g. Kraut (1983)) is the only author that I know of who has argued for the kind of variability of the identity relation that I have argued for here.

I have discussed only a few examples of belief ascriptions, but there are others, like the notion of *de se* belief and the relation between beliefs and indexicals, which I have not discussed at all. Also, I have been vague about the identity relation  $R$  by calling it a ‘context-dependent’ parameter. This leaves many questions open. For example, there is the question as to ‘where the parameter goes.’ Is  $R$  a part of ‘the context’ (in the same way as the time and place of utterance would be ‘contextually given parameters’) or is the parameter  $R$  a part of the logical form of a sentence? And wherever it goes, does such a parameter take a fully specified counterpart relation that is defined for each object as its value, or just a partial one holding between some objects, or even just a set of general constraints?

Another issue that has been left unaddressed is the question how the identity relation changes during discourse, or even within a single sentence containing several wh-phrases. There is also the question to what extent the notion of

transworld identity depends on the kind of modality that is studied. For example, if Kripke (1980) is right, then transworld identity coincides with ‘real identity’ in the possible worlds considered in the semantics for counterfactuals, and if I am right, then this relation is precisely *not* available when considering epistemic modalities.

I am planning to address at least some of this issues in future work on this topic.

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