Chapter 3

Dynamics

In dynamic semantics, different styles of quantification have been proposed that involve two different ways of interpreting free and quantified variables:

(i) Variables as denoting single partial objects;

(ii) Variables as ranging over a number of alternative total objects.

In the first part of the present chapter, I show that the first view leads to problems of underspecification and the second to problems of overspecification. In the second part, I propose a new style of dynamic quantification in which variables are interpreted in a way that avoids these problems:

(iii) Variables as ranging over a number of alternative definite objects (concepts).

I will then show that specific problems which arise when we quantify over concepts rather than objects, are avoided by relativizing quantification to ways of conceptualizing the domain.

3.1 Dynamic Semantics

In dynamic semantics,[1] the formal meaning of a natural language expression is identified with its potential to change an information state. An information state is generally characterized as a set of possibilities, consisting of the alternatives which are compatible with the information of the relevant agents. The nature of these possibilities depends on what particular aspect of the information change potential of a sentence one studies, and this is relative to the kind of phenomena

[1]Dynamic semantics originates from Kamp (1981), Heim (1983a), Groenendijk and Stokhof (1991) and Kamp and Reyle (1993). See Dekker (1993) and van Benthem et al. (1997) for excellent overviews.

one is willing to account for. In the present chapter, I study the interaction between anaphora and notions like epistemic modalities or presupposition, and, therefore, the type of information at issue concerns the state of the world, and what are possible antecedents for anaphoric pronouns.

Anaphora constitutes the traditional area of application of dynamic semantics (see Kamp (1981), Heim (1983a), Groenendijk and Stokhof (1991), Chierchia (1992), Dekker (1993), and others). Consider the following classical examples of inter-sentential and donkey-anaphora:

(123) I met a woman last night. She was feeding pigeons in the park.

(124) If a farmer has a donkey, he is rich.

These examples constitute a problem for a classical montagovian semantics since their arguably compositional logical representations in (125) and (126) do not reflect the intuitive meanings of the sentences, if interpreted in a standard fashion, since the variable x in the second conjunct in (125) and in the consequent in (126) occurs outside the syntactic scope of the existential quantifier $\exists x$ and hence it is not bound by it.

(125) $\exists x \phi_1(x) \wedge \phi_2(x)$

(126) $\exists x \psi_1(x) \rightarrow \psi_2(x)$

Dynamic semantics manages to solve these difficulties by encoding, as part of the meaning of indefinite NPs, their potential to introduce new items which can serve as antecedents for subsequent anaphora. Information about a potential antecedent is characterized as information about the possible values of a variable. The main feature of the dynamic existential quantifier is that it can bind variables outside its syntactic scope. The following are valid dynamic equivalences:

(127) $\exists x \phi(x) \wedge \psi(x) \equiv \exists x(\phi(x) \wedge \psi(x))$

(128) $\exists x \phi(x) \rightarrow \psi(x) \equiv \forall x(\phi(x) \rightarrow \psi(x))$

In what follows, I will use the traditional terminology and call *quantified* variables, variables occurring in the syntactic scope of a quantifier and *free* variables, variables occurring outside the syntactic scope of a quantifier. Crucially, such free occurrences may still be *dynamically bound* by a quantifier.

Epistemic modalities (see Veltman (1997)) and presupposition (Heim (1983b), Beaver (1995), van der Sandt (1992), Chierchia (1995) and others) constitute another traditional application area for a dynamic approach. Consider the following well-known examples:

(129) a. Someone is knocking at the door. It might be Mary. ... It is John.

b. Someone is knocking at the door. It is John. ... (?) It might be Mary.

(130) a. Bill likes Mary and John likes Mary too.

b. (?) John likes Mary too and Bill likes Mary.

Dynamic systems have been proposed, which view meanings as potentials to change factual information, and are thus able to capture the contrast between the (a) and (b) texts in (129) (see Veltman (1997)) and the projection of presupposition in conjunctions illustrated in (130) (e.g. Heim (1983b)). A characteristic, technical feature of a dynamic system, which is illustrated by these cases, is the fact that dynamic conjunction is not commutative:

(131) $\phi \wedge \psi \not\equiv \psi \wedge \phi$

Like we said, information about potential antecedents for future anaphora can be encoded by means of assignment functions (see Heim (1983a), Groenendijk and Stokhof (1991), etc.). Factual information can be represented by means of possible worlds (see Veltman (1997), Heim (1983b), etc.). A dynamic systems which sets out to investigate the interaction between anaphora, on the one hand, and epistemic modality and presupposition on the other, can characterize information states as sets of world-assignment pairs (see Heim (1982), Dekker (1993), etc.). The issue of the proper combination of these two kinds of information constitutes the main theme of the present chapter.

3.2 Quantification in Dynamic Semantics

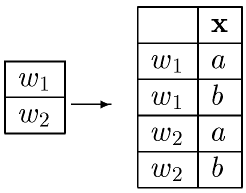
In a dynamic system, sentences describe transitions across a space of information states. As we said in the previous section, information states are defined as sets of possibilities (here world-assignment pairs) and meanings are state transitions, that is, functions or relations over the space of information states. An update with a sentence may reduce the size of a state or may yield richer states. Atoms or negations narrow down the alternatives under consideration by eliminating the world-assignment pairs that do not satisfy the information contents of these sentences. Existentially quantified sentences add structure to the state by setting up new items as potential topics for further discourse: $\exists x\phi$ adds x and selects a number of possible values for it; the fact that in the output state(s) x is defined means that recurrences of x in later sentences can have the effect of anaphoric reference.

Information about the values of variables is generally modeled in one of the following two ways:

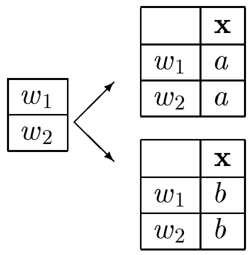
1. Variables are interpreted as single *partial* objects.[2] The introduction of new items is defined in terms of *global extensions* that involve adding fresh variables and assigning them as possible values all elements of the universe of discourse. All of the values which variables can take are considered simultaneously.

2. Variables are taken to range over a number of *total* objects. The introduction of a new item is defined in terms of *individual extensions* that lead to states in which the added variable is assigned a single element of the universe as its value. The values which variables can take are considered one by one as disjoint alternatives.

Individual and global extensions can be depicted as follows:[3]



1. Global Extension



2. Individual Extension

Global extensions yield unique output states, whereas individual extensions produce as many different outputs as there are members of the universe. This involves splitting up the initial state into different alternatives: later sentences will be interpreted with respect to each of them in a parallel fashion.

In the literature, three different interpretations have been proposed for the dynamic existential quantifier and they involve one or the other way of interpreting free and quantified variables:[4]

[2]Partial objects are the structured entities that constitute the interpretations of variables in information states. In Dekker (1993), they are defined as functions that assign to each possibility in a state the value of the corresponding variable in that possibility. A partial object is called total if it is a constant function. In the picture above, the partial object corresponding to the interpretation of the variable x is represented by the vertical column below x.

[3]I use these pictures to represent shifts on information states. The tables correspond to information states. On the topmost horizontal row, the variables that are defined in the state are displayed in bold characters. Each other horizontal row represents a world-assignment element of the state. The left column contains the world-coordinate and to its right the values of the assignment functions with each value displayed right below the variable which it gets assigned to. In this picture, the universe is assumed to consist of only two individuals a and b.

[4]Theoretically a fourth possibility is conceivable, according to which quantified variables are interpreted as ranging over total objects and free variables receive a partial interpretation. As will be clear from the following discussion, this possibility makes no intuitive sense, and, likewise, it has never been proposed in the literature.

Random Assignment (RA) is the standard interpretation. It is defined in terms of global extension; in RA fresh variables are assigned all individuals from the universe of discourse as possible values. In this way, quantified and free variables are interpreted uniformly as single indefinite partial objects, where further updates tend to make these objects more definite and less partial. See Heim (1982), Heim (1983b), Dekker (1993).

Slicing (SL) is defined in terms of individual extension; it involves splitting up the update procedure, so that the values that a variable can have are considered one by one, as disjunct alternatives, and not all at once. In this way, quantified and free variables are interpreted uniformly as ranging over a number of alternative total objects, where further updates tend to eliminate certain alternatives. See van Eijck and Cepparello (1994).

Moderate Slicing (MS) follows the slicing procedure as long as we are inside the syntactic scope of a quantifier, but lumps the remaining alternatives together once we are outside its scope. In this way, quantified variables range over a number of alternative total objects, whereas free variables are interpreted as single partial objects. See Beaver (1994), Dekker (1994), Groenendijk et al. (1996).[5]

These different styles of quantification lead to different results only in connection with notions that are sensitive to global properties of information states, i.e., notions that take a state as a whole and not point-wise with respect to the possibilities in it. This is not surprising: if we take states holistically it is obvious that it matters which possibilities are lumped together to form a state and which are kept separate. Examples of holistic notions are epistemic modals,[6] presupposition,[7] and the notion of support.[8]

Although the analysis of combinations of quantifiers and holistic notions motivated the use of (moderate) slicing instead of random assignment, I will argue that precisely in such contexts critical problems emerge for all three styles of quantification. Before turning to the illustration of these problems, let me introduce the relational dynamic semantics that supplies the general framework for the comparison of the three approaches.

Formal Framework

The core of the semantic framework that I take as a starting point is a relational version of the update semantics MDPL presented in Dekker (1993), with the ad-

[5]After the article has been written, upon which this chapter is based, Zuidema (1999) has proposed a system in which variables are introduced by individual extensions, but their possible values can be lumped together at later stages of the interpretation by means of a *collapse* operator. A proper discussion of this very interesting approach must be left to another occasion.

[6]See Dekker (1993), van Eijck and Cepparello (1994), Groenendijk et al. (1996), Veltman (1997).

[7]See Heim (1983b), Beaver (1994), Beaver (1995).

[8]See Groenendijk et al. (1996) and Dekker (1997).

dition of the presupposition operator introduced in Beaver (1995). The *language* $\mathcal{L}$ is a standard predicate logical language with the addition of two sentential operators, the epistemic modal operator $\Diamond$ and the presupposition operator ∂. Given $\mathcal{L}$, a *model* M for $\mathcal{L}$ is a pair $\langle W, D\rangle$ where W, the set of possible worlds, is a non-empty set of interpretation functions for the non-logical constants in $\mathcal{L}$, and D, the domain of discourse, is a non-empty set of individuals. Information states are sets of possibilities. They are defined as in Heim (1982) and Dekker (1993) as sets of world-assignment pairs in which all the assignment functions have the same domain.

3.2.1. Definition. [Information States] Let $M = \langle D, W\rangle$ be a model for $\mathcal{L}$. Let $\mathcal{V}$ be the set of individual variables in $\mathcal{L}$. The set Σ_M of *information states* based on M is defined as:

$$\Sigma_M = \bigcup_{X \subseteq \mathcal{V}} \mathcal{P}(W \times D^X)$$

I will use I^X to denote the set of possibilities $W \times D^X$ for some $X \subseteq \mathcal{V}$, and if $i = \langle w, a\rangle$ is a possibility, I will write w_i for w and a_i for a.

A possibility in an information state contains enough information for the interpretation of the basic expressions in $\mathcal{L}$.

3.2.2. Definition. Let α be a basic expression in $\mathcal{L}$ and i a possibility in I^X for some $X \subseteq \mathcal{V}$. *The denotation* of α in i is defined as:

(i) if α is a non-logical constant, then $i(\alpha) = w_i(\alpha)$;

(ii) if α is a variable in X, then $i(\alpha) = a_i(\alpha)$, undefined otherwise.

Meanings are relations over Σ_M. Before stating the semantic clauses, we need to define the auxiliary notion of survival.

Survival is a relation between a possibility and an information state and, indirectly, between two information states (cf. Dekker (1993)).

3.2.3. Definition. [Survival] Let $\sigma, \sigma' \in \Sigma_M$ & $i \in I^X$ for some $X \subseteq \mathcal{V}$. Then

(i) $i \prec \sigma$ iff $\exists j \in \sigma : w_i = w_j \;\&\; a_i \subseteq a_j$;

(ii) $\sigma \prec \sigma'$ iff $\forall i \in \sigma : i \prec \sigma'$.

A world-assignment pair i survives in a state σ iff σ contains a possibility j such that j is the same as i except for the possible introduction of new variables. A state σ survives in a state σ' iff all possibilities in σ survive in σ'.

We can now turn to the simultaneous definition of the main semantic clauses and of the notion of update and support in our system. (In this first definition, we skip the interpretation of $\exists\phi$ which will be discussed shortly.)

3.2.4. Definition. [Support] Let $\sigma \in \Sigma_M$ and ϕ in $\mathcal{L}$. Then

$$\sigma \models\!\approx \phi \quad \text{iff} \quad \exists\sigma' : \ \sigma[\phi]\sigma' \ \& \ \sigma \prec \sigma'$$

A state σ supports a sentence ϕ iff all possibilities in σ survive simultaneously in at least one of the states resulting from updating σ with ϕ, where updates are defined as follows:

3.2.5. Definition. [The Core of the Semantics]

$$\begin{array}{rll} \sigma[Rt_1, ..., t_n]\sigma' & \text{iff} & \sigma' = \{i \in \sigma \mid \langle i(t_1), ..., i(t_n)\rangle \in i(R)\}; \\ \sigma[\neg\phi]\sigma' & \text{iff} & \sigma' = \{i \in \sigma \mid \neg\exists\sigma'' : \sigma[\phi]\sigma'' \ \& \ i \prec \sigma''\}; \\ \sigma[\phi \wedge \psi]\sigma' & \text{iff} & \exists\sigma'' : \ \sigma[\phi]\sigma''[\psi]\sigma'; \\ \sigma[\Diamond\phi]\sigma' & \text{iff} & \sigma' = \{i \in \sigma \mid \exists\sigma'' \neq \emptyset : \sigma[\phi]\sigma''\}; \\ \sigma[\partial\phi]\sigma' & \text{iff} & \sigma \models\!\approx \phi \ \& \ \sigma[\phi]\sigma'. \end{array}$$

Updating a state σ with an atomic formula preserves those possibilities in σ which satisfy the formula in a classical sense. The negation of ϕ eliminates those i in σ which can survive after updating σ with ϕ. Conjunction is relational composition.

Modal sentences $\Diamond\phi$ are interpreted in Veltman's style, as consistency tests.[9] Updating with $\Diamond\phi$ involves checking whether ϕ is consistent with the information encoded in the input state σ. If the test succeeds, i.e., if at least one world-assignment pair in σ survives an update with ϕ, then the resulting state is σ itself, so nothing happens; if the test fails, the output state is the empty set, i.e. the absurd state (cf. Veltman (1997)).

∂ is Beaver's presupposition operator.[10] $\partial\phi$ should be read as 'it is presupposed that ϕ' and is interpreted as an update that is defined on a state σ only if ϕ is already supported in σ. Notice that presuppositions are not simple tests — the output state may vary from the input state in that it can contain new discourse items (cf. Beaver (1995)).

Consistency tests, presupposition and support are holistic notions because they relate to properties of the whole state, not of its individual elements.

Three different systems of interpretation can be developed from this core semantics depending on which of the three above-mentioned forms of dynamic existential quantification we adopt. To define them we need to introduce the auxiliary

[9]Many aspects of the meaning of epistemic modals in natural language are not captured by this analysis (see Roberts (1996a) for discussion). However, the one aspect that is addressed, namely that upon hearing *It might be that* ϕ one checks whether one's information is consistent with the information contained in ϕ, is significant and has a non-distributive nature.

[10]The empirical adequacy of Beaver's presupposition operator has been discussed (see van der Sandt (1992) and Geurts (1996) for discussion). However, the aspect that is captured by this definition, namely that an utterance of *John regrets that* ϕ is infelicitous unless the background state already supports the information that ϕ, is significant and has a non-distributive nature.

notions of an assignment operation, a global extension and an individual extension.

Assignment operations extend possibilities by adding fresh[11] variables and assigning to them as values individuals from the domain.

3.2.6. Definition. [Assignment Operations] Let $i \in I^X$ for some $X \subseteq \mathcal{V}$, $x \notin X$ and $d \in D$. Then

$$i[x/d] = \langle w_i, a_i \cup \{\langle x, d\rangle\}\rangle$$

We can now define both global and individual extensions.

3.2.7. Definition. [Extensions] Let $\sigma \subseteq I^X$, $x \notin X$ and $d \in D$. Then

(i) $\sigma[x] = \{i[x/d] \mid d \in D \;\&\; i \in \sigma\}$ (*global*);

(ii) $\sigma[x/d] = \{i[x/d] \mid i \in \sigma\}$ (*individual*).

Global extensions add fresh variables and randomly assign *all* elements of the universe of discourse to them. Individual extensions enlarge the domain of the state by assigning *single* elements of D to fresh variables. In terms of the notion of an extension, we can finally define Random Assignment, Slicing and Moderate Slicing.

3.2.8. Definition. [Three Styles of Quantification]

$$\begin{array}{rll} \sigma[\exists x\phi]_{RA}\sigma' & \text{iff} & \sigma[x][\phi]\sigma'; \\ \sigma[\exists x\phi]_{SL}\sigma' & \text{iff} & \sigma[x/d][\phi]\sigma' \text{ for some } d \in D; \\ \sigma[\exists x\phi]_{MS}\sigma' & \text{iff} & \sigma' = \cup_{d\in D}\{\sigma'' \mid \sigma[x/d][\phi]\sigma''\}. \end{array}$$

Universal quantification is defined in the standard way in terms of negation and existential quantification.

Since all of the operations defined are functional with the only exception of SL, if either MS or RA are assumed as the interpretation of the existential quantifier, then the whole semantics can be stated in terms of (partial) functions.

We can now turn to the illustrations of the problems.

[11] As in Heim (1982) and Dekker (1993), variables cannot be reset because resetting variables would involve losing information about their previous values. This 'downdate' effect would be problematic for the notions of negation and support, which crucially rely on the fact that no operations are considered that cause loss of information. There are other means, though, to avoid the 'downdate' problem, which allow reuse of variables, see for instance Groenendijk et al. (1996), Vermeulen (1996) and Dekker (1996). Notice that once we assume the style of quantification I eventually propose, we can reformulate the semantics in such a way that downdates are no longer problematic (cf. section 3.6). Finally observe that the novelty condition is a source of partiality. In addition to (i) presuppositions and (ii) formulas containing free variables, (iii) quantified sentences are partial updates as well. In the system I will present in section 3.6, only presupposition can cause undefinedness. Since partiality introduced by presupposition is not directly relevant to the issues discussed in the chapter, and partiality (ii) and (iii) do not occur in the final version of my system, I will pass over the issue of undefinedness in what follows.

3.3 Underspecification and Overspecification

In this section I will argue that of the two ways of interpreting variables that play a role in the three styles of dynamic quantification, the one that treats variables as single partial objects is too weak and leads to problems of *underspecification*. The other, which views them as place-holders for a number of alternative total objects, is too strong and leads to problems of *overspecification*.

Underspecification 1

If *quantified* variables are interpreted as *partial* objects, difficulties arise in connection with phenomena that involve quantification into the scope of holistic operators. Consider the following examples.

the suspect Treating variables in the syntactic scope of a quantifier as single underspecified objects has the unfortunate consequence that for all states σ the following holds (cf. Dekker (1993)):

(132) $\sigma \models\!\!\approx \exists x \Diamond \phi \quad \Rightarrow \sigma \models\!\!\approx \forall x \Diamond \phi$

So if we assume *RA*, sentences like the following two will contradict each other:

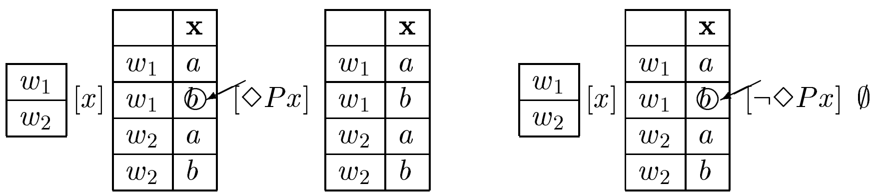
(133) a. Someone might be the culprit.

b. $\exists x \Diamond Px$

(134) a. Someone certainly is not the culprit.

b. $\exists x \neg \Diamond Px$

However, intuitively (133) and (134) express compatible pieces of information: you may hold the guilt of someone to be consistent with your information state and at the same time have evidence that someone else is innocent. The problem with *RA* is that the variable x introduced via global extension denotes exactly the same single underspecified object in both cases, which either verifies the modal sentence $\Diamond Px$, or falsifies it.



$w_1(P) = \{b\}$

If at least one member of the universe has the property P in some world (say individual b in world w_1 as in the picture), (133) is accepted and (134) is rejected. If this is not the case the opposite holds. So (133) and (134) cannot be accepted at the same time. This undesirable result obtains because, to quote from Beaver (1994), in *RA*, quantified variables don't vary enough: the one value that a variable can take cannot be considered separately from the others, because all the possible values are lumped together. This type of underspecification is also the source of the problem discussed in the following example.

the fat man This problem discussed in Heim (1983b) concerns the projection of presuppositions from quantified contexts. Consider (135):

(135) a. A fat man was pushing his bicycle.

b. $\exists x[\text{fat-man}(x) \wedge \partial(\exists y \text{ bike-of}(x, y)) \wedge \text{ pushing}(x, y)]$

Intuitively, (135) projects the presupposition that the intended fat man had a bicycle.[12] However, Heim (1983b), which assigns a random interpretation to variables, predicts the universal presupposition *Every fat man has a bicycle* for sentence (135), which is too strong intuitively.[13] The ∂ clause is interpreted with respect to the state resulting from adding x and updating with fat-man(x). If x is introduced by Random Assignment, this local state may contain several alternative values of x for each surviving world, namely all fat men in that world (a and b in the picture below). If any of these values is not a bike owner, then the ∂ clause turns out undefined. That is, in each world all fat men (all possible values of x) must own a bike, otherwise the sentence is not accepted.

$$\begin{array}{|c|}\hline w_1 \\ \hline w_2 \\ \hline \end{array} \quad [x] \circ [\text{fat-man}(x)] \quad \begin{array}{|c|c|}\hline & \mathbf{x} \\ \hline w_1 & a \\ \hline w_1 & b \\ \hline w_2 & a \\ \hline w_2 & b \\ \hline \end{array} \quad [\partial(\exists y \text{ bike-of}(x, y))]$$

[12] In Karttunen and Peters (1976), (135) is predicted to have the existential presupposition *Some fat man had a bicycle*. This prediction, as the authors admit, is clearly too weak, because intuitively, what should be projected in this case is the presupposition that the *same* fat man that verifies (135) had a bicycle, and *not* some other fat man. The problem arises because in K&P's system there is no obvious way to define scope and binding relations between the presupposition and the assertion, since these two components are represented by two mutually independent propositions. Note, however, that in dynamic semantics or DRT in which variables in one proposition can be bound by quantifiers in another proposition this problem does not occur. See Dekker (1998).

[13] In the same paper, Heim suggests remedying this inadequacy by stipulating the ready availability of an *ad hoc* accommodation mechanism in the evaluation of indefinite sentences. Standard accommodation mechanisms do not apply, because the relevant presupposition here must be accommodated locally.

Like Dekker's problem, Heim's problem results from the fact that in holistic updates all of the values that variables can take are considered all at once instead of one at a time.

Overspecification 1

If we use slicing, the two problems discussed above do not occur.[14] However, the *total* interpretation of *free* variables that SL involves, leads to the loss of a number of attractive properties guaranteed by MS in connection with phenomena of identification in situations of partial information.

the culprit Consider the following examples discussed by Groenendijk et al. in (1996) that involve dynamically bound variables occurring in the scope of Veltman's epistemic operator:

(136) a. Someone did it. It might be you. It might also not be you.[15]

b. $\exists x Px \wedge \Diamond(x = \text{you}) \wedge \Diamond(x \neq \text{you})$

(137) a. Someone did it. It might be anyone.

b. $\exists x Px \wedge \forall y \Diamond(x = y)$

These are coherent pieces of discourse, but if variables range over alternative total objects, they are both inconsistent. Take for example (137), which expresses an ultimate form of ignorance about the culprit's identity. If variables are place-holders for individuals, updating with (137) always yields the absurd state since it is impossible for one individual to be (possibly) identical to all the others (if $|D| > 1$). In RA and in MS, in which free variables are viewed as partial objects (136) and (137) are instead coherent, as should be the case.

Underspecification 2

The use of moderate slicing avoids the problems noted above, but runs into several others connected with the notions of presupposition, support and coherence. The source of the difficulties here is MS's *partial* interpretation of *free* variables.

[14] An alternative solution to underspecification 1 is obtained by defining presupposition (cf. Beaver (1992)) and modality (cf. Beaver (1993)) in a different way. However, by adopting (moderate) slicing (cf. Beaver (1994) and Groenendijk et al. (1996)), we obtain the same results with minor surgery.

[15] In this example, the deictic pronoun *you* is assumed to rigidly refer to the same individual in all epistemic possibilities.

the fat man again Heim's fat man problem arises not only for quantified variables, but for free variables as well. As an illustration, consider the following variation of (135), in which the occurrence of the variable x in the ∂ clause is dynamically bound by the existential quantifier:

(138) a. A fat man was sweating. He was pushing his bicycle.

b. $\exists x[\text{fat-man}(x) \wedge \text{ sweat}(x)] \wedge \partial(\exists y \text{ bike-of}(x, y)) \wedge \text{ pushing}(x, y)$

If we assume a partial interpretation of free variables (RA and MS), then, for the same reasons as above, (138) projects the presupposition that every fat man who was sweating had a bike, which is intuitively too strong.[16]

the wrong suspect Further difficulties for the partial view of free variables arise in connection with the notions of support and coherence. The notion of support (see definition 3.2.4) can be used to characterize when a speaker is licensed to utter a certain proposition. A speaker is licensed to utter ϕ iff her own information state supports ϕ. As a straightforward generalization we may say that a sentence is assertable iff there is a non-absurd state that supports it. In Groenendijk et al. (1996), texts satisfying this condition are called coherent texts; intuitively, such texts express mutually compatible pieces of information. Now, consider the following example (the pronoun in the second sentence should be read as co-referential with the indefinite in the first sentence):

(140) a. Someone might be the culprit. She is not the culprit.

b. $\exists x \Diamond Px \wedge \neg Px$

Intuitively (140) cannot be coherently asserted as a continuous monologue.[17] The first and second sentence express incompatible pieces of information. You cannot hold the guilt of a person to be consistent with your information and at the same time have the information that the same person is innocent. But if we use *MS* (or *RA*) and treat free variables as denoting single partial objects, (140) surprisingly comes out coherent, i.e. there are states that support it. Take as input a state σ^* consisting of two possibilities that supports the information that either individual a (in w_2) or individual b (in w_1) is P. In *MS* (as in *RA*), which

[16]In contrast with the original fat man case, standard accommodation could be used in this case. However, this does not improve the situation for an advocate of *MS* who would then have to explain why the free variable case (138) requires accommodation whereas the following bound variable variation does not:

(139) A fat man who was sweating was pushing his bicycle.

Intuitively, the two problems should be solved in a single move.

[17]Of course, you might be licensed to utter such a conjunction if there is a break between the two conjuncts. In the break you might have gained new information.

allows a partial interpretation of free variables, the first conjunct leads to a state with four possibilities in which both a and b are assigned as possible values to x for each world. Updating with the second conjunct keeps only those two possibilities that assign to x the individuals that are not P:

$$\begin{array}{|c|}\hline w_1\\\hline w_2\\\hline\end{array}\;[\exists x\Diamond Px]\;\begin{array}{|c|c|}\hline & \mathbf{x}\\\hline w_1 & a\\\hline w_1 & b\\\hline w_2 & a\\\hline w_2 & b\\\hline\end{array}\;[\neg Px]\;\begin{array}{|c|c|}\hline & \mathbf{x}\\\hline w_1 & a\\\hline w_2 & b\\\hline\end{array}$$

Even though the latter update eliminates possibilities, both possibilities in the initial state survive in the final state. So σ^* supports the sequence and hence the latter is coherent. It is impossible, however, for a state resulting from a successful update with the first sentence in (140) to support the second one. The fact that (140) still comes out coherent shows the 'non-compositionality' of the notion of support: we may have a state that supports a conjunction, whereas the same state updated with the first conjunct does not support the second one. The notion of support predicts that a speaker who is licensed to assert $\phi_1 \wedge \phi_2$ as a whole, is not necessarily licensed to assert ϕ_2 after asserting ϕ_1 and this is counter-intuitive.[18]

To summarize, in both MS and RA, in which free variables are interpreted as single partial objects, texts like (138) are predicted to project too strong universal presuppositions, texts like (140) come out counter-intuitively coherent, and, connected with this, we have a 'non-compositional' notion of support.

Overspecification 2

The *total* interpretation of *quantified* or free variables hides the conceptual presupposition that there exists a unique method of individuation across the boundaries of our epistemic possibilities. In Groenendijk et al. (1996), the total objects in an information state are taken to represent the ordinary individuals the agents are acquainted with and, following the 'russellian' tradition, these are specified as objects of perception. Given our trust in our perceptual capacities, it is quite reasonable to assume that if an individual is standing in front of us, then the *same* individual will be standing in front of us in all our epistemic alternatives. So demonstrative identification, as opposed to descriptive identification, is suggested as the unique correct method of cross-identification, and direct reference, that is, reference to the 'objects themselves', is specified as reference under such

[18] See Dekker (1997) and more recently Dekker (2000b), in which this problem is solved by introducing a new notion of support. All underspecification problems can be solved in RA by adopting different analyses for the three holistic notions. However, if underspecification can be avoided by simply using another style of quantification, then by dropping RA we account for three groups of phenomena by means of a single move.

a perspective. The problem with this characterization is that it fails to account for phenomena of identity and identification in situations of partial or mistaken information, that are precisely the kind of phenomena that quantified epistemic logic should account for.[19]

the man with the hood Suppose a man with a hood is standing in front of you and you haven't the faintest idea who he is. Groenendijk et al. have no obvious way of expressing this uncertainty. The following natural candidate, for instance, comes out inconsistent:

(141) $\neg\exists x\Box(x = \text{this})$

If variables range over total objects, (141) is accepted in a state iff the semantic value of the demonstrative is *not* a total object. The problem is that, if demonstrative identification is taken as the unique identification method, then that same man is standing in front of you with a hood on his head in all your epistemic alternatives, and so, by definition, you have identified him.

We could conclude that demonstrative identification was not the right characterization of identity across epistemic possibilities and that we should look further for a more adequate notion. However, it is easy to see that this would not be the right way to go. Similar problematic cases can be constructed for any other possible characterization of such a notion. Direct reference cannot be characterized as reference to the objects identified by the *one* favored mode of presentation, because there is not such a unique favored perspective. The following example supplies evidence for this point.

the soccer game Suppose you are attending a soccer game. All of the 22 players are in your perceptual field. You know their names, say a, b, c, ..., but you don't recognize any of them. Consider the following sentence:[20]

(142) a. Anyone might be anyone.

b. $\forall x\forall y\Diamond(x = y)$

It seems to me that (142) can be uttered in this situation. However, if we assume (moderate) slicing, (142) is inconsistent. The source of the difficulty is the uniqueness presupposition behind the total interpretation of variables. Intensional properties such as 'possibly being anyone' are not traits of individuals *simpliciter*, but depend on the perspective under which these individuals are looked at. Examples like (142) show that there is not one direct way of looking at the universe of discourse that characterizes the domain of quantification once and for all, instead different perspectives seem to supply different sets of ultimately partial objects over which we can quantify.

[19] See the classical articles Quine (1956), Kaplan (1969) and Kripke (1979) and more recently Gerbrandy (2000). See also the previous two chapters of this thesis.

[20] This is a modification of an example of Paul Dekker.

Synopsis The diagram below summarizes the contents of this section:

	RA	**SL**	**MS**
quant. var.	partial $\rightsquigarrow$ undersp 1	total $\rightsquigarrow$ oversp 2	total $\rightsquigarrow$ oversp 2
free var.	partial $\rightsquigarrow$ undersp 2	total $\rightsquigarrow$ oversp 1	partial $\rightsquigarrow$ undersp 2

3.4 Dynamic Quantification under Cover

In order to overcome the problems of over- and underspecification, I propose a new style of dynamic quantification that lies between random assignment and slicing, and which treats free and quantified variables in a uniform way. On the one hand, as in slicing, free and quantified variables range over alternative definite elements of some domain, and with respect to the different choices of these elements the interpretation proceeds in a parallel fashion. In this way, variables vary enough to avoid the underspecification problems. On the other hand, the overspecification problems are solved by allowing not one but many ways of conceiving the individuals over which we quantify. Different sets of possibly non-rigid concepts that cover the whole universe and that do not consider any individual more than once constitute suitable candidates for the domain of quantification.

Definite Subjects

In dynamic semantics, two levels of objects are assumed: the individual elements of the universe of discourse, and the partial entities that constitute the interpretations of variables in information states. The latter are introduced as items in conversation and can change, for instance by growing less partial, as the conversation proceeds. As we saw,[21] in Dekker (1993), these entities are called partial objects and are defined as functions that assign to each possibility in a state the value of the corresponding variable in that possibility. I extend Dekker's definition of partial objects and call a *subject* in an information state any mapping from the possibilities (world-assignment pairs) in the state to the individuals in the universe of discourse. Notice that in addition to explicitly introduced discourse items, potential items also count as subjects in a state.

Among the subjects, we can distinguish *rigid subjects* and *(in)definite subjects.* Rigid subjects are the constant functions among the subjects. Definite subjects are those that assign the same value to all possibilities that have the same world

[21] See footnote 2.

parameter. Definite subjects are contextually restricted (individual) concepts. They are *definite* in that they have a single value relative to a single world, but *partial* in that they may have different values relative to different worlds, and hence they do not always determine one individual. Indefinite subjects are subjects that are not definite, i.e., those assigning different values to possibilities with the same factual content.

In RA and MS, the presence of indefinite subjects as interpretation of some discourse items in a state reflects the indeterminacy of the addressee's perspective. Note that from the speaker's point of view indefinite items are senseless. Consider the following dialogue discussed in Dekker (1997):[22]

K: Yesterday a man came into my office who inquired after the secretary's office.
J: Was he wearing a purple jogging suit?
K: If it was Arnold, he was, and if it was somebody else, he was not.

Consider the following context: (α) K knows that Arnold *and* somebody else went to his office inquiring after the secretary's office. Dekker observes that in such a context, K's reply is odd, because K should have made up his mind about whom he wanted to talk before starting to tell the story. But now imagine another scenario: (β) K, who is blind but knows that Arnold always wears eccentric jogging suits, was wondering from the beginning whether it was Arnold who went to his office *or* somebody else. In β, the dialogue becomes quite natural.

Speakers do not introduce indefinite subjects (in scenario α the dialogue is odd), but may introduce non-rigid subjects (in scenario β the dialogue is natural). It seems fair to conclude that speakers introduce definite subjects. Now, dynamic semantics models the addressee's updating procedure and addressees often lack information about which definite subjects speakers intend to refer to. Questions

[22] See Dekker (1997) and van Rooy (1997). In (1997), Dekker uses such dialogues as a motivation for his interesting notion of dynamic support defined in term of *links* (see also Dekker (2000b)). As I said in a previous footnote, the adoption of Dekker's compositional support also allows a solution to the underspecification 2 problems. In van Rooy (1997), chapter 2, such dialogues are accounted for by assuming that specific indefinite NPs introduce speaker's referents, which are definite objects, rather than underspecified discourse items. Note that on van Rooy's account, overspecification 1 is also avoided, by positing two kinds of pronouns, referential and descriptive, the former referring back to total speaker's referents, the latter denoting possibly partial, but definite objects. Van Rooy's interesting distinction between referential and descriptive pronouns allows him to account for Barbara Partee's famous bathroom examples in an enlightening way. However, as I argued above, overspecification is not restricted to free variables, but arises for syntactically bound variables as well, and van Rooy's analysis does not have an explanation of the latter cases. The analysis I propose in the following sections avoids overspecification in general, but does not apply to the bathroom cases since the pronouns there are not dynamically bound. A combined approach might be the correct one, which treats syntactically and dynamically bound pronouns as ranging over elements of conceptual covers and dynamically unbound pronouns as van Rooy's descriptive pronouns.

like 'Who do you mean?' or 'Who are you talking about?' represent states of ignorance of this kind. In RA and MS, this type of ignorance is modeled in the same way as ordinary ignorance about what is the case, that is, by the presence in the information state of a number of world-assignment pairs in which the different individuals that the speaker might have in mind are represented by the different values that the relevant variable can take. A consequence of this strategy is the presence in states of indefinite subjects. In SL, instead, (lack of) information about the speaker's intentions is modeled on a higher level, namely by the presence of different alternative updates that run in a parallel fashion. In SL, the possible speaker's referents are modeled by the rigid subjects that constitute the interpretation of the relevant variable in the alternative parallel states. Going back to the dialogue above, K's reply is intuitively acceptable just in case K is assumed to be in doubt about the identity of the visiting person(s), so in a context like β. In cases in which K is assumed to know who the relevant persons were, the sentence is clearly unacceptable, because speakers cannot have doubts about their own intentions (as shown by the markedness of the sentence in α). Now, it is not obvious how RA, MS or SI can account for these intuitions. If the item introduced by K is modeled by an indefinite subject (RA and MS), the sentence would be judged acceptable even in case K is assumed to be omniscient with respect to information about the world. On the other hand, if we avoid indefinite subjects, but admit only rigid subjects (SL), then K's reply is never judged acceptable, which is also incorrect. The solution which suggests itself is to rule out indefinite subjects, while allowing possibly non-rigid ones and this is also my proposal.

	x
w_1	a
w_1	b
w_2	a
w_2	b

1. partial

	x
w_1	a
w_2	a

	x
w_1	b
w_2	b

2. total

	x
w_1	a
w_2	a

	x
w_1	a
w_2	b

	x
w_1	b
w_2	a

	x
w_1	b
w_2	b

3. definite

I propose to let variables range over definite subjects.[23] The interpretation

[23]Semantically my approach thus comes close in spirit to alternative approaches to anaphora

of the existential quantifier will involve splitting up a state as in the slicing procedure. The definite subjects (possibly non-rigid ones) which the speaker might have in mind are considered one by one as disjoint alternatives. It seems that in this way we can avoid underspecification without falling into overspecification. Since variables are taken to range over alternative elements of some domain, we avoid Dekker's or Heim's problem. In addition, since they can vary over non-rigid subjects, we have a good hope of solving the overspecification problems as well. Definite subjects seem to be the 'something in between' that we were looking for. Quantification over concepts is, however, quite an intricate affair. Difficulties arise almost immediately from the fact, evident from the picture above, that there are strictly more concepts in a state than individuals in the universe of discourse. Consider the following two examples.

the winner If we let quantifiers range over the set of all definite subjects, the following is a valid scheme:

(143) $\forall x \Diamond \phi \rightarrow \Diamond \forall x \phi$

This is clearly undesirable.[24] Suppose a game has been played; (143) says that if it is known that there are some losers ($\neg\Diamond\forall x Wx$), but we have no clue about who won, then we have no way of expressing this ignorance in a single quantified statement (since $\neg\forall x\Diamond Wx$ must also be true). (See also the shortest spy problems emerging for the system CIA, discussed in chapter 2, section 2.3.1.) Another example showing the same point is the smallest flea case.

the smallest flea Consider the following two sentences:

(144) Any flea might be the smallest flea.

(145) The biggest flea might be the smallest flea.

If we quantify over all concepts, a generalized version of universal instantiation holds and we can derive (145) from (144). This means that in ordinary situations in which fleas differ in size, (144) is never accepted. There will always be an element in the quantificational domain that falsifies it, for instance *the biggest flea*. Thus ignorance about the smallest flea's identity is inexpressible in such situations.

The examples above seem to show that quantifiers in natural language do not range over representations of individuals without further restrictions. If sentences

like e.g. E-type theory approaches as those of Evans (1977), Neale (1993), and in particular Slater (1986).

[24] Quine, though discussing a different point, shows the implausibility of the equivalent scheme $\Box\exists x\phi \rightarrow \exists x\Box\phi$: '...in a game of a type admitting of no tie it is necessary that some one of the players will win, but there is no one player of whom it may be said to be necessary that he win.' Quine (1953), p. 148.

like (144) were to quantify over representations, then we would have to accept the derivation of (145) from (144) as a trivial one. The fact that instead this conclusion strikes us as counter-intuitive means that natural language quantifiers do not work in this way. When we talk, we talk about individuals, not about representations of individuals, even in situations in which we lack information about their identity or are misinformed about that. To capture this feature of natural language quantifiers, we need a notion of *aboutness* which can work in situations of *partial information*. The traditional characterization of aboutness in terms of rigidity, implicit in (moderate) slicing, is inadequate in these cases. As we saw, in situations of partial information, we do not quantify over total objects (because we cannot). However, to deny the claim that quantifiers range over individuals in a direct way, we need not assume that we quantify *over* representations - it is enough to say that we quantify over individuals, but *under* a representation. Natural language quantifiers range over individuals under a *perspective*. To give some content to this abstract claim, let's consider the following example[25] in which we see such perspectives at work.

the butler Suppose a butler and a gardener are sitting in a room. One is called Alfred and the other Bill. We don't know who is who. In addition, assume that the butler committed a terrible crime. Consider now the following two discourses:

(146) The gardener didn't do it. So it is not true that anybody (in the room) might be the culprit.

(147) Alfred might be the culprit. Bill might be the culprit. So anybody (in the room) might be the culprit.

It seems to me that both (146) and (147) can be uttered in such a situation given the right circumstances. We can intuitively explain what is going on as follows: intensional properties, such as perhaps being the culprit, do not properly apply to individuals *simpliciter*, but depend on the perspective under which these individuals are conceived. Although the universal quantifier ranges over the same set in the two discourses, namely the set containing the two people in the room, in the two cases, the two individuals are identified from two different angles. For this reason no contradiction arises. In (146), individuals are looked at under the perspective of their profession; in (147) they are identified as referents of some proper name. Under the latter identification method, *the butler* may be Alfred or may be Bill. Yet, if we assume the other perspective, we can think of *the butler* as standing for a single object contrasted with *the gardener*. Perspectives are determined by contextual factors. In these two specific cases, the relevant contextual information is supplied by the preceding sentences, which, by mentioning one concept or the other, suggest one or the other way of classifying the domain.

[25] For more about examples of this kind see Gerbrandy (2000).

A natural way of representing a perspective over the universe of discourse is by means of a set of concepts. However, not all collections of concepts will do. The set of *all* concepts, for instance, is not a good candidate, as is evident from the winner and the smallest flea examples above. But there are many more inadequate conceptualizations.

Take a situation similar to the one above. Again we have Alfred and Bill sitting in some room, we know that one of the two is the butler, the other is the gardener, but we don't know who is who. Suppose you are interested in determining whether for anyone in the room, it is consistent with your information that an arbitrary property, say being bald, holds.

(148) Anyone might be bald.

Which of the following sentences constitutes a sufficient ground for a correct assertion of (148)?

(149) Alfred might be bald and Bill might be bald.

(150) The gardener might be bald and the butler might be bald.

(151) Alfred might be bald and the butler might be bald.

(152) Bill might be bald and the gardener might be bald.

In this particular situation, only the first two can ground (148). A derivation of (148) from either (151) or (152), would not be accepted as an example of correct reasoning. Even if the context may raise them as sets of salient concepts, the set consisting of *Alfred* and *the butler* as well as the set consisting of *Bill* and *the gardener* are not good conceptualizations in this specific case.[26] The reason for this is that, intuitively, they do not provide a uniform perspective over the universe of discourse: they mix up different perspectives and they do not cover the domain of individuals in an exhaustive way. In the following section I propose a way to formalize these intuitions.

Conceptual Covers

In this section, I restate the definition of the notion of a conceptual cover, introduced in the previous chapters, which is shown to be needed to account for the issues discussed in the previous sections.

Given a set of worlds W and a set of individuals D, an individual concept is any total function from W to D. A conceptual cover is a set of individual concepts

[26] Their inadequacy doesn't follow from the fact that they use definite descriptions *and* proper names, but depends on the specific information supported in this case. In other situations, such sets can provide good conceptualizations.

that satisfies the following condition: in a conceptual cover, in each world, each individual constitutes the value of one and only one concept.

Given a set of possible worlds W and a universe of individuals D, a *conceptual cover* CC based on (W, D) is a set of functions $W \to D$ such that:

$$\forall w \in W:\ \forall d \in D:\ \exists! c \in CC : c(w) = d$$

Conceptual covers are sets of concepts which exhaustively and exclusively cover the domain of individuals. In a conceptual cover, each individual d is 'seen' by at least one concept in each world (*existence*), but in no world is an individual counted more than once (*uniqueness*).

Two typical examples of conceptual covers are the following (let $\mathcal{C}$ be the set of individual constants in $\mathcal{L}$):

1. $RC = \{\lambda w\ d \mid d \in D\}$ (rigid cover)
2. $NC = \{\lambda w\ w(a) \mid a \in \mathcal{C}\}$ (naming)

RC is the set of constant concepts and NC is the set of concepts that assign to every world the denotation of a certain individual constant in that world (assuming exhaustive and exclusive naming practices). These two covers can be taken to model the two identification methods that played a role in most of the examples above (cf. for instance (142)), namely identification by ostension and identification by naming. However, these are just two among the many methods of identification that we normally assume when we think or talk about objects in our everyday practices. Other families of identification methods are, for instance, identification by description as in example (146), or by recognition like in the cases in which we identify strangers by bringing to mind the visual image of their faces that we perceived at one time. Our theory has no problem providing enough conceptual covers to model this multitude of identification methods.[27]

I propose to let variables range over the elements of a contextually supplied conceptual cover. The existential and the universal quantifiers will behave as ordinary quantifiers, that is, even if, technically, they range over concepts, the effect obtained is that of quantification over genuine individuals. It is precisely this ordinary type of quantification that motivates the two constraints on conceptual covers specified above, in particular the uniqueness condition which serves to guarantee that the objects over which we quantify eventually correspond to determinate individuals that can be said to be identical with themselves and distinct from one another. Sets of overlapping concepts do not characterize sets of genuine individuals in this sense. Consider again the situation described in the butler example above. Alfred and Bill are sitting in some room, we know that one of the two is the butler and the other is the gardener, but we don't know who

[27]See chapter 4, proposition 4.1.3.

is who. Take the set A consisting of the concepts *Alfred* and *the butler*. First of all, observe that A is not a conceptual cover. Given our assumptions, there will be some world w, in which someone is counted twice (namely the individual which is Alfred and the butler in w), and someone else is not 'seen' at all (namely the individual which is Bill and the gardener in w). So A does not satisfy either the uniqueness or the existence condition. Now, given the situation, the two elements of A cannot be regarded as standing for two determined individuals. Since we wonder whether Alfred is the butler, *Alfred* and *the butler* might be one individual or two. Crucially, inside exhaustive and exclusive sets of concepts, this kind of indeterminacy does not arise. Consider the set B consisting of *the butler* and *the gardener*, which, given our assumptions, is a conceptual cover. When taken in combination with *Alfred*, the concept *the butler* gives rise to individuation problems, but here, contrasted with *the gardener*, it comprises a completely determinate individual. Thus, only as an element of B and not as an element of A, *the butler* is capable of serving as a value of some bound variable.

To conclude, the elements of a conceptual cover represent the entities we quantify over and that we experience only via one or the other mode of presentation; yet it would be misleading to identify them with these modes of presentation.[28] The elements of a conceptualization are the individuals themselves, just thought, conceived or identified in a particular way.

Quantification under Conceptual Covers

To define quantification under conceptual covers, I need an operation that extends information states in the appropriate way.

3.4.1. Definition. [c-extensions] Let $\sigma \subseteq I^X, x \notin X$ & $c \in D^W$. Then

$$\sigma[x/c] = \{i[x/c(w_i)] \mid i \in \sigma\}$$

C-extensions lie between global and individual extensions. They introduce fresh variables and interpret them as certain definite subjects. Dynamic quantifiers are defined in terms of c-extensions; they range over elements of a contextually-given conceptual cover and, only indirectly, over the individuals in the universe. In this way, quantification is relativized to a particular way of conceptualizing the domain.

I add a special index $n \in N$ to the variables in $\mathcal{L}$. These indices range over conceptual covers and their value is assumed to be pragmatically supplied. As in chapter 2, I will write $\mathcal{V}_n$ to denote the set of variables indexed with n and $\mathcal{V}_N$ to denote the set $\bigcup_{n \in N}(V_n)$.

A model for this richer language $\mathcal{L}_{CC}$ is a triple $\langle D, W, C\rangle$ where D and W are as above and C is a set of conceptual covers based on (W, D). The interpretation

[28] Or with Fregean senses, characterized as ways of thinking of the referent of some singular term.

function $[\bullet]$ is relativized to *conceptual perspectives* $\wp$ which are functions from N to C.[29] Only the interpretation of dynamic quantifiers is directly affected by this relativization.

3.4.2. Definition. [CC-Quantification]

$$\sigma[\exists x_n \phi]^{\wp}_{CC}\sigma' \quad \text{iff} \quad \sigma[x_n/c][\phi]^{\wp}_{CC}\,\sigma' \text{ for some } c \in \wp(n)$$

A quantifier Qx_n, evaluated under a conceptual perspective $\wp$, is taken to range over the conceptual cover assigned by $\wp$ to n. The fact that each variable occurs with its own index allows different occurrences of quantifiers to range over different sets of concepts. Although different quantifiers range over the same sort of individuals, these may be identified in different ways.

If we assume quantification under cover, slicing and the classical theory of quantification arise as a special case, namely when all indices are assigned the rigid cover. Let $\wp^*(n) = RC$, for all n. We then obtain:

$$\sigma[\exists x_n \phi]_{SL}\sigma' \quad \text{iff} \quad \sigma[\exists x_n \phi]^{\wp^*}_{CC}\,\sigma'$$

RA and MS can be defined as derived notions in terms of c-extensions.

$$\begin{array}{lll} \sigma[\exists x_n \phi]_{RA}\sigma' & \text{iff} & (\cup_{c\in RC}\{\sigma[x_n/c]\})[\phi]_{RA}\sigma'; \\ \sigma[\exists x_n \phi]_{MS}\sigma' & \text{iff} & \sigma' = \cup_{c\in RC}\{\sigma'' \mid \sigma[x_n/c][\phi]_{MS}\sigma''\}. \end{array}$$

We can now relativize the notion of support to pragmatic contexts in an obvious way.

3.4.3. Definition. [CC-Support] Let $\wp$ be a conceptual perspective, σ be in Σ_M, and ϕ in $\mathcal{L}_{CC}$.

$$\sigma \approx\!\!\!\!|_{\wp}\ \phi \quad \text{iff} \quad \exists\sigma' :\ \sigma[\phi]^{\wp}\sigma' \ \&\ \sigma \prec \sigma'$$

A state σ supports a sentence ϕ under a perspective $\wp$ iff all possibilities in σ survive simultaneously in at least one of the states resulting from updating σ with ϕ under $\wp$.

3.5 Applications

In this section, I show how the use of conceptual covers solves the problems discussed earlier in this chapter.

[29] See chapter 1.

Underspecification Since variables in quantified contexts are taken to range over alternative definite objects, underspecification **1** is avoided. I will first consider Dekker's problem, which concerns the following two sentences:

(153) a. Someone might be the culprit.

b. $\exists x_n \Diamond P x_n$

(154) a. Someone is certainly not the culprit.

b. $\exists x_n \neg \Diamond P x_n$

Sentences (153) and (154) do not contradict each other, because different definite subjects are considered in isolation and they are not absorbed into a single indefinite one (as in *RA*). For instance, let σ be a state and c_1, c_2 be two concepts in some conceptual cover CC such that only c_1 takes as values individuals that have the property P in some possibilities of σ. Such a state σ will support both (153) and (154) under a perspective $\wp$ which assigns CC to n, since $\sigma[x_n/c_1] \mathrel{|}\!\!\approx_{\wp} \Diamond P x_n$ and $\sigma[x_n/c_2] \mathrel{|}\!\!\approx_{\wp} \neg \Diamond P x_n$. Heim's problem can be handled analogously:

(155) a. A fat man was pushing his bicycle.

b. $\exists x_n[\text{fat-man}(x_n) \wedge \partial(\exists y_m \text{ bike-of}(x_n, y_m)) \wedge \text{ pushing}(x_n, y_m)]$

If we assume quantification under cover, examples like (155) can be taken to project an existential presupposition, rather than a universal one, as we intuitively expect. As an illustration, consider the following variation of the butler situation. We have two fat men, Alfred and Bill. One is a gardener, the other is a butler. We don't know who is who, but it is established that while Alfred has a bike, Bill has none. As we saw, in *RA*, (155) is undefined in such a situation, because not all fat men have a bike:

$$\mathbf{RA:} \quad \begin{array}{|c|} \hline w_1 \\ \hline w_2 \\ \hline \end{array} \; [\exists x \text{ fat-man}(x)]_{RA} \; \begin{array}{|c|c|} \hline & \mathbf{x} \\ \hline w_1 & a \\ \hline w_1 & b \\ \hline w_2 & a \\ \hline w_2 & b \\ \hline \end{array} \; [\partial(\exists y \text{ bike-of}(x, y))]_{RA} \qquad (\ddot{\frown})$$

In *CC*, instead, if the index n is assigned a cover containing the concepts *Alfred* and *Bill*, (155) is defined, since the two possibilities of x_n being Alfred or Bill are considered in isolation (in the picture such a cover is assumed to be the rigid cover):

CC :

w_1
w_2

$[\exists x_n \text{ fat-man}(x_n)]^{\wp}_{CC}$

	$\mathbf{x_n}$
w_1	a
w_2	a

$[\partial(\exists y_m \text{ bike-of}(x_n, y_m))]^{\wp}_{CC}$ (☺)

	$\mathbf{x_n}$
w_1	b
w_2	b

$[\partial(\exists y_m \text{ bike-of}(x_n, y_m))]^{\wp}_{CC}$ (☹)

Note that, the sentence is still undefined, if n is assigned a cover containing the concepts *the butler* and *the gardener*, but not because a universal presupposition is projected in this case, but because, under such a cover, there is no possible intended fat man about whom it is established that he has a bike.

Underspecification **2** is also avoided, since only concepts may be introduced as new items. I just illustrate how the wrong suspect case is handled in the new system. Intuitively, example (156) comes out incoherent because there are no possible concepts under any conceptualization that can satisfy the two conjuncts at the same time.

(156) a. Someone might be the culprit. She is not the culprit.

b. $\exists x_n \Diamond P x_n \wedge \neg P x_n$

Formally, the incoherence of (156) follows from the fact that it is impossible for a state resulting from a successful update with $\exists x_n \Diamond \phi$ to support $\neg \phi$, in combination with the 'compositionality' of support. In the present semantics, if a conjunction $\phi \wedge \psi$ is supported in a state σ, then ψ must be supported in some σ' resulting from a successful update of σ with ϕ.

3.5.1. Fact. [Support of Conjuncts] Let $\sigma \in \Sigma_M$ and ϕ, ψ in $\mathcal{L}$.

$$\sigma \approx\!\!\!|_{\wp}\ \phi \wedge \psi \;\;\Rightarrow\;\; \sigma \approx\!\!\!|_{\wp}\ \phi \;\;\&\;\; \exists \sigma' : \sigma[\phi]^{\wp}\sigma' \;\;\&\;\; \sigma' \approx\!\!\!|_{\wp}\ \psi$$

Crucial to the proof of this fact[30] is the following property of the new system:

3.5.2. Fact. [Unique Extension] Let $\sigma[\phi]^{\wp}\tau$ for some perspective $\wp$, some states $\sigma, \tau \in \Sigma_M$ and some $\phi \in \mathcal{L}$, then the following holds:

$$\forall i \in \sigma : \forall j_1, j_2 \in \tau : i \prec j_1 \;\&\; i \prec j_2 \rightarrow j_1 = j_2$$

For any update in a system satisfying such a property, no two possibilities in the output state can extend one and the same possibility of the input state. Typical examples of systems in which the unique extension property does not hold are RA and MS, namely systems that allow a partial interpretation for free variables.

[30] We will come back to this later.

As an intuitive illustration of how the wrong suspect problem is solved, I will compare the interpretation procedures for (156) in MS, which allows branching of possibilities, and in the new system, in which the unique extension property holds. Let the input state be the state σ^* as above, consisting of two possibilities that supports the information that either individual a (in w_2) or individual b (in w_1) is P. As we saw, in MS, that allows a partial interpretation for free variables, σ^* supports the sequence and hence the latter is predicted to be coherent.

$$\textbf{MS:}\quad \begin{array}{|c|}\hline w_1\\\hline w_2\\\hline\end{array}\ \ [\exists x \Diamond Px]_{MS}\ \ \begin{array}{|c|c|}\hline & \mathbf{x}\\\hline w_1 & a\\\hline w_1 & b\\\hline w_2 & a\\\hline w_2 & b\\\hline\end{array}\ \ [\neg Px]_{MS}\ \ \begin{array}{|c|c|}\hline & \mathbf{x}\\\hline w_1 & a\\\hline w_2 & b\\\hline\end{array}$$

If, on the other hand, we adopt the style of quantification that I am proposing, we avoid this problem: the two initial possibilities do not survive both in one of the output states under any conceptual cover. In the picture below, we consider as an illustration the case in which $\wp(n) = RC$.

$$\textbf{CC:}\quad \begin{array}{|c|}\hline w_1\\\hline w_2\\\hline\end{array}\ \ [\exists x_n \Diamond Px_n]^{\wp}_{CC}\ \ \begin{array}{l} \nearrow\ \begin{array}{|c|c|}\hline & \mathbf{x_n}\\\hline w_1 & a\\\hline w_2 & a\\\hline\end{array}\ \ [\neg Px]^{\wp}_{CC}\ \ \begin{array}{|c|c|}\hline & \mathbf{x_n}\\\hline w_1 & a\\\hline\end{array} \\[2em] \searrow\ \begin{array}{|c|c|}\hline & \mathbf{x_n}\\\hline w_1 & b\\\hline w_2 & b\\\hline\end{array}\ \ [\neg Px_n]^{\wp}_{CC}\ \ \begin{array}{|c|c|}\hline & \mathbf{x_n}\\\hline w_2 & b\\\hline\end{array} \end{array}$$

As a matter of fact, no state can be found that supports (156) under any conceptualization. The sentence is incoherent.

Overspecification Since variables are not taken to range over individuals *simpliciter*, but over individual under a conceptualization, the overspecification problems are solved as well. The inequalitarian attitude towards ways of identifying objects implicit in (moderate) slicing is overcome and different identification methods are given equal status. We can look at the individuals in the universe under different perspectives and, if the context justifies it, we can change perspective within the same discourse. Problems of identification can be represented as problems of mapping elements from different conceptualizations onto each other. As a result, the overspecification **1** cases are solved.

(157) a. Someone did it. It might be anyone.

b. $\exists x_n P(x_n) \wedge \forall y_m \Diamond(x_n = y_m)$

Examples like (157) come out coherent, if interpreted in a perspective $\wp$ that assigns different conceptual covers to n and m. For example, if the existential quantifier introduces non-rigid subjects and the universal ranges over the rigid conceptualization ($\wp(m) = RC$), a state like σ^* above supports (157).

Overspecification **2** is avoided in a similar way. Example (158) can be accepted, if x_n is not taken to range over the cover representing demonstrative identification, RC.

(158) $\neg\exists x_n \Box(x_n = \text{this})$

A good example of this obtains when n is assigned naming. Thus we can express ignorance about the identity of some object of perception, and in addition, by shifting conceptualization we can account for any situation of partial identification in an enlightening way. Examples like 'I wonder who Alfred is', or 'I wonder who the culprit is' are not problematic for this approach.[31] The soccer game case is explained as well.

(159) a. Anyone might be anyone.

b. $\forall x_n \forall y_m \Diamond(x_n = y_m)$

Example (159) is acceptable, if x_n and y_m are taken to range over different conceptualizations. In this specific situation, n and m are assigned as value the cover by perception and the cover by names respectively. Notice, however, that if no shift of cover is assumed the sentence is unacceptable: $\forall x_n \forall y_n \Diamond(x_n = y_n)$ is inconsistent in the present approach (unless the domain contains a single individual).

Cardinality Since the set of all concepts is not a conceptual cover, the winner problem and the smallest flea problem do not occur. The problematic scheme:

(160) $\forall x_n \Diamond\phi \to \Diamond\forall x_n \phi$

is *not* valid and hence sentences like 'Anyone might be the winner' can be accepted in situations in which it is known that there are some losers. Furthermore, only a restricted version of universal instantiation holds:

(161) $(\forall x_n \phi \wedge \exists y_n \Box(t = y_n)) \to \phi[x_n/t]$

So, since the universal sentence 'Any flea might be the smallest flea' can be accepted only under a conceptualization that does not contain *the biggest flea*,[32] the problematic implication to 'The biggest flea might be the smallest flea' is blocked.

[31] See chapter 1.
[32] Unless we have a domain with a single flea.

To summarize, if we assume quantification under cover, underspecification does not occur since only definite subjects may constitute interpretations of variables. At the same time, overspecification is also avoided since different occurrences of quantifiers may range over different sets of (possibly partial) concepts. Finally, by taking as domain of quantification only sets of concepts which exhaustively and exclusively cover the universe of individuals, we avoid the cardinality problems that normally arise when we quantify over concepts rather than objects.

3.6 Conceptual Covers in Dynamic Semantics

In the previous sections, I have compared three different intensional dynamic systems using three different styles of quantification: RA, MS and SL, and I have discussed specific problems arising for each of them. I have then introduced a new style of dynamic quantification, quantification under cover, and I have shown how, by adopting such a form of quantification, the previously discussed problems are avoided. In this section, I show how dynamic semantics under conceptual cover can be formulated in a much more elegant fashion.

In what follows, I present Dynamic Modal Predicate Logic under Conceptual Covers (CC). I abandon the relational version of MDPL, which I used for the comparison of the four different styles of dynamic quantification, and I formulate the CC system in a style which is closer to the logic presented in chapter 2. The proposed semantics will be an 'under cover' version of the Dynamic Modal Predicate Logic (DMPL) introduced in van Eijck and Cepparello (1994). The choice of formulating the semantics in the style of DMPL is not unmotivated. Indeed, this formulation clearly shows important properties of CC-quantification, because it crucially exploits them. Furthermore, DMPL has a distinct advantage over MDPL, namely that the reuse of variables does not cause the 'downdate' problem (see footnote 11). The fact that quantification under cover allows this kind of re-formulation constitutes a further motivation for its assumption – for RA and MS cannot be reformulated in this way. I start by discussing the issue of non-accessibility in an MDPL style formulation of CC-quantification.

Non-accessible states

We can think of meanings in a system S as describing transitions between different information states. I will call a state S*-accessible*, if it is reachable from the state of minimal information $1 = \{\langle w, \emptyset\rangle \mid w \in W\}$ by a number of S-transitions. I will call a state CC*-accessible under* $\wp$, if it is reachable from the state of minimal information by a number of CC-transitions under $\wp$.

CC-accessible states under some perspective $\wp$ satisfy the following condition: in such a state, variables which are indexed in a uniform way are interpreted as elements of one and the same conceptual cover. I will call this condition $\wp$-

uniformity. Let $[x_n]_\sigma$ denote the partial object which constitutes the interpretation of the variable x_n in σ, i.e., $[x_n]_\sigma$ is the function $f : \sigma \to D$ such that $\forall i \in \sigma : f(i) = i(x_n)$; let c_σ denote the restriction of the concept c to σ, i.e., c_σ is the function $f : \sigma \to D$ such that $\forall i \in \sigma : f(i) = c(w)$. The following proposition trivially holds:

3.6.1. PROPOSITION. [$\wp$-uniformity] Let $\sigma \subseteq I^X$ be a CC-accessible state under some perspective $\wp$. Then the following holds:

$$\forall n \in N : \forall x_n \in X : \exists c \in \wp(n) : [x_n]_\sigma = c_\sigma$$

As a corollary of this proposition, CC-accessible states have the important property that they do not contain indefinite subjects.

3.6.2. COROLLARY. [Definiteness] Let σ be a CC-connected state. Then the following holds:

$$\forall i, j \in \sigma : w_i = w_j \;\Rightarrow\; i = j$$

Since not all MDPL information states are $\wp$-uniform or definite, it follows that, in CC, not all states are accessible.[33] In what follows I want to argue that, firstly, non-accessible states are not useful, and, secondly, they can be harmful and hence we have good reasons to get rid of them.

There are many ways in which we can acquire new information, and linguistic communication is just one of these ways. We may wonder whether non-accessible states might be useful to encode information, obtainable by some non-linguistic means, which cannot be encoded by some accessible state. I do not believe this is the case. The only kind of information which can be encoded in a non-accessible state and cannot be encoded in an accessible state concerns indefinite subjects. In ordinary dynamic semantics indefinite subjects originate from the interpretation of indefinite NPs, but I have already argued in favor of a definite interpretation of such expressions. Indefinite subjects are used to express lack of information about the actual intended denotation of a discourse item,[34] but, as we have seen, this kind of ignorance can also be expressed by means of (a set of) definite state(s).[35] Thus, non-accessible states do not add any expressive power to our system, and, therefore, we do not have any reason to maintain them. Instead, we have reasons to eliminate them. Indeed, non-accessible states affect the logical notions

[33]Something similar holds for SL as well. Note that in RA and MS all states are accessible.

[34]For discussion about the role of discourse referents see Dekker (2000a) and Zimmermann (1999).

[35]This point can be compared with that of Stalnaker in the debate with Lewis about indexical belief. See Lewis (1979) and Stalnaker (1981).

of our system in an undesirable way. In order to see this, consider the notion of coherence, which we have focused upon in the previous sections. Compare the following two notions of coherence where the first involves existential quantification over all states and the second restricts quantification to accessible states (I use $\mathrm{Acc}_\wp(\sigma)$ to denote that σ is CC-accessible under $\wp$):

3.6.3. Definition. [CC-Coherence 1] Let ϕ be in $\mathcal{L}_{CC}$.

$$\approx\!\!\!\!|_{CC1}\ \phi \text{ iff } \exists M, \exists\wp, \exists\sigma \in \Sigma_M : \sigma \neq \emptyset \ \&\ \sigma \approx\!\!\!\!|_{\wp}\ \phi$$

3.6.4. Definition. [CC-Coherence 2] Let ϕ be in $\mathcal{L}_{CC}$.

$$\approx\!\!\!\!|_{CC2}\ \phi \text{ iff } \exists M, \exists\wp, \exists\sigma \in \Sigma_M : \mathrm{Acc}_\wp(\sigma) \ \&\ \sigma \neq \emptyset \ \&\ \sigma \approx\!\!\!\!|_{\wp}\ \phi$$

Coherence 1 and 2 are not the same notion. Consider the following sentence:

(162) $\Diamond\, x_n = y_n \wedge \Diamond\, x_n \neq y_n$

If we assume the second notion of coherence, (162) is incoherent. If we assume the first, it is not. Indeed, a non-accessible state which does not satisfy $\wp$-uniformity can support the sentence:

(163) $\approx\!\!\!\!|_{CC1} \Diamond\, x_n = y_n \wedge \Diamond\, x_n \neq y_n$

(164) $\not\approx\!\!\!\!|_{CC2} \Diamond\, x_n = y_n \wedge \Diamond\, x_n \neq y_n$

Example (162) expresses the negation of the uniqueness condition on conceptual covers. Since x_n and y_n are equally indexed, we expect them to range over elements of the same cover, but their denotations are neither separated (they coincide in some possibility) nor equal (do not coincide everywhere). Above I have argued that it is because of the uniqueness condition that covers constitute suitable domains of quantification. Since the elements of a cover do not merge and split once we move from one possibility to the other, they behave like genuine individuals and, therefore, are capable of serving as the value of some bound variable. For this reason, we would like a sentence like (162), which negates the very nature of conceptual covers, to be incoherent in CC. The most natural way to obtain this consists in eliminating non-accessible states. We can model CC-quantification in an MDPL style dynamic semantics, in such a way that non-accessible states are neutralized. We can restrict all logical notions to accessible states or redefine the notion of a state in such a way that only $\wp$-uniform states can count as states. None of these moves is particularly elegant. I take this as an indication that an MDPL style dynamic semantics, which was the right framework for the comparison among the four styles of dynamic quantification, is not a natural choice for CC (and SL). In what follows, building on van Eijck and Cepparello (1994), I reformulate quantification under cover in a way which does better justice to its arguably desirable features. In the new formulation, the problematic non-accessible states are not even definable. Furthermore, in the new semantics, as in the original Groenendijk and Stokhof formulation of Dynamic Predicate Logic, 'downdates' are not problematic. Thus, all the complications connected to the issue of the reuse of variables which arise for an MDPL style formulation are avoided here.

Dynamic Modal Predicate Logic under Cover

A model for a language $\mathcal{L}_{CC}$ is, as above, a triple $\langle W, D, C\rangle$ where C is a set of conceptual covers on D and W. A *state* $s \in S_M$ in the new formulation is a subset of W, as in the original formulation of update semantics in Veltman (1997). A CC-*assignment* g is a function mapping conceptual cover indices $n \in N$ to conceptual cover elements of C and n-indexed individual variables $x_n \in \mathcal{V}_n$ to concepts which are elements of $g(n)$ (see definition 2.4.1, in chapter 2).[36] Thus, the information that, in the previous formulation was encoded separately in the old assignments and in the conceptual perspectives, is encoded in an integrated fashion here. Terms are interpreted as follows:

3.6.5. DEFINITION. [CC-Interpretation of terms]

(i) $[t]_{w,g} = g(t)(w)$, if t is a variable;

(ii) $[t]_{w,g} = w(t)$, if t is a constant.

Sentences ϕ are interpreted with respect to pairs of input-output assignment functions $[\phi]^g_h$. The denotation $[\phi]^g_h$ of ϕ with respect to g and h is a function from states to states.

3.6.6. DEFINITION. [CC-Semantics]

$$\begin{array}{rll}
s[Rt_1, ..., t_n]^g_h = t & \text{iff} & g = h \;\&\; t = \{w \in s \mid \langle [t_1]_{w,g}, ..., [t_n]_{w,g}\rangle \in w(R)\}; \\
s[\neg\phi]^g_h = t & \text{iff} & g = h \;\&\; t = \{w \in s \mid \neg\exists k : w \in s[\phi]^g_k\}; \\
s[\exists x_n]^g_h = t & \text{iff} & g[x_n]h \;\&\; t = s; \\
s[\phi \wedge \psi]^g_h = t & \text{iff} & \exists k : (s[\phi]^g_k)[\psi]^k_h = t; \\
s[\Diamond\phi]^g_h = t & \text{iff} & g = h \;\&\; t = \{w \in s \mid \exists k : s[\phi]^g_k \neq \emptyset\}; \\
s[\partial\phi]^g_h = t & \text{iff} & s = t \;\&\; s = s[\phi]^g_h.
\end{array}$$

where $g[x_n]h$ iff $h(x_n) \in h(n)$ & $\forall v \in (N \cup \mathcal{V}_N) : v \neq x_n \;\Rightarrow\; g(v) = h(v)$ (note that for all CC-indices n: $h(n) = g(n)$).[37]

[36] Note that assignments are total functions here. You can choose to have partial assignments, if you wish, but you don't have to.

[37] Note that variables can be reset. In the present formalization, this feature does not cause any 'downdate' problem (see footnote 11).

I will write $\exists x_n \phi$ to denote $\exists x_n \wedge \phi$, and, as usual, $\forall x_n \phi$ for $\neg\exists x_n \neg\phi$; $\Box\phi$ for $\neg\Diamond\neg\phi$; and $\phi \rightarrow \psi$ for $\neg(\phi \wedge \neg\psi)$. This implies the following semantics for $\rightarrow$:

$$s[\phi \rightarrow \psi]^g_h = t \quad \text{iff} \quad g = h \;\&\; t = \{w \in s \mid \forall k : w \in s[\phi]^g_k \;\Rightarrow\; \exists r : w \in (s[\phi]^g_k)[\psi]^k_r\}$$

It is easy to see that the following version of the update property holds now:

3.6.7. Proposition. [Update property] $s[\phi]^g_h \subseteq s$

The evaluation process takes place on two levels: on the level of the states, where it is eliminative (as in the original formulation of Update Semantics of Veltman); and on the level of the assignments, where it proceeds in a point-wise relational fashion (as in the original formulation of Dynamic Predicate Logic of Groenendijk and Stokhof). This separation of levels is illuminating, because it shows the important difference between world and discourse information[38] which is assumed by the *CC* style of quantification. While factual information is functional, discourse information can yield more than one output.

I now define the notions of support and coherence.

3.6.8. Definition. [CC-Support] $s \approx_g \phi$ iff $\exists h : s = s[\phi]^g_h$

3.6.9. Definition. [CC-Coherence] $\approx_{CC} \phi$ iff $\exists M, g, \exists s \in S_M$: $s \neq \emptyset \;\&\; s \approx_g \phi$

It is easy to see that the notion of CC-support is 'compositional'. If a state supports $\phi \wedge \psi$, then ψ must be supported in some intermediate state resulting from a successful update with ϕ (the proof is straightforward and relies on the update property):

3.6.10. Proposition. [Support of Conjuncts]

$$s \approx_g \phi \wedge \psi \;\Rightarrow\; s \approx_g \phi \;\;\&\;\; \exists h : s[\phi]^g_h \approx_h \psi$$

In the present semantics, we manage to match Dekker's predictions on when a speaker is licensed to utter a certain proposition.[39] You are not licensed to utter $\phi \wedge \psi$, if you are not licensed to utter ψ after ϕ. As we saw, this property of CC-support allows us to solve the underspecification 2 difficulties. Indeed, the wrong suspect sentence is not coherent in CC:

(165) $\not\approx_{CC} \exists x_n \Diamond P x_n \wedge \neg P x_n$

The following three sentences are instead coherent and this shows that we avoid the underspecification 1, overspecification 1 and 2 respectively:

[38] On this issue see van Eijck and Cepparello (1994).

[39] See Dekker (1997) and Dekker (2000b).

(166) $\approx\!\!\!\!|_{CC}\ \exists x_n \Diamond P(x_n) \wedge \exists x_n \neg \Diamond P(x_n)$

(167) $\approx\!\!\!\!|_{CC}\ \exists x_n P(x_n) \wedge \forall y_m \Diamond (x_n = y_m)$

(168) $\approx\!\!\!\!|_{CC}\ \forall x_n \forall x_m (\Diamond x_n = x_m)$

In what follows, I state the relation between the old and the new formulation of dynamic semantics under conceptual covers. By the old formulation I mean the MDPL style formulation with the logical notions restricted to CC-accessible states.

Comparison

The old and the new formulations of dynamic semantics under cover do not define the same logical notions because the new formulation does slightly better than the old one in connection with the possibility of reusing variables. Let $\approx\!\!\!\!|_{old}$ be $\approx\!\!\!\!|_{CC2}$ (the chosen definition of coherence in the old system), and $\approx\!\!\!\!|_{new}$ be $\approx\!\!\!\!|_{CC}$ (the presently defined one). We then obtain the following:

(169) $\not\approx\!\!\!\!|_{old}\ \exists x \phi \rightarrow \exists x \phi$

(170) $\approx\!\!\!\!|_{new}\ \exists x \phi \rightarrow \exists x \phi$

However, if we disregard these sorts of variable clashes, the two versions of the semantics are equivalent. I will show this for the notion of coherence, which is the only general notion we have introduced so far. I will say that ϕ is *novel in* σ, if updating σ with ϕ does not involve any violation of the novelty condition; and ϕ is *novel*, if there is a σ such that ϕ is *novel* in σ. The sentence in (169) and (170) is an example of a non-novel sentence. I will also say that ϕ is *safe* in σ, if it is novel in σ and all its occurrences of free variables are defined in σ. The following proposition states that the old and the new formulation of the CC-semantics define the same notion of coherence, if we disregard cases of reuse of variables.

3.6.11. PROPOSITION. Let ϕ be novel. Then

$$\approx\!\!\!\!|_{old}\ \phi \quad \text{iff} \quad \approx\!\!\!\!|_{new}\ \phi$$

One direction of the proof hinges on the fact that given a new state s, a new assignment g and a novel sentence ϕ, we can construct an old state σ and perspective $\wp$, such that if $s \approx\!\!\!\!|_g\ \phi$ (new), then $\sigma \approx\!\!\!\!|_\wp\ \phi$ (old). For the other direction, we show that also given an old state σ connected under a perspective $\wp$, we can find a new state s and a new assignment g such that for all ϕ, if $\sigma \approx\!\!\!\!|_\wp\ \phi$ (old), then $s \approx\!\!\!\!|_g\ \phi$ (new). For the proof of proposition 3.6.11, see appendix A.3.

Truth and Entailment

I define now the notion of truth in a state s with respect to an assignment g.

3.6.12. Definition. [CC-Truth] $s \models_g \phi$ iff $\forall w \in s$: $\exists h$: $w \in s[\phi]^g_h$

The following proposition states the relation between truth and support.

3.6.13. Proposition. Let ϕ be a sentence, s a state and g an assignment.

$$s \models\!\approx_g \phi \;\;\Rightarrow\;\; s \models_g \phi$$

The converse does not hold. As an illustration, consider again the wrong suspect example:

(171) $\exists x_n \Diamond P x_n \wedge \neg P x_n$

This sentence is true in a state $s = \{w_1, w_2\}$ that encodes the information that either individual a (in w_2) or individual b (in w_1) is P, but, as we saw, it is not supported in it (see section 3.5).

(172) $s \models_g \exists x_n \Diamond P x_n \wedge \neg P x_n$ & $s \not\models\!\approx_g \exists x_n \Diamond P x_n \wedge \neg P x_n$

From this example, it is clear that the notion of truth is not a suitable notion for the characterization of licensing. However, truth is the right notion for the definition of entailment.

3.6.14. Definition. [CC-Entailment]

$$\phi_1, ..., \phi_n \models_{CC} \psi \;\text{ iff }\; \forall M, s, g, h : s[\phi_1 \wedge ... \wedge \phi_n]^g_h \models_h \psi$$

Under this definition the following proposition is easily proved:[40]

3.6.15. Proposition. [Deduction Theorem]

$$\phi, ..., \phi_n \models_{CC} \psi \;\text{ iff }\; \phi_1, ..., \phi_{n-1} \models_{CC} \phi_n \rightarrow \psi$$

Note that if we had defined entailment in terms of support rather than truth, we would have lost the deduction theorem. In the next subsection we say something more about the relation between entailment, truth and support.

Here are some typical examples of valid dynamic entailments:

(173) $\exists x_n P(x_n) \models_{CC} P(x_n)$

(174) $\exists x_n P(x_n) \rightarrow Q(x_n), P(z_n) \models_{CC} Q(z_n)$

[40] The proof is an easy exercise and follows directly from the definitions of entailment and implication.

The following schemes, which rule the interaction between quantifiers and modal operators, are also valid:

(175) $\models_{CC} \Diamond\exists x_n P(x_n) \rightarrow \exists x_n \Diamond P(x_n)$

(176) $\models_{CC} \exists x_n \Diamond P(x_n) \rightarrow \Diamond\exists x_n P(x_n)$

(177) $\models_{CC} \Diamond\forall x_n P(x_n) \rightarrow \forall x_n \Diamond P(x_n)$

Whereas the following is an example of a non-valid formula:

(178) $\not\models_{CC} \forall x_n \Diamond P(x_n) \rightarrow \Diamond\forall x_n P(x_n)$

The failure in (178) shows that the present semantics avoids the cardinality problems discussed above.

I conclude the section by briefly discussing the issue of the context (in)dependence of dynamic logic sentences.

Context (In)dependence

Quantification under conceptual covers formalizes the intuitive idea that quantifiers in natural language range *over* individuals *under* a perspective. Which perspective you adopt plays a role only in specific cases. In what follows, I briefly describe under which circumstances perspectives do and do not play a role.

First of all, consider the following two examples of non-valid entailments:

(179) $\exists x_n \Box\, P(x_n) \not\models_{CC} \exists x_m \Box\, P(x_m)$

(180) $\forall x_n \Diamond\, P(x_n) \not\models_{CC} \forall x_m \Diamond\, P(x_m)$

Quantification into holistic operators is sensitive to shifts of conceptualization, and this feature allows us to account, for instance, for the butler situations.

Let's see now what happens in the absence of holistic operators:

(181) $\exists x_n P(x_n) \models_{CC} \exists x_m P(x_m)$

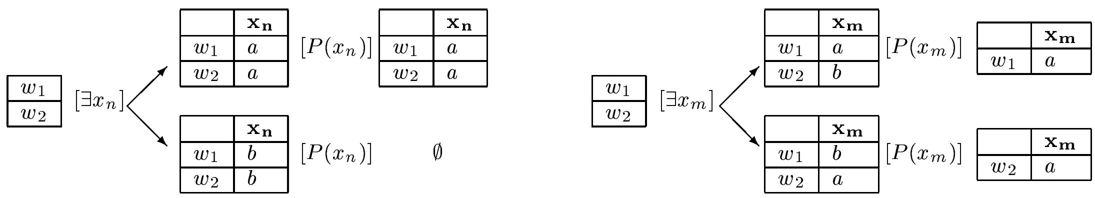
(182) $\forall x_n P(x_n) \models_{CC} \forall x_m P(x_m)$

If there are no holistic operators around, quantification is perspective independent with respect to truth and entailment, as we expected. On the other hand, note that in connection with the holistic notion of support, existential sentences, even if no holistic operator occurs in them, are sensitive to conceptual covers. Indeed, we can have a situation with one and the same state supporting one of the sentences in (183) and not supporting the other.

(183) a. $\exists x_n P(x_n)$

b. $\exists x_m P(x_m)$

The updates with the two sentences can have different effects in contexts where n and m are assigned different values. Let $s = \{w_1, w_2\}$ be such that individual a is the only P in w_1 and in w_2. Let g assign the rigid cover to n and another cover to m. The picture illustrates the two different results obtained by updating s with the two sentences with input assignment g.



Example (183a) is supported by s with respect to g and (183b) is not.

(184) $s \mid\!\approx_g \exists x_n P(x_n)$ & $s \mid\!\not\approx_g \exists x_m P(x_m)$

As an intuitive illustration, let $A = \{$Alfred, Bill$\}$ be the cover assigned to n, and $B = \{$the butler, the gardener$\}$ be the cover assigned to m. Furthermore, let P be the property 'having come to your office today'. Then s above can be taken to represent the belief state of a subject K finding himself in a by now well-known butler situation. There are two men, Alfred and Bill. One is the butler, the other is the gardener. K does not know who is who. K further believes that Alfred came to your office today. Consider now the following sentence which is true in s:

(185) Someone came to your office today.

The result in (184) then shows that the CC analysis predicts that K is licensed to utter (185) under cover A, but not under cover B. This prediction is intuitively correct. Indeed, if the addressee asks: 'Who?', then K can answer 'Alfred' under A, but he would have to admit 'I don't know' under B.

Thus conceptual covers matter for constructions containing quantification into some holistic operator (cf. examples (179) and (180)) or introducing some new discourse item (cf. example (184)), but note that this is the case only in situations of partial information. In a situation of total information, conceptualizations lose their bite. A state of maximal information is formalized by a set containing a single world $\{w\}$, but, with respect to a single world, all different conceptualizations collapse into one (see chapter 4, corollary 4.1.4). It follows that shifts of index do not matter in such a situation:

3.6.16. FACT. Let s be such that $|s| = 1$, and h be an assignment.

$$s \models\!\!\approx_h Q\, \vec{x}_{\vec{n}}\, \phi \quad \text{iff} \quad s \models\!\!\approx_h Q\, \vec{x}_{\vec{m}}\, \phi\, [\vec{x}_{\vec{n}}/\vec{x}_{\vec{m}}]$$

The presence of contrasting perspectives is a sign of ignorance. The one who knows everything knows how to map the possible conceptualizations onto each other, and, therefore, since he has a unique perspective over the domain, he can quantify over the individuals disregarding how these individuals are identified.

To conclude, quantification under conceptual covers is quantification over individuals under a certain perspective. Which perspective you choose only plays a role in certain circumstances, namely, in situation of partial information, for expressions introducing some discourse item and for sentences involving quantification into the scope of a holistic operator. These are typically the constructions in our formal language that are used to represent linguistic phenomena involving some notion of aboutness, such as *de re* attitude attributions, knowing-who constructions and specific uses of indefinite NPs. When we talk *about* individuals in situations of *partial* information, we do it under a conceptualization.

3.7 Conclusion

The combination of dynamic quantification with holistic notions is a dim affair, because it adds to the obscurity of quantification into modal contexts[41] problems typical of dynamic environments. In this chapter, I have tried to show that by bringing conceptual covers into the picture, we don't add obscurity to obscurity, but we shed some light on these difficult issues.

[41] See the concluding remarks in Quine (1956).