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Indices *and*
contexts
of discourse

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As is well-known, referring to a single, invariant universe of discourse is not sufficient to account for the use of quantified noun phrases in natural languages. In logic and philosophy of language there are different ways of implementing the idea that the variability of universes of discourse is an essential ingredient of the semantics of noun phrases. An interesting tool, from this point of view, is the introduction of suitable indices (as symbols in the semantic metalanguage) to refer to different contexts of discourse.

The purpose of the paper is to show that this solution can be incorporated into the classical semantics in a simple and elegant way which allows for a generalisation to indexicals and intensional contexts.

1. Fiction

In a paper I wrote in 1977 (later included in Bonomi (1979)) I addressed this kind of problem. Suppose that two literary critics are discussing the possibility of finding, for each important character in Proust's *Recherche*, a corresponding “model” in our world. When they consider the case of Monsieur de Norpois, the diplomat who has a love affair with Madame de Villeparisis, they come to the following conclusion:

- (1) All the diplomats are dissimilar from the diplomat who has a love affair with M.me de Villeparisis.

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If we try to translate (1) into a first-order language, what we obtain is the following formula:

$$(2) \quad \forall x[\text{Diplomat}(x) \rightarrow \text{Dissimilar}(x, \text{ty}[\text{Diplomat}(y) \wedge \text{Has_a_love_affair_with_M.V.}(y)])].$$

It is easy to see that this formula does not capture the intended meaning of (1). In fact, under the (plausible) assumption that the set of diplomats is not empty, (2) entails that there is a diplomat in this set who is dissimilar from himself. But what the two critics mean when uttering (1) is quite clear and consistent from an intuitive point of view: in the real world there is no diplomat who resembles the diplomat who, in the *Recherche*, has a love affair with M.me de Villeparisis. The idea is that the first noun phrase refers to the domain of reality, but the second noun phrase (i. e. the definite description) refers to the universe of the *Recherche*. To account for this situation, a modification of the formation rules for the first-order language is proposed in the paper: whenever a quantifier is introduced, a suitable domain must be specified; as a consequence, different quantifiers in the same sentence may refer to different domains. For this purpose, a set **I** of indices is added to the usual vocabulary of the first-order language. The indices in **I** refer to domains of discourse and, from a formal point of view, they have a crucial role in the rule associated with the introduction of a quantifier. A (simplified) version of the rule is the following:

$$(3) \quad \text{If } A \text{ is a formula and } i \text{ is an index, then } \forall x[A]_i \text{ is a formula.}$$

Since a particular domain of discourse D_i corresponds to an index i , the natural interpretation of a formula such as $\forall x[A]_i$ is that it is true if and only if every individual in D_i satisfies the subformula A .

In the case of our example, the formula we would obtain is the following:

$$(4) \quad \forall x[\text{Diplomat}(x) \rightarrow \text{Dissimilar}(x, \text{ty}[\text{Diplomat}(y) \wedge \text{Has_a_love_affair_with_M.V.}(y)])_i].$$

In the intended interpretation, i and j refer to the domain of the real world and to the domain of the *Recherche* respectively, and the problem raised by the usual logical form, i. e. (2), is solved, because the diplomat denoted by the defi-

nite description and the diplomats quantified over do not belong to the same domain. So, it is perfectly possible that all these diplomats are dissimilar from the diplomat at issue.

2. Contexts

There is an important point which is not taken into account in this kind of analysis. To deal with an example such as (1), indices are associated with heterogeneous universes of discourse: the domain of the real world and the domain of a fictional world, for instance. But, as witnessed by other familiar examples¹, the variability of domains in the same sentence is not restricted to the cases in which, so to speak, the whole ontological frame changes, and different worlds are involved. There are situations in which the ontological background is represented by a single universe, but *different segments* of this universe can be relevant in the same sentence. To see that the variability of reference detected in (1) is just an illustration of a more general and systematic phenomenon, consider this new example, where a single world is referred to (in the sense that no fictional entity is involved), although a reference to local domains is required:

(5) All the linguists voted for the linguist who did not vote for anybody.

As before, the corresponding first-order formula would not be satisfiable (unless the set of linguists is the empty set):

(6) $\forall x[\text{Linguist}(x) \rightarrow \text{Vote}(x, \iota y[\text{Linguist}(y) \wedge \neg \exists z[\text{Vote}(y, z)]])]$.

Yet, it is not difficult to imagine situations in which (5) is not only meaningful but also true.

We have so far considered cases in which, to avoid inconsistency, different noun phrases in the same sentence must be associated with distinct local domains. But a suitable restriction of the domain - and, as a consequence, its vari-

¹ See Recanati (1996:453-457) for several examples of this kind.

ability in different *contexts* of discourse - is necessary even in simpler cases, where a single noun phrase is involved.

When you say that *all the dogs* are sleeping, you hardly mean that all the dogs in the world are sleeping. Rather, a context is likely to make a particular set of dogs relevant, and what you mean is that all the dogs of *this* set are sleeping. And if you say that *the dog* is sleeping, usually this statement does not entail that there is just one dog in the world, and this dog is sleeping. Once more, a context will serve to pick out the intended dog, so that your statement ascribes something to *this* dog.

3. Zooming.

One might object that there is nothing special in such situations. Since we are not committed to any particular assumption about the size of the domain, we can each time refer to a suitable universe. So, in the recursive definition of truth the clauses concerning our quantifiers can be left unchanged: the determination, *for each sentence*, of the relevant universe is a pragmatic matter which can be ignored if the idealised perspective of (model-theoretic) semantics is adopted. We are allowed to choose, each time, an appropriate universe.

To see the inadequacy of this strategy, consider the following example.

John's life in his country house is gladdened by the presence of five nice dogs. The only problem, with these lively pets, is that they often run off and pick a fight with the cats they meet. The neighbours have complained, and John is a little worried. So, when he hears a dog barking in the distance, he gives his wife a look of anxiety. Perhaps some of the dogs ran into Bill's cat. But she reassures him. She says:

- (7) All the dogs are sleeping peacefully for they do not hear the barking dog.

The reason why this utterance cannot be accounted for along the lines of the strategy we have just mentioned is quite simple. A *single* sentence is at issue here. So just one universe must be selected (on "pragmatic considerations") as the relevant one. There are two plausible candidates: a more restricted domain (which includes only sleeping dogs) and a larger domain (where there is a

barking dog). But the sentence turns out to be false (or lacking a truth-value) in both cases, because if the former universe is picked out no dog is barking, and if the latter is selected, not all the dogs are sleeping. In short, according to the traditional view a sentence such as (7) is not satisfiable; but this clashes with our assumption that, in the given situation, (7) is true.

A similar problem is raised by the following sentence:

(8) The linguist kissed a linguist.

In fact Russell's uniqueness condition associated with the definite description *the linguist* entails or presupposes the existence of only one linguist, whilst the verb phrase *kissed a linguist* contains an indefinite description that entails or presupposes the existence of another linguist.

The traditional view is not the only victim of this kind of counterexample. Think, for instance, of Bar-Hillel's approach. The idea is that, in order to account for the contextual nature of reference and quantification, what we have to evaluate is not a sentence, but an assertion (or a "judgement", as he says): i.e. a pair $\langle s, \mu \rangle$, where s is a sentence (or, more exactly, a sentence-token) and μ the intended context. Yet, this strategy will fail in the case of (7) and (8), for the same reason as before: there is no *single* context that we can refer to in order to give *both* noun phrases in each sentence their intended interpretations. (The same problem arises in Kaplan's semantics, which is based on Bar-Hillel's intuition: the entire sentence is processed with respect to a single context.)

A radical solution seems to emerge from these reflections: *each* quantified noun phrase in a sentence is to be connected with a specific context.

Our last informal reflections hinted at an essential connection between the referential power of a noun phrase and the suitable delimitation of a local setting that specifies, within the given model, which properties and relations characterise a relevant set of individuals. The usual assimilation of a model to a complete picture of the world might suggest a metaphor: referring presupposes a sort of zooming, which each time isolates the intended portion of the world.

This metaphor is tempting, but it requires a qualification. In zooming we are bound by the spatial coherence of the scene. This is why the term 'portion' (or 'segment') of the world is appropriate. We can widen the scene, or we can make it smaller. But what occurs in the scene depends on the *physical* point of view we have adopted. On the other hand, the notion of context we have in mind

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does not have this realistic flavour. The way properties and relations are circumscribed is not subject to any particular restrictions: it only depends on the pragmatic needs of the discourse. A "spatial" characterisation of the situations associated with referring noun phrases may be attractive. But to see how misleading it is, just think of a situation in which John's five dogs are, respectively, in Milan, Sidney, Toronto, Nairobi, Shanghai. (Suppose, for instance, they are taking part in different dog shows). After some phone calls, John's wife says:

(9) All the dogs are fine.

Now, what keeps these dogs "together" (as a partial but unitary domain of quantification) is neither the spatial homogeneity of the situation, nor any other intrinsic property of the world. The cohesive force of the context is determined only by pragmatic reasons, where intentionality plays a central role.

The conclusion is the following. Formal semantics must exhibit structures whose articulation is "fine-grained" enough to make a distinction between the given universe and the set of countless possible contexts. Such an articulation must be accounted for in the recursive truth-conditions that the semantical analysis attributes to sentences.

4. Bare contexts.

After a short reflection on these phenomena, the reader might argue as follows. So far, so good. But, after all, what you need is a sort of parametrization of the noun phrases. And a well-known device to get this result is already available for a specific case: Kaplan's contexts provide the parameters needed to account for indexicals. If you introduce other kinds of contexts the resulting picture might prove messy: how many theoretical entities are required? So, we have to face the following issues: (i) in what sense is the notion of context we are examining distinguishable from the notion which is already available in the analysis of indexicals? (ii) conversely, is it possible to accommodate indexicals in the framework under discussion?

In Kaplan's logic of demonstratives (or, more generally, indexicals), contexts have a very *austere* nature. They are elegant and simple devices which provide the parameters required by indexical expressions. For example, with respect to

a given utterance, a context specifies the value of the parameter AGENT (of the utterance) in order to assign a referent to the indexical expression *I*; it specifies the value of the parameter TIME in order to assign a referent to the indexical expression *now*; and so on. From this point of view, "context is a package of whatever parameters one needs to determine the referent [...] of the directly referential expressions of the language" (Kaplan 1979).

Formally speaking, in this logic of demonstratives contexts are *new* theoretical entities which are *added* to the usual machinery of model-theoretical semantics in order to account for indexicals. This *ad hoc* character of contexts is justified by the nature of the expressions the logic of demonstratives is about: "pure" indexicals (as *I*, *here*, *now*, etc.) and "true" demonstratives (*that*), i. e. expressions whose reference is determined by the associated *demonstration*.

But it is not clear how this machinery works if other, less "pure", expressions are taken into account. For example, we are not sure that the most typical (and common) use of demonstratives like *that* is characterised by its association with a demonstration, which is an essential ingredient of "true" demonstratives in Kaplan's sense. In most cases, demonstration is *not* essential (and, in fact, is completely absent), for the interaction between the built-in sortal (*book*, for instance) and the context is sufficient to determine the intended referent. If you say *This book is boring* you are likely to use no demonstration, since the situation in which the utterance takes place is (usually) definite enough to specify what the relevant book is. In our opinion, it is easier to conceive of uses of demonstrative phrases without an associated demonstration than to imagine cases in which the built-in sortal is what is lacking. And the reason is obvious: any demonstration is potentially ambiguous without an associated sortal term. Suppose you say: *That is expensive* pointing to a table. If, for instance, a book is on the table, a possible way of reacting to your utterance might be: *That what? The book? The table?* And the specification of the suitable sortal term (which is an (expanded) common noun, in most cases) will settle the matter.

5. Furnished contexts.

But this is not the point. We do not have to discuss here whether the most typical use of demonstratives entails demonstration rather than the essential presence of a sortal. What counts is that "impure" demonstratives (i.e. phrases

with a built-in sortal such as *this book* or *that ashtray on the table*) are very common in ordinary discourse. Now, to account for the way they are used, the notion of context as a "package" of parameters is no longer sufficient. What we need is something with a more articulated structure: local states of affairs in which individuals have properties (to account for the presence of the sortal term in the noun phrase *this BOOK*) and relations (to account for the presence of the relational term in the noun phrase *that ashtray ON the table*), so that individuals are identified thanks to those properties and relations.

It is instructive to see how a class of expressions related to impure demonstratives is treated in Kaplan's framework. What we have in mind is the class of definite descriptions used in a demonstrative manner. As is well-known, Kaplan has a special operator to generate these expressions: given a definite description α , '*dthat* (α)' is a term whose referent is determined both by the demonstration and the property that the description expresses. More exactly, ignoring here for the sake of simplicity such parameters as time and assignation, the denotation of a *dthat*-term is given by the clause:

$$|dthat(\alpha)|_{c,w} = |\alpha|_{c,c(w)}$$

which means: the denotation of '*dthat* (α)' in the world w with respect to the context c is the denotation of the description α in the world of the context c . But notice that in model-theoretic terms $c(w)$ - the world of the context c , which may not coincide with w - is a complete or global state of affairs: something related to the usual notion of model, as regards its "size". As a result we run, once more, into the problems of the traditional view. In order to pick out the intended denotation, we are told to look not at a reasonable segment of the universe, but at the *whole* universe itself, although such a description as 'the barking dog' has no denotation with respect to a world where there are countless barking dogs. Certainly, nothing here prevents the advocates of this theory of contexts from introducing "partial" worlds (or, more exactly, "pieces" of worlds) to get round this situation. But, in this case, a new theoretical entity is needed besides contexts (in Kaplan's sense) and standard possible worlds: and this proves that the notion of context elaborated by that theory is of no use when the noun phrase at issue is not an indexical or a "pure" demonstrative.

Is there any reason to keep these problems separate, by referring to a notion of context that accounts for indexicals and related expressions, and to another

one that accounts for quantified expressions, definite and indefinite descriptions, and so on? After all, both cases have to do with the *contextual* nature of language.

In the previous discussion, we have remarked that contexts, as they are conceived of in the logic of demonstratives, are *ad hoc* devices which provide the parameters required by indexicals. They are added *from outside*, so to speak, to usual first-order models (ignoring here the possible-world machinery imposed by other intensional notions). But if we scan a model, conceived of as a complete state of affairs, we find out that all the necessary information is already present in it. The parameters we need in order to determine the referents of such indexical expressions as *here*, *I*, *you*, are given by the fact that, *somewhere* in the model, *someone* has the property of speaking to *someone else*. And this fact, because of the completeness of a model *M*, must be part of *M* itself; we just have to isolate it from the rest by looking at the relevant *segment* of *M* (that we shall call a *submodel* of *M*). If we conceive of contexts as model-theoretic constructs that we get by looking at the *internal* structure of the model, the ad hoc character we have spoken about disappears. As a result, a single notion of context is required to account for indexicals *and* quantified expressions, for in both cases we must refer to a local specification of the properties and relations characterised by the model. It is this specification which determines who is the speaker denoted by the expression *I*, or what dogs we must take into account when we utter or interpret sentences with noun phrases such as *all the dogs* or *the barking dog*.

The idea is that the denotation of a "pure" indexical such as *I* is fixed with respect to a context *c* consisting of a particular event of speaking (with an agent, a patient, etc.); the denotation of an "impure" demonstrative such as 'that ashtray on the table' is fixed with respect to a particular state of being on the table (with an agent, a patient, etc.)

6. Sketch of a formalism.

I will conclude these remarks by taking up an approach formerly discussed from a different standpoint². The idea is to evaluate sentences (and noun phrases) with respect to local universes of discourse, or contexts. To make this idea more precise, suppose we have defined the notion of a first-order language L and the associated notion of a model $M = \langle D, I \rangle$, where D is a domain of entities and I a function such that $I(t) \in D$ if t is an individual constant and $I(P^n) \subseteq D^n$ if P^n is a predicate letter (for every $n \geq 1$). We define a submodel of M as a pair $\mu = \langle D, I_\mu \rangle$, such that, for any individual constant t , $I_\mu(t) = I(t)$ and, for any predicate letter P^n , $I_\mu(P^n) = \langle X, Y \rangle$, where $X \subseteq I(P^n)$, $Y \subseteq D^n \setminus I(P^n)$ (that is, Y is a subset of the complement of $I(P^n)$): therefore $X \cap Y = \emptyset$ and $X \cup Y \subseteq D^n$; if $D^n \cdot X \cup Y$ for some predicate P^n such that $I_\mu(P^n) = \langle X, Y \rangle$, μ will be said to be a *proper* submodel of M . X and Y will be designated respectively by ' $I_\mu^+(P^n)$ ' (the "extension" of P^n in μ) and ' $I_\mu^-(P^n)$ ' (the "counterextension" of P^n in μ). Let \mathbf{M} be the set of the submodels of M and \leq the relation on \mathbf{M} such that $\mu \leq \nu$ iff, for any P^n , $I_\mu^+(P^n) \subseteq I_\nu^+(P^n)$ and $I_\mu^-(P^n) \subseteq I_\nu^-(P^n)$. In view of other applications, it should be noticed that \leq is a partial order with a least element (which is the submodel where both the extension and the counterextension of every predicate letter are empty) and a greatest one, where, for every predicate letter, its extension and its counterextension cover the entire domain. This submodel is M itself: it can be seen as the context that unrestricted noun phrases refer to.

In the previous discussion about contexts, I stressed that they are required to qualify some entities of the domain with respect to some properties and relations. This is exactly what a submodel does, since it allows an interpretation of the predicates that does not necessarily cover the entire universe but only a part of it. Furthermore, submodels are abstract enough to capture, for example, the situation described in the case of (9), that is *All the dogs are fine*, where there is no physical or "realistic" state of affairs keeping the intended dogs together. To account for this situation we have simply to refer to the submodel in which the

² See Bonomi (1979), where each quantifier in a sentence can refer to a particular context of discourse. Unfortunately, this point was obscured by the adoption of a complex modal language. A more accurate presentation of the notion of submodel can be found in Bonomi (1992).

interpretation of the predicate *dog* gives a definite value only in the case of the five pets at issue, leaving the rest indefinite.

Thus, given a model M , a context can be seen as a submodel of M , i. e. as an element in \mathbf{M} , so that the interpretation of the language will not consist of the simple model M , but of the pair $M^* = \langle M, \mathbf{M} \rangle$, i. e. a model in association with the set of its submodels. Without going into details, the idea is that noun phrases come with a variable for contexts and that they get their full interpretation when this variable is associated with a definite value, that is when a context is selected. To illustrate this point, let us treat the noun phrases of the previous examples as generalised quantifiers. The only difference is that a determiner like *all* or *the* does not apply to a simple common noun CN , but to an indexed common noun CN_{μ} , where μ is a variable for contexts. For instance, in the case of (8), repeated here:

(8) The linguist kissed a linguist

the denotation of the definite description *the linguist* (in the model M), with respect to an assignation c which gives a value to the contextual variables, is the following:

$$| \text{the linguist } \mu |_{M,c} = \{X: \exists y[\{y\} = I_{c(\mu)}^+(\text{linguist}) \ \& \ \{y\} \subseteq X]\}.$$

That is, once we have selected a context $c(\mu)$, the denotation of the definite description *the linguist* with respect to $c(\mu)$ is the set of sets that include the singleton of the only individual (if any) which is in the extension of the predicate *linguist* in that context. And a sentence of the type *The linguist is P* is true iff the set of things that are P belongs to this set of sets. (To simplify things, I have adopted a non-presuppositional treatment of definite descriptions. But this point is not essential to our discussion.) As for (8), the truth-conditions we obtain can be paraphrased as follows:

| the linguist μ kissed a linguist ν | $_{M,c}$ = 1 iff there is an individual x which is the only linguist in the context $c(\mu)$ and an individual y which is a linguist in the context $c(\nu)$ such that x kissed y .

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As desired, (8) turns out to be satisfiable, for $c(\mu)$ and $c(\nu)$ can be different contexts. In the former context only one individual is a linguist (presumably it is the person we have in mind when we refer to our department, where there is exactly one linguist), but in the latter several individuals can be linguists (for it is a different context, e. g. the entire university).

I have already mentioned the possibility of a unified treatment of contextually restricted quantifiers and indexicals such as *I, you*, etc. This can be done if we keep in mind that what is relevant to the latter class of expressions is just a particular kind of context: those that specify who is the speaker, the addressee, etc., of an utterance, i. e. a bundle of properties and relations characterising a linguistic situation. For instance, in the case of the pronoun *I*, its denotation might be described as follows:

$$|I|_{M,c} = \{X: \exists y[\{y\} = I_c(\mu)^+(\text{speaker}) \ \& \ \{y\} \subseteq X]\}.$$

In other words, assuming that $c(\mu)$ is the utterance context, the denotation of *I* is the set of predicates satisfied by the individual who is the speaker in *that* context (so that the indexical nature of the term is preserved). This is tantamount to saying that the essential contribution of an indexical pronoun such as *I* is to fix the parameter AGENT (with respect to the utterance context) required to determine the intended referent.

7. Appendix. Intensionality and de re readings.

We have just seen that indices are an appropriate device to account for the variability of domains. In what follows, I will try to show that this approach can be generalised, and that other interesting phenomena can be properly analysed by adopting an indexed semantic metalanguage. By referring to three different types of intensional contexts, we shall see that using fixed indices makes the exportation of the relevant expression dispensable in the analysis of the de re interpretation.

- (a) Propositional attitudes

The purpose of the example I am about to discuss is to show that the ambiguity between the *de re* and the *de dicto* readings is a very general phenomenon which does not concern only noun phrases, but, in this specific case, a common noun. This means, in particular, that the *de re* reading cannot be restricted to the situations where the "object" of a belief (a desire, a thought, etc.) is an individual and must be extended to the cases in which this "object" is represented by a set or a property. The example is the following:

"The local soccer team includes fifteen players. One evening, after a match, they go to a restaurant and sit down at a table near Leo and his friend Teo. They are the only customers that evening. So, when Leo goes out of the restaurant and notices a dog waiting outside, he thinks that the pet belongs to someone in the group he has just seen and expresses this conviction to his friend. (Actually, the dog belongs to Ernie, the cook.) Now, Teo, who (unlike Leo) knows that the other customers at the restaurant are the soccer players, reports the situation in the following terms:

(10) Leo believes that a soccer player [in the local team] has a dog.

The problem is how to account for (10) in formal terms." (Bonomi, 1993.)

It should be noted that neither logical form that current intensional treatments assign to statements such as (10) is of use in this case. In fact the usual representation for the *de re* reading, i. e.

(11) $\exists x[\text{Soccer_Player}(x) \wedge \text{Leo believes } (\text{Has_a_dog}(x))]$

is false in the given circumstances, because Leo's belief is *not* about any *particular* person. (He just believes that one of the clients has a dog.) And it is obvious that the usual representation for the *de dicto* reading, i. e.

(12) Leo believes $(\exists x[\text{Soccer_Player}(x) \wedge \text{Has_a_dog}(x)])$

is also false. (Recall that Leo does not know that the persons he has just seen are the players in the local soccer team).

To sum up, the appropriate (and true) reading of (10) in this situation is the *de re* one, but not in the form expressed by (11), which involves a particular individual. In the case of (10) the "object" of this *de re* attitude is a property or a

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set of individuals, which is described from the reporter's point of view. According to this interpretation, (10) is equivalent to the statement:

- (13) The set of the soccer players is such that Leo believes that one of them has a dog

whose formal representation, thanks to the exportation of the predicate, would be the following:

- (14) $\lambda P[\text{Leo believes } (\exists x[P(x) \wedge \text{Has_a_dog}(x)])](\lambda x[\text{Soccer_Player}(x)])$.

What is interesting, in connection with the main topic of the present paper, is the fact that the effect ensured by the exportation of the predicate *soccer player* in (14) can also be obtained by associating that predicate to a fixed index. To see this, suppose that propositions are represented (as usual) as sets of possible worlds. Then, in an indexed language, the meaning expressed by (14) can be expressed by the following formula:

- (15) $\text{believes}(\text{Leo}, \lambda w \exists x[\text{Soccer_Player}_r(x) \wedge \text{Has_a_dog}_w(x)])$

where r is the real world (or, more exactly, the context represented by the restaurant scenario). What (15) means is that Leo has a de re belief about a particular set of individuals (identified once and for all by the given context) which does *not* change from world to world. The belief is, of course, that someone in *this* set has a dog. What is crucial, in such a reconstruction, is the fact that in the different worlds compatible with Leo's beliefs the same set of individuals is involved. This can easily be seen if (14) is compared with the logical form corresponding to the de dicto reading of (10):

- (16) $\text{believes}(\text{Leo}, \lambda w \exists x[\text{Soccer_Player}_w(x) \wedge \text{Has_a_dog}_w(x)])$

where we can have different sets of soccer players in different worlds. (Notice that (16) is false in the given situation, as expected in the case of the de dicto reading of (10).)

- (b) Tense

Let us consider a more familiar case, in which exportation involves a noun phrase. The intensional context is represented, this time, by tense. A sentence such as:

(17) Leo met the President of Burundi

has two readings, corresponding to the following logical forms ('P' is Prior's Past operator):

(18) $\mathbf{P}[\text{meet}(\text{Leo}, \lambda x[\text{President_of_Burundi}(x)])]$

(19) $\lambda x \mathbf{P}[\text{meet}(\text{Leo}, x)] (\lambda x[\text{President_of_Burundi}(x)])$.

Once more, the crucial difference is represented by exportation. But the distinct meanings expressed by (18) and (19) can also be expressed by using indices to refer to time intervals (n is an index for the present time):

(20) $\exists t[t < \text{now} \wedge \text{meet}_t(\text{Leo}, \lambda x[\text{President_of_Burundi}_t(x)])]$

(21) $\exists t[t < \text{now} \wedge \text{meet}_t(\text{Leo}, \lambda x[\text{President_of_Burundi}_n(x)])]$.

(20) says that there is a past time t at which Leo meets the person who is the President of Burundi at t. (21) means that there is a past time t at which Leo meets the person who is currently the President of Burundi.

(c) Aspect

In languages such as Italian, aspect is an important intensional phenomenon. Consider for instance the following sentence, in which the imperfective form (unlike the perfective one) must be interpreted in terms of universal (or “generic”) quantification over events or intervals:

(22) Quando Leo faceva un discorso, il decano si complimentava con lui
[When Leo make (past, imp.) a speech, the dean congratulate (past, imp.) him = Whenever Leo made a speech, the dean congratulated him].

If, as before, indices refer to times, the ambiguity of this sentence can be easily accounted for by two different logical forms:

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(23) $\forall t[t < \text{now} \wedge \text{make_a_speech}_t(\text{Leo}) \rightarrow \text{Congratulate}_t(\text{tx}[\text{Dean}_t(x)], \text{Leo})]$

(24) $\forall t[t < \text{now} \wedge \text{make_a_speech}_t(\text{Leo}) \rightarrow \text{Congratulate}_t(\text{tx}[\text{Dean}_n(x)], \text{Leo})]$.

The proposition expressed by (23) is that, at any past interval t at which Leo makes a speech, Leo is congratulated by the person who is the dean at t , whilst (24) can be paraphrased by saying that the person who is currently the dean congratulated Leo whenever he made a speech.

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