"She" 's Character

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When it comes to the interpretation of pronouns or variables, theories of interpretation generally adduce contexts in which these elements feel at home. When pronouns are, thus, accommodated conveniently, they pretty passively do what the contexts tell them to do, which is hardly anything. These elements nevertheless succeed in oiling the wheels of efficient linguistic information exchange.

Upon closer inspection, it is hard to say what the meaning of pronouns precisely is. They turn out to have subtle indexical presuppositions but they easily go unnoticed because pronouns so eagerly require these to be satisfied whenever *they* are there. In this paper we try to uncover the character of pronouns and to identify their lexico-logical needs. We attempt a characterization of their indexical presuppositions in what we call an 'intentional space', a concept formulated within a many-sorted modal logic.

1 Introduction

Pronouns are sensitive creatures. They are hardly noticed when they are smoothly and comfortably accommodated in linguistic environments, but when they are taken out of their natural habitat they scream for attention. Some people manage to spend their life searching for *her*, or devote their life to *him*; some are in search of *themselves*. These facts may be more challenging for philosophers and psychologists than they are for semanticists. Still it is a major formal semantic issue what is the meaning or character of pronouns, and what are the (pragmatic and semantic) principles that govern their interaction with the space in which they are dropped.

Pronouns are often associated with the variables from formal languages. There are many resemblances and variables have been used to play the part of pronouns in the logical forms of natural language sentences. Variables seem to be void, without content, and eliminable, and pronouns, too, may be eliminable and without content. Nevertheless, pronouns do exist, in some languages at least. In this paper we attempt to identify their character (in the sense of Kaplan), because, after all, pronouns, quite unlike variables, are used in a bewildering world by actors, jokers and impostors who may profit from abusing them.

In what follows we will first review some of the received wisdom about variables and pronouns from a formal semantic point of view. Pronouns can be conceived of as identity or projection functions over contexts. We will next formulate their interpretation in the context of a very simple fragment of natural language, the interpretation of which can be rendered in the language of first order predicate logic. We first restrict ourselves to pronominal reference to individuals referred to in linguistic contexts by means of indefinite noun phrases. Then we will attempt a more specific characterization of their idiosyncratic semantic and pragmatic features, which is both more self-contained, and more general. Their indexical presuppositions are given a tentative formulation in a modal type-logic. We end the paper discussing some of the questions which our approach elicits.

2 VARIABLES, PRONOUNS AND IDENTITY

In many formal languages variables serve one major goal. They serve to indicate the argument positions of simple and compound predicates, which are controlled by quantifiers (or other variable binding operators) which are associated with the same variable. Variables fulfill this function in a most transparent way. An operator Qx, associated with a variable x, controls all those argument places which x occupies in the scope of that quantifier, and which are not in the scope of another quantifier in the scope of Qx.[1]

On the semantic level, variables range over all possible values of an appropriate kind. For a proper assessment of an existentially or universally quantified statement $\exists x\phi$ or $\forall x\phi$, the variable x in ϕ must in principle be able to have each of the individuals in the domain of quantification as its value. This requirement is met only in an indirect way. Variables themselves don't range over the individuals in the corresponding domains, they are generally assigned values by variable assignments and it is by suitably varying possible variable assigments that the variables may receive their alternative values. Thus, variables range over all possibly relevant individuals only

[1]Notice that this is not always the case; in some formal and semi-formal languages, the relation between scope and control is different, for instance when they allow for the possibility of introducing and dropping variables.

by the rules of the system of interpretation in the context of which they are interpreted.[2]

If we stick to the more or less standard systems of interpretation, we can say that variables mainly indicate 'open' positions in expressions, and that contexts—which are variable assignments here—are used to determine what, if anything, is to fill these holes. The meaning or 'character' of such an open expression α is, thus, context dependent, and for this reason it is appropriate to characterize it as a function. Such a function $\mathcal{A}$ ranges over the possible assignments of values to the open places of α, and for any such assignment g, $\mathcal{A}(g)$ is the interpretation of α under assignment g, cf., e.g., (Janssen, 1986; Montague, 1974).

Since our formulation of the character of an open expression as a function from variable assignments is fully general, it also applies to the character of variables themselves, of course. Obviously the interpretation of a variable depends on a context which is a variable assignment, and such a variable assignment completely determines the interpretation of the variable in that context. The meaning of a variable x can therefore be equated with that function $\mathcal{X}$ that assigns to every variable assignment g the value g assigns to x: $\mathcal{X}(g) = g(x)$. At first glance, it seems, this is all one can say about the meanings of variables in formal systems.

However, there is something intriguing about the meaning of a variable as we have just now characterized it. For, formally, there is a one-to-one mapping between the domain of variables and that of their meanings. To see this, notice that, on the one hand, the meaning of a variable can be derived from the variable itself by a standard type-logical lifting operation $\mathcal{L}$. Such a lifting operation $\mathcal{L} = \lambda e_a \lambda f_{\langle a,b\rangle}\ f(e)$ can be used to send an object d of type a to its 'lift' $\mathcal{L}(d) = \lambda F\ F(d)$ of type $\langle\langle a,b\rangle,b\rangle$.[3] Thus, the meaning of a variable x can be characterized as its lift $\mathcal{L}(x) = (\lambda y \lambda g\ g(y))(x) = \lambda g\ g(x)$, where g ranges over the set of variable assignments.[4]

It can also be noticed that, on the other hand, given some variable meaning $\mathcal{X}$, we can determine which variable x has $\mathcal{X}$ as its meaning. For any such entity $\mathcal{X}$ is the meaning of the unique variable x such that the lift of x is $\mathcal{X}$, so that $x = \iota y \forall Y(\mathcal{X}(Y) = Y(x))$. Given these two observations, we may interchangeably use the domain of variables and that of variable meanings. As (Landman, 1986, p. 111) observed, "there is no reason not to equate the variable meaning with the variable itself." Ordinary variables, in other words, have trivial meanings.

[2]Notice that these rules may vary as well; in, for instance, so-called 'guarded fragments' not all variable assignments which are theoretically possible are always taken into account.

[3]Metaphorically speaking, the lifting operation involves a shift of power. Intuitively, a function g can be said to control an argument d to which it is applied in the sense that it 'transforms' d into the object $g(d)$. After lifting d, the lifted element takes over control and $\mathcal{L}(d)$ may apply to the argument g. In effect, of course, nothing changes. For, for any two objects d and g of types a and $\langle a,b\rangle$, $\mathcal{L}(d)(g) = g(d)$.

[4]Following up on the metaphor from the previous footnote, we may observe that, on the one hand, the value of a variable is controlled by the current context, whereas, on the other, the meaning of a variable determines, given such a context, what value it has. Again, the difference is in effect immaterial, but this may change when we start looking after other, maybe more intuitive, kinds of contexts.

This last point might seem puzzling, but, upon reflection, we think it is not. After all, variables figure in well-defined formal frameworks, and they don't really *do* anything there, except for having a value which the contexts (variable assignments) tell them to have. Variables are mere instruments by means of which variable binding operators get a hold on the argument positions which they control, and, as such, they *are* superfluous. In a closed formula, that is, a formula in which all variables are bound, every variable can be substituted for any other, and as (Quine, 1960) has shown, they can be explained away entirely.

Our findings concerning variables in formal languages can, with suitable care, be transposed to the pronouns of natural languages. In the first place, pronouns can be bound by other noun phrases, as in e.g., *Every man thinks he is smart.* In such examples, the pronouns figure as place holders of argument positions controlled by other noun phrases, just like variables did for variable binding operators.[5] In the second place, pronouns can also occur free, as in *But they are not.* In such examples, pronouns can as well be taken to induce open propositions, the interpretation of which is context dependent. Obviously, variable assignments do not qualify as intuitive types of contexts for natural language interpretation, but the principles of interpretation are similar.

What can we say of the meaning of a clause with a non-bound pronoun, either a pronoun bound by a noun phrase in a matrix sentence, or for instance, a demonstrative or an anaphoric pronoun? Again, this can be characterized as a function $\mathcal{X}$, from contexts (determining possible values for the pronouns), and such that for any such context c, $\mathcal{X}(c)$ is the meaning of the clause under an interpretation of the pronoun as determined by c. In a simplified setting we can think of these contexts as the possible referents of the pronouns themselves. If an individual presents itself as most salient, or if the interpretation of a quantified noun phrase presents an individual for evaluation, then that individual is the value of the pronoun in that context of evaluation. In this simplified setting, the meaning or character of a pronoun can be identified with the identity function $\lambda x\ x$ over the domain of evaluation. Actually, this interpretation is proposed and worked out in detail in (Jacobson, 1999; Szabolcsi, 1997). Notice that also under this understanding of the meaning of pronouns they are semantically (almost) vacuous. Their value is the value which the context assigns to them. If we think of the rules of interpretation as instructions for a parser telling him what to do upon hearing certain linguistics expressions, then a pronoun comes with the instruction: 'Just give me a possible value and I take it.'[6]

[5] Significant in this context is the existence of languages in which bound arguments are not occupied by anything, thus suggesting that pronouns, if they do occur in other languages, hardly have substantial semantic impact. However, even if such pronouns are semantically vacuous, they still exist. And from a compositional semantic point of view we do have to specify what they mean, even if they are vacuous.

[6] Notice that, logically speaking, the identity function is a close relative of the lifting operation which we discussed above. Swopping the two arguments of a lift $\lambda d \lambda f\ f(d)$ gives us $\lambda f \lambda d\ f(d) \equiv \lambda f\ f$, the identity function in a functional type.

Jacobson and Szabolcsi's analysis of pronouns is cast in a framework which deals, mainly, with the (compositional) interpretation of constructions in which they are bound. However, essentially similar analyses have been given of indexical and anaphoric pronouns. Upon the classical analyses of, e.g., (Kaplan, 1989) and (Stalnaker, 1978), personal pronouns like 'I' and 'you' and other indexical terms like 'here' and 'now' are (only) properly used and evaluated in contexts in space and time, in which a specific speaker addresses a certain audience. (Of course, such a presupposition of use is satisfied in (most) ordinary contexts.) Such contexts can therefore be equated with ordered n-tuples $\langle s, h, t, p, \ldots \rangle$, determining the speaker s, hearer h, time t, place p and whatever may be further relevant for the interpretation of an utterance. In order to make things work out fine, these contexts (tuples) are always constructed in the same order, so that, e.g., the speaker is always specified first, the time of utterance at, say the third place, etc.

Conceiving of contexts as ordered n-tuples, indexical elements are suitably interpreted as projection functions. Thus the character of the first person personal pronoun is the function which, for any such sequence $\vec{e}$, gives us the first element, the speaker, as a value. Similarly, the the temporal adverb 'now' is associated with the projection function selecting the third element of a given sequence, the time of utterance. The difference with the interpretation of pronouns of Jacobson and Szabolcsi here is mainly that it is more general. For if we focus on expressions with only one pronoun, our domain of contexts may be the set of one-tuples of individuals, which corresponds to the domain of individuals, and the only possible projection function is the identity function.[7]

The interpretation of context dependent constructions as functions over n-tuples of elements is also basically similar to (Tarski, 1956)'s evaluation of (open) expressions of a formal language. Tarski defines a satisfaction relation between sequences of individuals and (open) formulas, thus specifying the truth or falsity of the formula when its first free variable is interpreted as the first element of the sequence, the second as the second, etc. Here, too, the meaning of such a formula can be conceived of as a function over sequences of individuals, which, for any sequence $\vec{e}$, yields true if and only if the sequence satisfies the formula in Tarski's system.

The only, we think non-substantial, difference between all of the mentioned ways of dealing with the interpretation of context dependent elements resides in the specific setting up of contexts, and in the specific design of the whole system. At this point we may close the circle, by noting that sequences of individuals in their turn correspond to variable assignments. If our set of variables is linearly ordered, then the set of sequences of n individuals is isomorphic to the set of assignments of individuals to the variables $\{x_1, x_2, \ldots, x_n\}$, and such that any sequence

[7]Of course, this is not to say that Jacobson and Szabolcsi do not deal with expressions with more than one pronoun. If an expressions contains n (unbound) pronouns, it is associated with a function requiring n arguments of the appropriate type, one argument for each pronoun. Observe that the set of functions over n arguments is isomorphic to the set of functions over n-tuples of arguments, so that the analogy remains close.

$\vec{e} = e_1 \ldots e_n$ corresponds to that assignment g such that for all i: $e_i = g(x_i)$ (for $1 \leq i \leq n$). In all of the mentioned analyses of variables and pronouns, they can be conceived to be functional on the context, and void of any content.

3 Variables in First Order Contexts

It has often been observed that expressions of natural language are not only context dependent, but also that their use may bring about changes in that very same context. As observed in the seminal (Stalnaker, 1978), an utterance changes the context in that after the utterance, and not before, it is true that that utterance has been made. Moreover, the epistemic situation of the interlocutors changes, in that, e.g., what has been said by the speaker becomes part of the common ground, that is, if none of the interlocutors objects.

The ways in which utterances change the context of interpretation relevant for the interpretation of pronouns has been the subject of study in systems of dynamic semantics, such as discourse representation theory (*DRT*, (Kamp, 1981; Kamp and Reyle, 1993)), file change semantics (*FCS*, (Heim, 1982)) and dynamic predicate logic (*DPL*, (Groenendijk and Stokhof, 1991)). In these frameworks the systematic effects are modeled which the use of, in particular, indefinite noun phrases have upon the interpretation of subsequent anaphoric pronouns. For example, an utterance of (1) can be taken to mention or introduce an incoming beatle, which the pronoun in (2) then can be taken to refer to as well:

(1) A beatle has just entered.

(2) He is going to sing a love song.

In systems of dynamic semantics, such systematic pragmatic effects associated with the use of indefinite noun phrases and anaphoric pronouns have been integrated in the semantic interpretation procedure, and, thus, the interpretation of (1–2) as a whole is taken to be that a beatle who has just entered is going to sing a love song. Notice that the addressee of an utterance of (1-2) may be unable to determine whom the speaker is talking about, without this hampering him to establish the anaphoric relationship.

In this section we present a system of interpretation which also accounts for the interpretation of anaphoric pronouns in a discourse, and which connects up nicely with the conception of pronouns presented in the preceding section. Like many others, we restrict our attention to the cases in which anaphoric pronouns are coreferential with indefinite noun phrases, and all of this in a fragment of natural language the interpretation of which can be modeled by a first order predicate logic, which has an additional category of pronouns (Predicate Logic with Anaphora, *PLA*, cf., (Dekker, 1994, 2001)).

Interpretation in the system of *PLA* is based upon two assumptions regarding the use of indefinite noun phrases. In the first place, the use of an indefinite typically does not reveal to the hearer which individual the speaker is talking about. Thus, they are both like and unlike pronouns. They are like pronouns in that they have a variable interpretation, and they are unlike pronouns in that the context need not make clear what their referent actually is. Nevertheless, and this is our second assumption, we believe that indefinites in general ought to be used with referential intentions. By this we mean that a speaker may use an indefinite if she thereby intends to speak about a particular individual. If she conveys information in this way, she must believe the information to apply to that individual, either because she has a particular individual in mind, or because she believes it applies to the individual which she was told about by yet another informer.[8] This outlook upon the use of indefinites neatly fits in with the causal/intentional chain theory of reference, and it is close in spirit to the intuitionistic and game-theoretical call for witnesses for existentially quantified noun phrases.[9]

Let us first sketch the language of *PLA*, which is that of first order predicate logic extended with a category of pronouns $(\mathrm{p}_1, \mathrm{p}_2, \ldots)$. For ease of exposition, we focus on a minimal language without names and identity, which is built up from variables, pronouns, and m-ary relation expressions by means of negation $\neg$, existential quantification $\exists x$ and conjunction $\wedge$. As is usual, we use existentially quantified expressions to model the interpretation of indefinite noun phrases. Conditional sentences can be modeled using implication $\rightarrow$, which is defined by $\phi \rightarrow \psi \equiv \neg(\phi \wedge \neg\psi)$.

The indices on pronouns are used to disambiguate them. Like we said, we here focus upon pronouns which are coreferential with (antecedent) indefinite noun phrases. The index then determines which indefinite this is. If the index of a pronoun p_i is i, then the pronoun is coreferential with the i-th potential antecedent found when going back in the discourse.[10][11]

[8]Notice that, in the latter case, the speaker can even be said not to know whom she is talking about, without this hampering referential intentions. If she herself was told that a beatle came in, then, by communicating this to another party, her referential intentions are justified if her use of the indefinite is intended to be about the individual which the person who informed her intended to refer to with his use of the indefinite.

[9]Notice, too, that referential intentions can be justified, also if they are unsuccessful. As a speaker can be justified in saying something false, if she at least believes it to be true, she similarly may speak of non-existent imaginary objects, or of non-uniquely determined individuals, as long as she believes them to be existent and unique. Notice, finally, that the requirement for referential intentions generally disappears when indefinite noun phrases figure in a negation, in the restriction of a quantifier or in questions. Pragmatic or game theoretical explanations can be given for this as well (cf., e.g., (Dekker, 2001)).

[10]The relevant order of indefinites does not always correspond to their linear surface order. It is given by syntactic structure, and, thus, an indefinite in the scope of another indefinite precedes it. In formal terms, $\exists y$ comes before $\exists x$ in $\exists x(\ldots\exists y(\ldots))$, although, of course, it comes after $\exists x$ in $\exists x(\ldots) \wedge \exists y(\ldots)$.

[11]And indeed, as is obvious, in the system of *PLA* some system of pronoun resolution is taken for granted, as it

Since we restrict our attention to rigid anaphoric relations between indefinite noun phrases and pronouns, the contextual information which is relevant for the interpretation of pronouns concerns the individuals which preceding indefinite noun phrases may have referred to. Obviously, this information is provided by the interpretation of preceding discourse. A first thing to determine, then, is that of the number of potential antecedents which a discourse or formula comes with. To this end, we define what we call the length $n(\phi)$ of a formula ϕ as the number of indefinites (existential quantifiers) *not* in the scope of a negation in that formula:

(3) $$\begin{array}{llll} n(R(t_1 \ldots t_m)) & = 0 & n(\exists x\phi) & = n(\phi)+1 \\ n(\neg\phi) & = 0 & n(\phi \wedge \psi) & = n(\phi)+n(\psi) \end{array}$$

As may be clear, if an atomic formula ψ with a pronoun p_i is conjoined with a preceding formula ϕ, and if $i \leq n(\phi)$, then the pronoun is coreferential with a term in ϕ and the pronoun is called 'resolved' in the conjunction $\phi \wedge \psi$. (And if all pronouns in a formula ϕ are resolved there, then the whole formula counts as resolved.) If, on the other hand, $n(\phi) < i$, then the pronoun is not resolved, and it will be taken to refer back to the $(i - n(\phi))$-th potential antecedent before the conjunction $\phi \wedge \psi$.

We now turn to the semantics of *PLA* itself. The semantics of *PLA* is specified as a Tarskian satisfaction relation between sequences of individuals and formulas. This relation holds of a sequence and a formula if the formula can be judged true if its open places are filled with the corresponding individuals in the sequence. Notice that the sequences this time do not determine the values of the free variables of a formula. Variables and variable binding is dealt with by means of variable assignments. The open places which we are concerned with here are those induced by indefinite noun phrases and pronouns.

Like we said, the interpretation of indefinite noun phrases is modeled by means of existentially quantified expressions and their use is associated with referential intentions. In order to account for anaphoric coreference by means of subsequent pronouns, the individuals which the indefinites can be taken to refer to are taken up in the semantics. Thus, the first $n(\phi)$ individuals in a sequence satisfying a formula ϕ, are possible witnesses for the existentials in that formula, or possible speaker's referents of the associated indefinites. In *PLA*, the first element of such a sequence corresponds to the indefinite used last in ϕ. This is the most 'salient' one, so to speak. The second is the one but last individual, etc. Unresolved pronouns in ϕ go further in that they impose restrictions on individuals referred to before ϕ was used. Unresolved pronouns in ϕ constrain the evaluation of preceding discourse by imposing restrictions on the values of elements $\vec{e}_i$

is in most formal systems of interpretation. This paper has little to say about the resolution of pronouns, apart from a run of the mill order of the introduction of possible referents in *PLA*, and some indexically stated requirements mentioned in the next section. As one reviewer correctly observes the "last in first out" option is intuitively not that plausible. In this respect we see again that a semantic approach really needs to access more pragmatic considerations.

of sequences $\vec{e}$ satisfying ϕ, where $i > n(\phi)$.

With these introductory remarks in mind, the interpretation of *PLA*'s terms relative to a variable assignment and a sequence of individuals is fairly obvious. Variables are assigned the value which the current variable assignment assigns to them, and a pronoun p_i selects the i-th individual from the sequence, thus indicating that it is coreferential with the i-th potential antecedent in preceding discourse:

(4) $\quad [x]_{g,\vec{e}} = g(x) \qquad [\mathrm{p}_i]_{g,\vec{e}} = \vec{e}_i$

Satisfaction is defined relative to a first order model M, a variable assignment g and an (infinite) sequence of individuals $\vec{e}$. A model $M = \langle D, E \rangle$ consists of a domain of individuals D and an interpretation E for the non-logical constants. If a sequence $\vec{e}$ satisfies a formula relative to a model M and an assignment g we will write $M, g, \vec{e} \models \phi$. Satisfaction is defined as follows:

(5)
$$\begin{array}{ll}
M,g,\vec{e} \models R(t_1 \ldots t_m) & \text{iff } \langle [t_1]_{M,g,\vec{e}}, \ldots, [t_m]_{M,g,\vec{e}} \rangle \in E(R) \\
M,g,\vec{e} \models \exists x \phi & \text{iff } M, g[x/\vec{e}_1], \vec{e}{-}1 \models \phi \\
M,g,\vec{e} \models \neg \phi & \text{iff } \neg \exists \vec{c} \in D^{n(\phi)}\text{: } M, g, \vec{c}\vec{e} \models \phi \\
M,g,\vec{e} \models \phi \wedge \psi & \text{iff } M,g,\vec{e} \models \psi \text{ and } M,g,\vec{e}{-}n(\psi) \models \phi
\end{array}$$

where $\vec{c}\vec{e}$ is the concatenation of the sequences $\vec{c}$ and $\vec{e}$,
and $\vec{e}{-}m$ is the sequence $\vec{e}_{m+1}, \vec{e}_{m+2}, \ldots$

Atomic formulas are evaluated in a Tarskian way, relative to both sequences of individuals and variable assignments. An existentially quantified formula $\exists x \phi$ behaves like an ordinary quantifier in the sense that it binds free occurrences of the variable x in its scope. More interestingly, it also behaves like a free variable itself. The quantifier is also concerned with the first open slot in the sequence relative to which the quantified formula is evaluated. If $\vec{e}$ is a sequence satisfying ϕ under an assignment of d to x, then $d\vec{e}$ satisfies $\exists x \phi$. It is precisely by interpreting indefinites as open places, that they can be addressed by subsequent pronouns.

The negation of a formula ϕ tells us that ϕ has no future, that there is no way to fill ϕ's open places with a sequence $\vec{c}$. In this way a negation binds the existential holes of the formula in its scope, so that, e.g., $\neg \exists x F(x)$, as usual, means that no x is F.

If we evaluate a conjunction $\phi \wedge \psi$ relative to a sequence $\vec{e}$, we evaluate the first conjunct ϕ relative to $\vec{e}{-}n(\psi)$, which is $\vec{e}$ with the contribution of ψ stripped of. (Remember that $n(\psi)$ is the number of indefinites (existential quantifiers) in ψ not in the scope of $\neg$.) Intuitively, this says that ϕ is evaluated *before* ψ has contributed its discourse referents. Maybe it is easier to read it in a constructive way. If $\vec{e}$ satisfies ϕ, and $\vec{c}\vec{e}$ satisfies ψ, where $\vec{c}$ fits the indefinites contributed by ψ (so the length of c must be $n(\psi)$), then $\vec{c}\vec{e}$ satisfies $\phi \wedge \psi$ as well. One could say that all of the dynamics resides in the update of sequences $\vec{e}$ satisfying ϕ with the information that $n(\psi)$ more terms have occurred. Thus conceived, the set of sequences satisfying a conjunction just is the intersection of those satisfying the second conjunct with the updates of those satisfying the first.

Because our sequences reflect the introduction of corresponding quantifiers in reversed order, it is convenient to write them in reverse order themselves. Satisfaction of a conjunction can then be pictured in the following, more perspicuous, way. Let i be the length $n(\psi)$ of ψ. Then:

(6)
$$\begin{array}{lll} M, g, \ldots d_{i+1} d_i \ldots d_1 & \models \phi \wedge \psi & \text{iff} \\ M, g, \ldots d_{i+1} & \models \phi & \text{and} \\ M, g, \ldots d_{i+1} d_i \ldots d_1 & \models \quad\;\; \psi & \end{array}$$

Now we see, firstly, how each conjunct may contribute its sequence of (possible) witnesses, and, secondly, that pronouns can be related to open terms from previous discourse. Notice that such a 'dynamic' conjunction is stated in terms of a static satisfaction relation.

Let us now see how *PLA* handles the key-note examples of systems of dynamic interpretation:

(7) A bird hurt a nerd. $[\exists x(B(x) \wedge \exists y(N(y) \wedge H(xy)))]$

Obviously, the length of this formula is 2, and some pretty straightforward calculations show that:

(8) $M, g, cd\vec{e} \models [7]$ iff $c \in E(B)$, $d \in E(N)$ and $\langle c, d\rangle \in E(H)$

that is, if, and only if, c is a bird who hurt nerd d. Now consider:

(9) She referred to his concert. $[\exists z(C(z) \wedge OF(z\mathrm{p}_2) \wedge R(\mathrm{p}_1 z))]$

The length of this formula is 1, but it imposes restrictions, not only on the first element which it mentions, but also on two preceding subjects. The formula is satisfied by a sequence $bcd\vec{e}$:

(10) $M, g, bcd\vec{e} \models [9]$ iff $b \in E(C)$, $\langle b, d\rangle \in E(OF)$ and $\langle c, b\rangle \in E(R)$

that is, if and only if b is a concert of d which c referred to. In the conjunction of (7) and (9), the two pronouns are resolved:

(11) A bird hurt a nerd. She referred to his concert. $[7 \wedge 9]$

The length of the conjunction is 3, and the whole is resolved:

(12) $M, g, bcd\vec{e} \models [11]$ iff $M, g, bcd\vec{e} \models [9]$ and $M, g, cd\vec{e} \models [7]$ iff
c, a bird who hurt d, a nerd, referred to b, the concert of d

Since a speaker, by uttering (7), mentions a bird and a nerd she hurt, the two subsequent pronouns can be identified with the intended referents of the two terms, as indeed is the case in *PLA*.

Let us now consider a so-called 'hinny sentence', a sentence of the form:

(13) If a bird hurt a nerd she referred to his concert. $[7 \to 9]$

Like we said, the *PLA* notion of implication is defined in the usual way in terms of negation and conjunction, and if we work it out we find:

(14) $M, g, \vec{e} \models \phi \to \psi$ iff $\forall \vec{c} \in D^{n(\phi)}$ if $M, g, \vec{ce} \models \phi$ then $\exists \vec{a} \in D^{n(\psi)}$: $M, g, a\vec{ce} \models \psi$

For our example [13] this amounts to the following satisfaction conditions:

(15) $M, g, \vec{e} \models [7 \to 9]$ iff
$\forall cd \in D^2$: if $M, g, cd\vec{e} \models [7]$ then $\exists b \in D$: $M, g, bcd\vec{e} \models [9]$ iff
$\forall cd \in D^2$: if $c \in E(B)$, $d \in E(N)$ and $\langle c, d \rangle \in E(H)$
then $\exists b \in D$: $b \in E(C)$, $\langle b, d \rangle \in E(OF)$ and $\langle c, b \rangle \in E(R)$

In short, the resolved implication (13) will be satisfied by any sequence $\vec{e}$ provided that every bird referred to a concert of every nerd which she hurt. Notice that these are the standard truth conditions associated with an implication of the form [13] in systems of dynamic semantics.

4 'HER' INDEXICAL PRESUPPOSITIONS

In general, the interpretation of pronouns or variables is stated formulated in an arguably circumstantial manner. It is specified in conjunction with the items which are contributed by (possible) linguistic contexts (assignments, sequences, or what have you). As a matter of fact this is a roundabout way of approaching things. In a truly compositional theory of interpretation the lexical semantics of pronouns and their preconditions ought to be specified in one gloss. Instead of defining contexts in which the use of certain pronouns or variables is felicitous, we would like to approach the issue precisely from the perspective of the pronominal creatures themselves, and state their meanings as functions over contexts. When we are dealing with more realistic linguistic contexts this appears not to be a trivial exercise.

Pronouns can be seen to require there to be certain elements in the context which they are taken to stand in for and such presuppositions should be formulated as belonging to their meaning or character. Besides, we would like to try and generalize the account to other uses of pronouns than anaphoric ones only. In this section we therefore set out to identify basic features of a pronoun's interpretation.[12] We take our cue from demonstratively used pronouns, and then try to generalize our findings to other uses, including the anaphoric uses discussed in the previous section. We will see that pronouns have indexical presuppositions which essentially refer to their contexts of use and that these contexts have modal and intentional aspects.

Pronouns can be taken to presuppose that there is something in their context of utterance which they refer to. If there is no such individual present, a sentence 'She takes good care of herself' is not evaluable, and neither is its negation 'She is not taking good care of herself.' Obviously, the presence of such an individual is required for a proper interpretation of the pronoun, and the requirement surely is not part of the pronoun's descriptive or semantic content. This presupposition thus seems to be indisputable, and it has actually been accepted in most theories of interpretation. (In many a theory of interpretation, such a presupposition either is explicitly stated as a presupposition, or it is generally rendered satisfied, because the system of interpretation is set up in a way so as to safeguard satisfaction of the presupposition under all circumstances of use.)

With this indexical presupposition, however, another one comes along which is easily left unobserved. For to presuppose that there is some definite individual in the pronoun's context of use, the pronoun must be used in the first place. This presupposition is of course trivially satisfied on all occasions of use, whence it even might be deemed fully negligible. However, we do have to take this presupposition into account precisely because the more substantial indexical presuppositions of pronouns crucially rely on the fact that it is satisfied, and there seems to be no way of formulating a pronoun's presupposition without reference to its context of use.[13]

The presupposition that a pronoun is uttered can be encoded in the character of the pronoun, in a way reminiscent of Lewis' self-locating beliefs (Lewis, 1979). Lewis characterizes these beliefs by means of an accessibility relation $\mathcal{B}$ between possible individuals. Intuitively, this relation holds between two possible individuals a and c iff agent a does not exclude the possibility that she is actually c, and that the actual world is like the world of which c is a part. Thus, a's information about the world is characterized, indirectly, in terms of the possible worlds which she, according to $\mathcal{B}$, thinks she may be part of, but always relative to the perspective of the agent which a thinks she might be in that world. Similarly, the character of a pronoun can

[12] So, in what follows, we will only attempt to capture the meanings of pronouns from a more systematic point of view and neglect the important issue of resolution. It must be clear that resolution is guided, simultaneously, by features of a more syntactic nature (number, gender, ...), of a semantic nature (properties attributed to the referent of the pronoun), and of a pragmatic one (focus, information structure). The interaction of these features must be beyond doubt, but, unfortunately, it is beyond the scope of this paper.

[13] In representational accounts of presupposition like that of (Geurts, 1995; van der Sandt, 1992), this kind of presupposition is not articulated, because the represented presuppositions already come with their own locus of use. In this respect representational accounts of presupposition seem to suffer from a defect generally attributed to semantic systems of dynamic interpretation, where it is assumed that indefinites and pronouns exhibit their resolution by means of the indices they carry on their sleeves.

be characterized by means of a relation $\mathcal{R}$ between possible uses of the pronoun and possible referents. Intuitively, this relation holds between possible utterances i and possible individuals d iff i is indeed an utterance of the pronoun and d is 'present' at the utterance location. The presupposition of the pronoun then can be said to be that there is such an occasion of use i, and a 'present' individual d, and its semantic contribution then simply is d.

In a suggestive gloss, the character of a pronoun 'she' then can be specified as follows:

(16) $[\![she]\!] = [\lambda i : \text{`}she\text{'}(i)][\lambda x : F(x) \wedge P(i,x)]\ x$

In the gloss, the bits between the brackets '[' and ']' specify the presuppositions of the pronoun, and the bit that follows it its semantic content, (the value of) x. Informally, this gloss presupposes an utterance, and a female (F) individual 'present' at the utterance, and semantically it contributes the said individual itself.[14]

It will be clear that our characterization of a pronoun's character invokes two notions which call for further elaboration, that of a 'use' or 'utterance' of a pronoun, and that of 'presence'. Quite generally, when it comes to the interpretation of indexical expressions, we seriously have to take 'tokens' or 'utterances' of these expressions into account. For although we can say, in the abstract, that 'I' refers to *the speaker*, or that anaphoric 'he' refers to the referent of an *antecedent* term, this only makes sense if we understand these locutions as referring to or quantifying over specific uses of these pronouns. In order to indicate a possible use of a pronoun we have assumed predicates like 'he', 'she', 'it', ..., to be available which are assumed to apply to individual utterances of pronouns.[15] The utterances themselves are conceived of here as physical objects or events located in space-time which, probably, can only be properly identified by embedding them in an intentional environment.

Another concept that stands in need of further clarification is that of presence. Although we, deliberately, leave it a unspecified here what that precisely means, some things need to be said though. Intuitively, presence may be to taken to boil down to physical presence, but physical presence is not a necessary condition, nor a sufficient one. Pronouns may refer to individuals

[14] An anonymous reviewer acutely observes that the presuppositions of pronouns cannot be 'accommodated' in interpretation, and this sets them apart from other presupposition triggers. In this respect, deemed 'demonstrative' and deemed 'anaphoric' uses of pronouns behave alike. In either case, the interpreter may suspect there to be a (non-linguistic, or linguistic) context of use, which has escaped his attention. If, as is usual in felicitous contexts of exchange, the assumption of such a context is implausible or flawed, the hearer may quite rightly disqualify the use of the pronoun as improper, and accommodation will not take place. What sets pronominal presuppositions apart from other presupposition triggers is that they are (almost) void of descriptive content, and (almost) entirely indexical. No accommodation is sensible.

[15] As a matter of fact it is not so clear what the right kind of object of investigation is, 'utterances', 'uses', 'tokens', or what have you. Besides, even if we choose 'utterances' as our target, as we do here, it is far from clear how to identify and individuate utterances and their parts. Cf., e.g., (Perry, 1997§ 3.2) for some interesting discussion.

who are not present but who, for instance, have been mentioned previously, a case which we will come back to below. Furthermore, for a pronoun to refer to, say, a designated piece of wood, it is not sufficient that the piece finds itself at a certain highlighted location, but there also must be some reason for it to be 'salient' in competition with other potential referents.

Consider, for instance, the use of a simple demonstrative pronoun which is accompanied by a pointing gesture. In many colloquial cases such pointings are unproblematic, and people usually have no problem in identifying the intended referent. Still, technically speaking, it is not so obvious how this is achieved. Various objects and parts of objects can be present in the direction of the pointing gesture or in or near the area pointed at. Besides, the designated objects need not be the intended referents themselves. A person can refer to an actual spatial location (Cargèse, Corse) by pointing at a corresponding location on a map, or to well-known figures by pointing at their name or photograph. Besides, also without demonstrative pointing gestures, pronouns may refer to individuals which are not actually present. A man may enter the bar, silently and sadly, and one of the guests can say to another 'she just died', thereby referring to the man's cat who, as both guests know, was very sick. And one can very well say 'She is absolutely fantastic' and refer to Veronica, if she was just mentioned in previous discourse, or if the interlocutors are looking at her picture. Quite often, what is said about the intended referent helps to determine which referent actually is intended, as do the interlocutor's expectations about each other's interests and beliefs.

As these examples are meant to show, the notion of presence which is relevant here is not simply that of physical presence, but it also has all kinds of additional modal and intentional aspects. 'Presence', really, has to be understood as some kind of 'intentional presence', or, as we will call it, 'presence in intentional space'. However, by this we do not mean to say that the notion of presence relevant in the specification of the presuppositions of pronouns is cognitive presence, or believed or intended presence. Linguistic rules, also those residing at the pragmatics / semantics interface, ought to be objective, even if they are intentional. If, as we think, these rules have a normative nature, then it certainly does not suffice to define the referent of a pronoun to be the individual which the interlocutors think it is or intend it to be. As a rule of interpretation, it ought to characterize what is a proper interpretation, and enable us to say what would be an improper interpretation on a certain occasion of use, or what would be a use of a pronoun with an improper intention. For this reason we will try and set out to give a rudimentary explication of intentional presence, which, although it relates to the epistemic states of the agents, is not functionally dependent upon them.

Formally, intentional space is part of logical space, which is a multi-dimensional entity. There are spatio-temporal dimensions, but also modal-intentional ones and each dimension constitutes a possible source of variation. The reference of a phrase like 'the temperature' varies when one moves along any of these dimensions, in space, in time, or into alternatives of space-time conceived possible or desirable. (As, similarly, the truth value of sentences with referring expressions may change when they are evaluated with reference to different individuals.) Intentional spaces, as well as the meanings of sentences, can be characterized as chunks of logical space, viz., sets of points in some n-dimensional grid where the intentions are realized, or where the corresponding sentences are true.[16]

Typically, when we evaluate modal or temporal operators we move along certain dimensions of this space, and when we enter intentional space we do likewise. For this, we assume an accessibility relation $\mathcal{IS}$ over logical space which specifies for each coordinate what are the coordinates intentionally accessible from there. Intuitively, the set of accessible coordinates can be seen to represent the actual utterance situation, but also situations depicted or described in that situation. Next to this accessibility relation we assume a 'representation' relation $\mathcal{R}$ which, for all coordinates, tells us which individuals the represented situations really are about, if any situation is represented at those coordinates. Using these two relations, we can say that an individual d is intentionally present iff it is represented in intentional space, relative to a world w, space time region r, etc. in the following way:

(17) $w, r, \ldots, d \models P(x)$ iff $(\mathcal{R}_{w,r,\ldots}(\mathcal{IS}_{w,r,\ldots}))(d)$

As for an illustration, suppose the actual intentional space at an occasion (given by $\mathcal{IS}$) involves an 'a bird hurt a nerd' situation. Suppose, furthermore, that this situation, which need not be actual, really concerns Lois and Clark (by $\mathcal{R}$). Then Lois and Clark are rendered intentionally present at that occasion. Similarly, suppose intentional space is made up of the mutual beliefs of the interlocutors that they both are thinking of Ronny's cat Dido, and that their beliefs actually derive from Dido. Then Dido is intentionally present, besides, probably, Ron.[17]

It will be clear from these sketchy and incomplete comments that our notion of presence in intentional space leaves room for a couple of 'delightful anomalies', to borrow a term from Kaplan. For instance, a speaker and her addressee may firmly believe the speaker uses a pronoun to refer to some individual Dido, when, objectively, she is referring to Lars, or when there actually is no referent at all. We also allow for cases where the speaker may fail to know the identity of an individual which she is referring to when she is using a pronoun. In order to finish this section, let us briefly inspect two examples of the latter case.

In the present set up, intentional space may consist of a course of events reported on in preceding

[16]Individuals and situations can also be conceived of as such chunks; individuals, for instance, as a certain kinds of worms, cf., e.g., (Bartsch, 1995).

[17]As noticed before, 'intentional presence' as such is not a uniquely identifying property of possible individuals. Syntactic properties of a pronoun, semantic properties attributed to its possible referent, and pragmatic features like focus and information structure may (or rather: must) help in determining its actual value.

discourse, or of a situation depicted by a photograph. In such cases it may escape the speaker and the hearer which individuals really are involved in the reported event, or which individual really is the one photographed. Nevertheless, we think that this does not (need to) hamper their exchange of information about such individuals.

As we have seen above a pronoun can also be used to refer to an individual mentioned by means of an indefinite description in previous discourse. Consider an utterance of the following conjunction:

(18) Last year, a girl borrowed Otto's bike, and she returned it in two pieces.

The pronoun 'she' here refers back to the girl, whoever she is, who is said to have borrowed Otto's bike. The speaker may state this because she has actually seen that, say, Anna borrowed Otto's bike, in which case $\mathcal{R}$ relates her use of the term 'a girl' to Anna, and in that case the pronoun refers to Anna as well. However, it can very well be that the speaker simply reports what she herself has heard, without knowing that it concerned Anna. In that case we may assume that her own informant used the term 'a girl' in relation to Anna (by $\mathcal{R}$), and, consequently, $\mathcal{R}$ relates the present speaker's use of 'a girl' to Anna as well. In that case, however, neither the speaker nor the hearer need to know that it is Anna who is intentionally present. For all they know, the pronoun in the second sentence refers to the individual mentioned in the first, which—as they don't know—actually is Anna.

The situation sketched is not problematic, because it allows for a truthful exchange of information. Even the hearer can use the speaker later as a source when he asserts (18) to yet another party. Again, if the original informant had truthfully spoken of Anna, the speaker has done so as well and the hearer will now also be speaking truthfully of Anna, although he doesn't realize that it is all about Anna. An anomaly would, however, arise, if the original informant simply had made things up. In that case, our speaker would probably have said something false when she uttered the first conjunct of (18), and the second conjunct would be anomalous, by failure of a referent for the pronoun 'she'. Here, (failure of) reference and (non-)truth can be seen to behave on a par. Semantically, the speaker's two statements are incorrect: one is false, the other anomalous. Pragmatically, however, the speaker's utterances are not infelicitous. If she believes what she has been told before, she cannot do better than believing the first statement to be true, and the second fine (referring) and true, too.

5 CONCLUSIONS

In this paper we have studied the interpretation of pronouns from three angles, ranging from a more formal to a more natural one. From a logical perspective, pronouns or variables have been seen to be place-holders, which can be interpreted adequately as functions from variable assignments to semantic values, or, more simply, as identity functions. In the first order system of *PLA* pronouns have next been given a slightly more autonomous interpretation, as projection functions over sequences of individuals generated by previous discourse—in a sense generalizations of identity functions. It was observed that, for these pronouns to act appropriately, they must be used in environments where the (linguistic) context supplies a suitable range of possible antecedents. As we have seen, this presupposition was given a metalinguistic formulation, not as a presupposition belonging to the pronouns' characters. We therefore set out to develop an independent statement of a pronoun's presuppositions and character. To this end we have adopted a many-sorted modal logic in which the referents of pronouns are required to be found in the intentional space surrounding their contexts of use. A pronoun 'she' is taken to refer to a person in its (not her) intentional presence.

Surely several questions have been left open, among which we shall shortly address three. In the first place it has remained unclear how presuppositions are to be dealt with in the rules of semantic construction. The character of a pronoun is specified above as: $[\lambda i : \text{`}she\text{'}(i)][\lambda x : F(x) \wedge P(i, x)]\ x$, and this gloss suggests an interpretation as a partial function. Such a function would only be defined for those u and d which are utterances and individuals (intentionally) present at the utterance location, and relative to such an utterance u the function would yield d as its semantic value. However, we tend to favour an alternative, structured interpretation of presuppositional expressions, more in line with the approaches of (Geurts, 1995; Karttunen and Peters, 1979; van der Sandt, 1992). Under such an interpretation the presupposed part of an expression is a proper constituent which must be matched with the context, either by finding appropriate values for the λ-bound variables, or by projecting these.

It seems that such an, arguably more computational, approach has to be favoured when it comes to the interpretation of so-called functional pronouns. As observed by many authors, and as emphasized by Jacobson, pronouns (as well as *wh*-phrases, indefinites, and definites) can have functional readings:

(19) Whom does every Englishman admire most? His mother.

(20) Every man loves a woman (viz., his mother), but hardly any man wants to marry her.

(21) Harvey dates a girl at every convention. He always comes to the banquet with her.

These functional readings can be neatly accounted for, by 'Geaching' the relevant terms with the type-logical rule of division $\mathcal{D}$ (Geach, 1972; Jacobson, 1999). This rule $\mathcal{D}$ divides the argument of a function ϕ of type $\langle b, c\rangle$ into a functional argument of type $\langle a, b\rangle$, by relating it to an additional argument of type a: $\mathcal{D}(\phi) = \lambda f_{\langle a,b\rangle} \lambda x_a\ \phi(f(x))$. By means of the rule $\mathcal{D}$ a pronoun with a 'Jacobson' meaning $\lambda x_e\ x$ can be 'Geached' into $\lambda f_{\langle e,e\rangle} \lambda x_e\ f(x) = \lambda f\ f$ and by means of further, fairly obvious, combinatorial rules the intuitive readings of the above examples can be derived.

Our point here is that if the presuppositions of pronouns are characterized by means of partial functions, then the rule of division would give rather unintuitive results. For if we divide a partial function $[\lambda x : \alpha(x)]\beta(x)$ it seems we can only get $[\lambda f \lambda x : \alpha(f(x))]\beta(f(x))$, which is defined for those f and x only if the initial presupposition α holds of $f(x)$. For the pronoun 'her' in our example (21) this would require there to be a function f assigning a girl Harvey dated to each convention he visited, and to presuppose the intentional presence of the girl $f(x)$ for every convention x. This does not seem to be right. Intuitively, it seems only the function f is supposed to be intentionally present. We think that such a 'divided' presupposition is derivable, in a principled manner, if presuppositions are dealt with in the more structured account suggested above.

A second issue is, of course, what may constitute the intentional space at a certain index of evaluation. Apart from some suggestions about what the space can be in a couple of examples, we haven't given any real effort in the paper to constrain these possibilities, neither will we do so in this conclusion. However, we do find this a proper place to connect this issue up with a more theoretical one.

Like we said, if a speaker has reported some event or situation, the individuals mentioned or referred to in the report may qualify as intentionally present. The relevant facts can be stated as follows. If we have two spatio-temporal regions r and r', in between which a sentence has been uttered, then we can assume the meaning of the sentence to contribute to the intentional space at r'. Thus, in one las tsuggestive gloss, we can stipulate that:

(22) if $r <$ 'S' $< r'$, then $\mathcal{IS}_{r'} \models S$

Intuitively this says that an utterance of 'S' contributes to intentional space, and, besides, that if terms used in 'S' are actually related to individuals by means of causal/intentional chains, then these individuals are intentionally present at r'. For this reason we can use pronouns, at or just after r', to refer to these individuals, if, that is, the relevant chains are not broken.

This point is interesting because it predicts that if a speaker has used terms with referential intentions, she may assume the associated referents to be intentionally present, even if her assumptions are not actually correct. Likewise, if the addressee has no reason to suspect otherwise, he may entertain the very same assumption. Thus, generally, the use of a term licenses a subsequent use of a pronoun, coreferential with that term. Really, this observation is a reformulation or even explanation of a principle taken to heart in virtually all systems of dynamic interpretation, that the terms used in the descriptions of events and situations bring up potential antecedents for subsequent anaphoric pronouns.

Our findings here serve to illustrate a more theoretical point stated in (Dekker, 2001), where it is shown that dynamic interpretation really involves the systematic integration of a static semantics with a dynamic / pragmatic notion of conjunction. It is argued in that paper that we can do with a concept of meaning which is basically the classical one. Dynamic conjunction then can be analyzed as an ordinary form of conjunction, which has taken the fact to heart that an utterance of the second conjunct has to be evaluated in a context where the first has already been uttered. The relevant change which the utterance of one conjunct may bring about resides in the fact that it contributes individuals to intentional space which satisfy the presuppositions of pronouns used in an utterance of the second. Upon our analysis, this phenomenon is of a pragmatic nature, not a semantic one.[18]

Systems of dynamic interpretation thus can be said to capitalize upon the fact that the presuppositions of pronouns can in principle be satisfied, in an arguably systematic manner, by precedent uses of terms. By taking it for granted that the presuppositions of pronouns can, thus, be systematically satisfied, they abstract away from the possible uses of sentences, and they thus enable a significant simplification of the interpretation procedures. Consequently, and as is obvious from systems like *DPL* (and *PLA*, for that matter), the 'update procedures' of agents and the ensuing update logics can be studied in a much more transparant manner.

Obviously, our view upon the interpretation of anaphoric pronouns is more involved than the one endorsed in systems of dynamic interpretation, as ours invokes reference to intentional spaces and reference to the individuals which they are actually about. However, even though it is less transparent, we claim it to be more generally applicable. Our specification of the character of pronouns applies to both anaphoric and demonstrative uses of them, and, arguably, to uses of them as bound variables. Besides, our analysis is not contingent upon the epistemic situations of the interlocutors who use these pronouns. In systems of dynamic interpretation, the link between pronouns and their antecedents normally is a rigid one—as a matter of fact, this constitutes one of their main logical merits. Our analysis is much more flexible and, we suggest, realistic, as it allows for the possibility that, unbeknownst to a speaker, a term actually fails to have a referent, and that, consequently, a subsequent use of a pronoun becomes undefined.

[18] The fact that the world which we inhabit is dynamic, and that utterances are among the acts that take place in that world, was already acutely observed in (Stalnaker, 1978). The implications of this observation for the understanding of dynamic conjunction have, to my knowledge, first been drawn in (Stalnaker, 1998) and they have been taken up in (van Rooy, 1997, Ch. 2, § 4), and systematically investigated in (Dekker, 200x).

A final comment relates to the main thrust of the present paper, which has been guided by the aim of giving an independent statement of the character of expressions such as pronouns. However, as may also appear from the discussion in (Hendriks, 1993, Ch. 2, § 4), this is almost like a Sisyphean task, and it can be observed that we haven't yet succeeded to give a completely independent statement of the meanings of pronouns. For the relevant specifications are given relative to some (quite unspecified) models, and relative to some intended interpretation of the structures of such a model, be it a first order, or a modal logic one. Apparently, the use of these constructions to model self-locating meanings must be a metameta-logical issue then, rather than just a meta-logical one.

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