

Information Structure and Discourse Semantics*

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Information structure has been assumed to be an autonomous part of grammar for more than 100 years. It is represented as a partition of the sentence into two units, e.g., *focus - background*, *topic - comment*, *focus - topic*, *focus - presupposition* etc.¹ Even though information structure is sometimes understood as textual or discourse structure, its organizational level is still defined with respect to the sentence or the proposition that is expressed by the sentence. Information structure is often described as effecting felicity conditions, rather than truth conditions. However, focus-sensitive particles interact with information structure exhibiting truth-conditional or presuppositional effects. This interaction is called association with focus and stands in the center of interest of semantic theories of information structure. These theories also assume that focus indicates a partition of the sentence into two informational units. The focus particle is translated into an operator that takes these informational units as its arguments. Like for other functional words, the semantics of the operator is defined as its contribution to the propositional content of the whole sentence. Again, informational effects are restricted to the propositional level, while effects on the discourse level are not taken into considerations.

In the beginning of the 80s, a new family of semantic theories was established. They were designed to describe discourse semantics, i.e. effects that extend the sentence boundaries. The central concern of discourse semantics are cross-sentential anaphora. The main insight of the new theories is that anaphoric relations do not relate linguistic expressions to their denotations, but they relate so-called discourse referents to each other. Discourse referents "live" on an intermediate representational level that mediates between the linguistic expression and its denotation.² Thus discourse representation theories (cf. Kamp 1981, Heim 1982) give a model of how we organize our discourse. The representation of the discourse is incrementally built up: Each sentence contributes its representation to the representation of the previous discourse. Different conditions govern this process, e.g., discourse referents must be linked, subdomains are created that correspond to the scope of operators, additional representations are inserted by accommodation if the previous discourse does not license certain conditions etc. The development of discourse representation theories led to new ways of explaining other discourse

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¹ The theoretical, methodological and empirical problems of this sentence dichotomy are discussed in von Heusinger (1999, ch. 3) and von Heusinger (to appear).

² An alternative conception was developed in the newer Prague School (Sgall 1967, Sgall et al 1973, Sgall et al 1983). There is no additional level of representation, but the referents are evaluated with respect to stock of shared knowledge (SSK); the SSK impose an order on the potential referents in a text according to parameters like salience, recency etc.

phenomena, as well. For example, the notoriously difficult concept of presupposition got a new structural description at this level.

I will apply these new tools of discourse semantics for describing information structure, which I take to be a cover term for a wide variety of different discourse relations corresponding to the complex structure of the discourse representation. Combining the insights of discourse representation theory with the detailed analysis of truth-conditional effects of information structure, I will give a new account of these phenomena in terms of discourse semantics. This account is then applied to other domains of information structure as well, without relying on any of the three traditional characteristics for information structure, namely the assumption of an autonomous level for information structure, the assumption of the dichotomy of the sentence, and the underlying subject-predicate structure of the informational structuring.³

The argument will be structured as follows: First I discuss a problem that arises if one analyses focused expressions that are part of full NPs, such as definite NPs, rather than proper names. It will be shown that these cases cannot be solved by traditional semantic theories of focus. In a first step to solve this problem, I introduce the basic concepts of Discourse Representation Theory (DRT) by the example of anaphoric relations and quantification. I extend the analysis to texts and text relations by introducing segmented Discourse Representation Theory (SDRT) of Asher (1997). In a second step I propose a new view of information structure in the framework of Foreground-Background Semantics. The basic assumptions of this new approach can be integrated into the framework of SDRT and finally, it will be shown how the problems for traditional theories of focus semantics can be solved in the new framework.

1. Information structure and focus

Focus as one aspect of information structure is associated with different functions as illustrated by examples (1)-(4). In (1) the focus on *Fred* relates the sentence to the already established discourse as indicated by the paraphrase (1a), which describes the felicity conditions for uttering the sentence (1). This is the prototypical case for theories of information structure that do not assume truthconditional effects of focus.

- (1) Sam talked to FRED_F.
 (1a) It is part of the background or of the shared knowledge that Sam talked to someone. There are alternatives to Fred under discussion.

Discourse structure and information structure are conceived as additional levels that organize the processing or the make-up of the psychological models of discourse. The problem, of course, is to find clear linguistic contrasts in order to develop a linguistic descriptive system.

Such clear linguistic contrasts are generated by the interaction of focus particles and focus, or association with focus, as illustrated in (2) and the paraphrase (2b), where the particle is understood to be translated into a quantifier that operates on alternatives to the focus. In contrast

³ See von Stechow (to appear) for a detailed discussion and rejection of these three traditional assumptions.

to (2), sentence (3) expresses a clearly different content due to the placement of the falling pitch accent on *talked*.

- (2) Sam only talked to FRED_F.
- (2a) Nobody but Fred is such that Sam talked to him or her.
- (2b) for every element x that is a reasonable alternative to Fred, if x fits the background "Sam talked to x" then x is identical with Fred.
- (3) Sam only TALKED_F to Fred.
- (3a) Fred did nothing to Sam but talk.

Association with focus gave rise to a series of semantic frameworks, such as structured propositions (Jacobs 1983, Krifka 1992) or Alternative Semantics (Rooth 1985). However, the problems of those theories are that they identify the focus-background structure with the arguments of the operator involved and that the operator quantifies over alternatives to the focus. This claim can be refuted by examples like (4), where the focused phrase is part of a full NPs, rather than a simple proper name. The theory of structured propositions analyses (4) by quantifying over nationalities, rather than over professors. However, intuitively we quantify over professors, disregarding the focused modifier *Dutch* for the establishing the domain of quantification, as paraphrased in (4b):

- (4) Sam only talked to [the DUTCH_F professor]_{NP}.
- (4a) Sam talked to nobody but the Dutch professor.
- (4b) Sam talked to no professor but the Dutch professor.

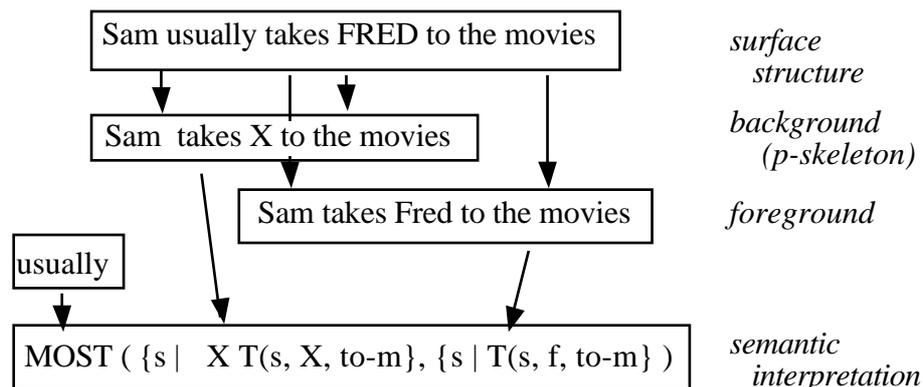
In an attempt to account for this problem, Krifka (1996) introduces the *Focus Phrase*, which associates with the particle, while containing the focus. Thus the focus does not interact directly with the operator. However, even this extension of focus semantics does not solve the problem (see von Heusinger 1998 for an extended discussion).

Alternative Semantics (Rooth 1985) had already abandoned the claim that a syntactic dichotomy of the sentence into focus and background corresponds to the arguments of focus operators. It rather assumes that the focus evokes alternatives that are compositionally built up at a different denotational level. However, it has similar problems in analyzing examples like (4) since it generates alternatives to *the Dutch_F professor* of the form *the X professor* with *X* standing for different nationalities. However, the uniqueness condition of the definite article would restrict this set of alternatives in a very unnatural way (see von Heusinger 1998). To sum up, both main semantic approaches to association with focus have major problems in describing full NPs with focused constituents. I argue in von Heusinger (to appear) that this arises from the assumption of the dichotomy of the sentence meaning in two distinct units: the focus and background. We need an information structure that is based on discourse structure, rather than on sentence structure and sentence meaning.

What is called for is a discourse semantics that (i) describes the embedding of sentences into the discourse and (ii) provides the adequate semantic objects that can be used as arguments of focus operators. In contrast to the dichotomy of the sentence in focus and background I propose two

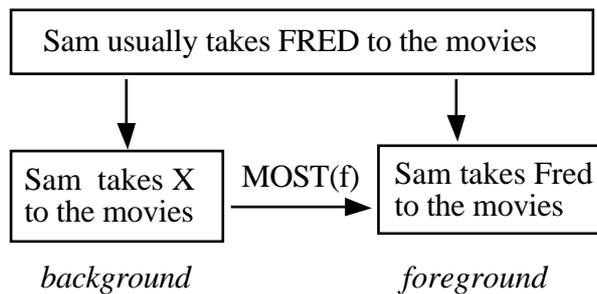
representational units, the *foreground* and the *background*. The latter is what Jackendoff (1972) and others call the p-skeleton. The foreground representation contains all material supplied by the sentence. The background contains the discourse information expressed by the sentence. It is constructed from the sentence minus the focused expressions, which are substituted by designated variables. The interpretation of the foreground yields the ordinary meaning, while the existential closure over the designated variables of the background yields the alternatives to the ordinary meaning. The interaction of foreground and background representations is informally illustrated by the interaction of an adverb of quantification with a focused constituent, as in (5). The operator ranges over sets that are constructed from the foreground and the background representation as in (5b).

- (5) Sam usually takes FRED_F to the movies.
 (5a) For most times in which Sam takes someone to the movies, he invites Fred to the movies.
 (5b) Most {t | Sam takes someone to the movies at t}
 {t | Sam takes Fred to the movies at t}
- (6) Schematic mapping relations for adverbs of quantification



In the following I define focus operators as ranging over the representations themselves, rather than as ranging over denotations of these two representations. Focus operators express relations between the different representations of a sentence, i.e. between the discourse information present in the sentence and the full information of that sentence. Since the background contains the same material as the foreground, save the focused expressions which are replaced by designated variables, one can describe the relation between background and foreground in terms of underspecification: The background is underspecified with respect to the foreground. The adverb *usually* can be defined as ranging over functions that map the underspecified background onto the specified foreground, as in (7):

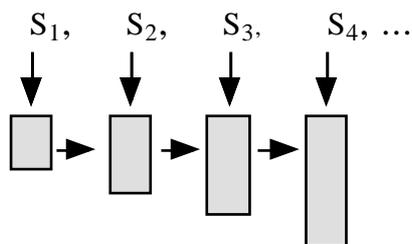
(7) Foreground-background representation for focus



2. Discourse Representation Theory

The initial problem that motivated discourse representation theories is the interpretation of nominal and temporal anaphora in discourse. The phenomenon of cross-sentential anaphora forces a semantics to extend its limits from the sentence to the discourse. The key idea in the way of thinking about the semantics of discourse in context exemplified in (Heim 1982) and (Kamp 1981) is that each new sentence or phrase is interpreted as an addition to or 'update' of the context in which it is used. This update often involves connections between elements from the sentence or phrase with elements from the context. Informally described, a sequence of sentences S_1, S_2, S_3, S_4 is interpreted by incrementally constructing a discourse representation as in (8). Anaphoric relations and definite expressions are captured by links between objects in this representation. In order to derive the truth condition of the sentence, the representation is embedded into a model.

(8) Construction of a discourse representation structure (DRS) in classical DRT



The particular lay-out of File-Change Semantics of Heim (1982) and Discourse Representation Theory of Kamp (1981), DRT in short, was influenced by philosophical work on context change (Stalnaker 1978), by linguistic research on anaphoric relations (Karttunen 1976) and models of artificial intelligence to discourse (Webber 1979). Kamp ([1981] 1984, 1) formulates the two roots of DRT as follows:

Two conceptions of meaning have dominated formal semantics of natural language. The first of these sees meaning principally as that which determines conditions of truth. This notion, whose advocates are found mostly among philosophers and logicians, has inspired the disciplines of truth-theoretic and model-theoretic semantics. According to the second conception meaning is, first and foremost, that which a language user grasps when he understands the words he hears or reads. This second conception is implicit in many studies by computer scientists (especially those involved

with artificial intelligence), psychologists and linguists - studies which have been concerned to articulate the structure of the representations which speakers construct in response to verbal inputs.

Corresponding to these different sources for the discourse representation, there is a debate on what kind of object the DRSs constitutes. Asher (1993, 64) enumerates three interpretations of the intermediate level of representation: (i) the DRS is a level of "logical form"; (ii) the DRS is a "partial model" of what is said in the discourse; or (iii) the DRS is a "mental representation" of the content of a discourse formed by a recipient of it. I assume a position along the linguistic view (i) of DRS, i.e., I assume that DRSs, their objects, and their relations are linguistic entities that can be described by linguistic methodology.

The representation at this level is constructed from the surface structure of sentences and it serves as a structure that can be embedded in a model in order to analyze the truth conditions. I concentrate on two basic structural properties of DRT: the realization of anaphoric relations and the quantification theory of nominal and adverbial quantifiers.

3. Anaphoric relations

Geach (1962) was among the first to note that cross-sentential anaphora cannot be described by means of classical binding since the scope of the existential quantifier cannot extend across a sentence boundary. In the classical representation (9a) of sentence (9), the last occurrence of the variable x is not bound, i.e. the anaphoric relation is not expressed. Geach proposes a different kind of existential quantifier, a text quantifier that takes the whole text into its scope, as illustrated in (9b). However, he did not account for its compositional properties or for the construction of such a formula.

- (9) A man walks. He whistles
 (9a) x [man(x) & walk(x)] & whistle(x)
 (9b) x [man(x) & walk(x) & whistle(x)]

A related problem was noted by Karttunen (1976), who observed that referents introduced by indefinites may have different "life spans", which is indicated by their potential to act as antecedents. The pronoun *it* in (10) can be anaphorically linked with the indefinite NP *a donkey*, while in (11) this is not possible. The life span of the referent introduced by *a donkey* cannot exceed the domain that is defined by the negation. Since a referent in the external world exists independently of any linguistic construction, Karttunen concludes that the notion of "life span" holds not of referents in the external world but of semantic objects that he named "discourse referents". Discourse referents are entities that are defined by expressing anaphoric relations and the interactions with domain creating operators like negation, modals or verbs of attitudes.

- (10) Pedro owns a donkey. He beats it.
 (11) John does not own a donkey. *He beats it.

A third puzzle concerns the quantificational force of indefinites, which depends on the construction in which they occur. The indefinite *a man* in (9) has existential force, while the indefinite *a donkey* in (12) or (13) expresses a universal force. Both sentences are interpreted by the formula (13a) expressing the universal force of the indefinite NP.

- (12) Every farmer who owns a donkey beats it.
 (13) If a farmer owns a donkey, he beats it.
 (13a) $x \ y \ [(\text{farmer}(x) \ \& \ \text{donkey}(y) \ \& \ \text{own}(x, y)) \ \rightarrow \ \text{beat}(x, y)]$
 (13b) $\text{Always}(\text{farmer}(x) \ \& \ \text{donkey}(y) \ \& \ \text{own}(x, y)) \ (\text{beat}(x, y))$

Kamp (1981) and Heim (1982) represent indefinite and definite noun phrases as variables (in the relevant argument position) and as open sentences (expressing the descriptive content), rather than as quantifier phrases. The indefinite noun phrase does not express any quantificational force by itself, but it receives the quantificational force from an operator in the construction. Sentence (9) is governed by an (invisible) existential text operator as proposed by Geach (1962), while the variable introduced by the indefinite *a donkey* in (12) is bound by the universal quantifier *every*. In (13), the conditional is analyzed as an (invisible) universal quantifier *Always*, which unselectively binds all occurrences of free variables. Other occurrence of such unselective binder are the adverbs of quantification, like *sometimes*, *usually* etc. (cf. Lewis 1975). Hence, the view that indefinites introduce variables that can be bound by other operators unifies the semantics of indefinites with the analysis of adverbs of quantification.

The best way to get acquainted with DRSs is to look at an example (cf. Asher 1993, 66f). The DRS for the first sentence in (9), repeated as (14) is (14a). The DRS in (14a) graphically describes an abstract, information structure, a discourse representation structure (in short DRS), with two parts. One part is called the *universe* of the DRS, the other its *condition set*. A DRS is an ordered pair consisting of its universe and condition set, written as $\langle U_K, \text{Con}_K \rangle$. The DRS in (14a) has as its universe one *discourse referent* x and as its condition a set of properties that are ascribed to the discourse referents in the universe. In (14a) the property of being a man and of walking is ascribed to the discourse referent x . Instead of the DRS in (14a), often the form (14b) is chosen, which consists of the set of discourse referents and the set of conditions separated by a "|":

- (14) A man walks.
 (14a)

x
$\text{man}(x)$ $\text{walk}(x)$

 (14b) $\{x \mid \text{walk}(x) \ \& \ \text{man}(x)\}$

To give the truth conditions for (14), we need to define a *proper embedding* for the DRS. Informally, a proper embedding for a DRS in an (extensional) model $M = \langle D, \|\ \|\rangle$, consisting of a domain D and an interpretation function $\|\ \|\$, is a function f that maps the discourse referents onto elements of the domain of M such that the elements are in the extension of the

predicates that are ascribed to the discourse referents. For example, the DRS (14a) is true just in case that $f(x)$ is a man and $f(x)$ walks.

The sequence or conjunction of two sentences as in (9), repeated as (15), receives a DRS in steps. We start with the already established DRS for the first conjunct in (15a), then a new discourse referent for the pronoun *he* and a condition for the predicate *whistle* is added in (15b). The anaphoric link of the pronoun is graphically represented as $y=?$, indicating that the pronoun is still unresolved. The discourse referent that stands for an anaphoric expression must be identified with another *accessible* discourse referent in the universe, here the y is identified with the x , as in (15c). The whole sentence can also be represented as (15d) corresponding to (15c):

(15) A man walks. He whistles

(15a)

x
$\text{man}(x)$
$\text{walk}(x)$

(15b)

x, y
$\text{man}(x)$
$\text{walk}(x)$
$y=?$
$\text{whistle}(y)$

(15c)

x, y
$\text{man}(x)$
$\text{walk}(x)$
$y=x$
$\text{whistle}(y)$

(15d) $\{x,y \mid \text{walk}(x) \ \& \ \text{man}(x) \ \& \ y=x \ \& \ \text{whistle}(y)\}$

This mini-discourse is true if there is an embedding function f onto a model such that $f(x)$ is a man and walks and $f(y) = f(x)$ and $f(y)$ whistles. The truth conditions of this are the same as for Geach' logical form (9b) above.

Kamp & Reyle (1993, 70) give the construction rule for pronouns:

(16) Construction rule for pronouns in a DRS (Kamp & Reyle 1993)

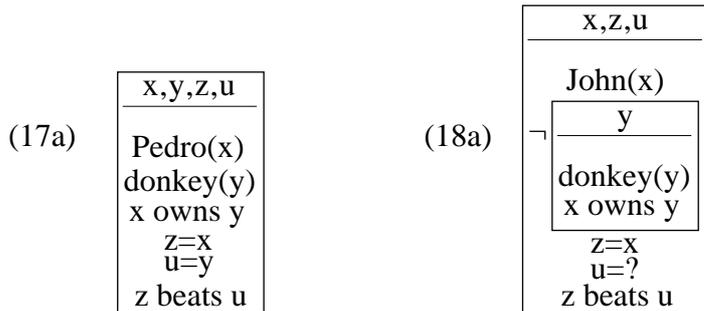
1. Introduce a new discourse referent into the universe of the DRS
2. Introduce a condition obtained by substituting this referent for the NP-node of the local configuration that triggers the rule application in the syntactic structure containing this configuration and delete that syntactic structure.
3. Add a condition of the form $a = b$ where a is a new discourse referent and b is a suitable discourse referent chosen from the universe of the DRS.⁴

The new discourse referent introduced by the pronoun must be linked or identified with an already established and accessible discourse referent. DRT defines accessibility in terms of structural relations, i.e., the discourse referent must be in the same (or a higher) universe. With

⁴ The question what "suitable" means is not accounted for in DRT. However, the Pragmatic approaches take this as a starting point: the most salient element in the stock of shared knowledge (SSK, e.g. Sgall et al 1983) is a suitable candidate. See also my attempts to reconstruct saliency with choice functions (von Heusinger 2000).

this concept of accessibility, the contrast between (10) and (11), repeated as (17) and (18) can be described by the difference in the set of accessible discourse referents for the pronoun *it*. The construction rule for the negation in (18) creates an embedded discourse universe with the discourse referent *y* and the conditions *donkey(y)* and *x owns y*. The anaphoric pronoun *it* in the second sentence cannot find a suitable discourse referent since it has no access to the embedded discourse universe with the only fitting discourse referent *y*.

- (17) Pedro owns a donkey. He beats it.
- (18) John does not own a donkey. *He beats it.

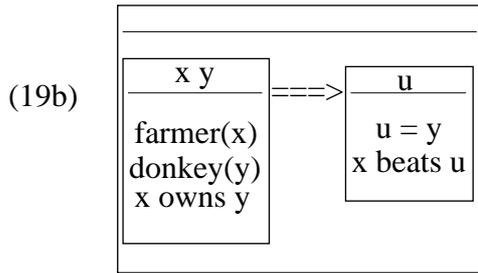


In DRT like in File-Change Semantics or other types of dynamic semantics, definiteness is captured as one instance of anaphora. Thus the linguistic relation of anaphora as well as the linguistic category of definiteness is reconstructed as the construction rule to link one entity at the discourse representation with another accessible. Accessibility is reconstructed as the structural embedding relations between discourse universes. Certain semantic operators, like negation, introduce their own universe, as illustrated in (18a). Other operators introduce even more complex structures.

4. Quantification

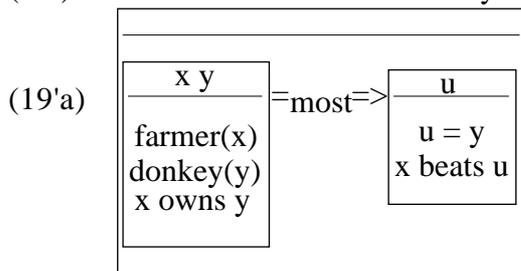
Quantifiers like *every*, *most*, *at least*, *no* etc. induce a more complex discourse representation structure. They are represented by two embedded DRSs and a quantificational relation between them. This structure is sometimes called a *box-splitting*-structure. For example, sentence (19) with the universal quantifier *every* and the logical form (19a) is represented as the DRS in (19b). The restriction *farmer who owns a donkey* is represented by the left DRS and the nuclear scope *beats it* by the right DRS. Note that the pronoun *it* can be linked to the discourse referent *y*, even though *y* is not in the same or a higher discourse universe. An additional rule of DRT licenses anaphoric links between the two DRSs of a quantifier structure.

- (19) Every farmer who owns a donkey beats it.
- (19a) x [(farmer(x) y [donkey(y) & own(x,y)]) -> beat(x,y)]



Based on observations of Lewis (1975), Heim (1982) develops a new semantics for *adverbs of quantification* like *always*, *usually*, *sometimes* etc. This semantics was translated into DRT: indefinites introduce discourse referents and the adverb of quantification induces a box-splitting-structure in the same way as a nominal quantifier. For example, the adverb *usually* in (19') causes the box-splitting in (19'a) with the descriptive material of the subject and its relative clause in the left universe and the matrix verb in right universe. The adverb is translated into an operator that quantifies over all free variables. It is said to quantify *unselectively* as in (19'b), which is the translation of (19'a) into a linear form.

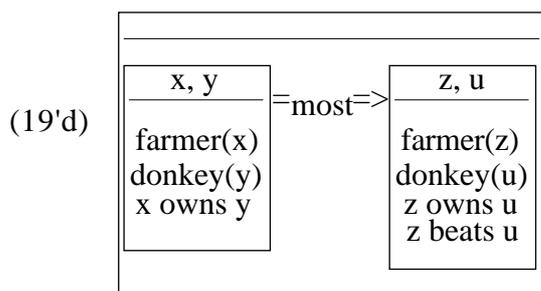
(19') A farmer who owns a donkey usually beats it.



(19'b) $\text{MOST}(\{x,y \mid \text{farmer}(x) \ \& \ \text{donkey}(y) \ \& \ \text{owns}(x,y)\}, \{u \mid u=y \ \& \ \text{beats}(x,u)\})$

However, the formula in (19'b) raises some question with respect to the binding of variables in the second argument $\{u \mid u=y \ \& \ \text{beats}(x,u)\}$. The DRT construction rules are built in a way that discourse referents can be associated with established discourse referents in the antecedent box of a split-box configuration. However, in the linear representation this additional rule cannot be instantiated. According to the DRT-construction rules, (19'a) corresponds to (19'c), where pairs of farmer-donkeys are compared. Thus, we cannot distinguish between a representation (19'a) and (19'd). According to the particular rules of DRT, both are equivalent (see Rooth 1995, 272 for a more detailed argument):

(19'c) $\text{MOST}(\{x,y \mid \text{farmer}(x) \ \& \ \text{donkey}(y) \ \& \ \text{owns}(x,y)\}, \{x,y \mid \text{farmer}(x) \ \& \ \text{donkey}(y) \ \& \ \text{owns}(x,y) \ \& \ \text{beats}(x,u)\})$



The structure (19'd) is very close to the proposed background-foreground structure in (7) above. The point of this brief introduction into DRT is that very central semantic notions, like anaphora, definiteness, and quantification, affect the representational level of the semantics, and operate over elements or structure of the DRSs. In the next section, I show that information structure and the concept of givenness can be reconstructed in a similar way to anaphora and definiteness. Furthermore, focus-sensitive particles operate on the same representational level as quantifiers and adverbs of quantification.

5. Discourse structure and background

Information structure in terms of given vs. new is often defined as the "packaging" of the propositional content of a sentence, which reflects the beliefs of the speaker about the beliefs of the hearer, but does not effect the truth conditions of the sentence. This view is still held by several approaches to information structure (for an overview see von Heusinger (to appear)), even though it was as early as 1972 when Dretske stated that information structure makes a difference for truth conditions as well (compare also Sgall 1967). Sentences with the same surface structure but different information structure – what Dretske calls contrastive foci – exhibit truth conditional contrasts when they are embedded in a larger context:

What I wish to show is that contrastive differences (...) are significantly involved in determining the meaning (hence, semantics) of a variety of larger expressions in which they can be embedded. If $C(U)$ is a linguistic expression in which U is embedded, and U can be given different contrastive foci (say U_1 and U_2), then it often makes a difference to the meaning of $C(U)$ whether we embed U_1 or U_2 . Linguistically this is important because it means that any adequate semantical theory, one that is capable of exhibiting the source of semantical differences between complex expressions, between $C(U_1)$ and $C(U_2)$, will have to be provided with the resources for distinguishing between U_1 and U_2 . (Dretske 1972, 412)

This classical quotation expresses the claim that whatever the nature of informational structure is, if it affects the meaning, i.e., the semantics, then it must be analyzed in terms of semantic theory. Dretske (1972, 412) further argues that a semantic understanding of these contrasts is necessary for the way we speak about the knowledge or the consciousness of speaker and hearer:

Philosophically speaking this is important because when philosophers are talking about explanation, about evidence, about reason (for doing and believing), and about knowledge, they are concerned, at least in part, with trying to understand what it means to say that S knows that U , S has a reason to believe that U , E is evidence that U , and E is the explanation of the fact that U .

Until one understands how the contrastive differences in U can make a difference in what it *means* to say these things, one cannot hope to provide a correct analysis of these key ideas.

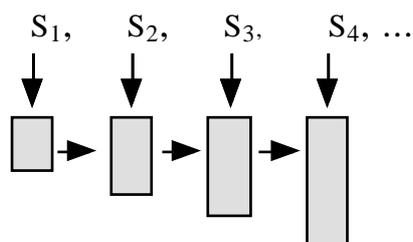
This program of investigating sentences and describing their informational properties with respect to the larger linguistic context has just started to be undertaken. In the remainder of this section I present Asher's theory of *segmented DRT* (= SDRT) as one of the rare examples of a semantic account of discourse. Even though Asher starts by defining discourse relations in terms of propositions, he eventually must make reference to the internal structure of sentences in order to capture basic discourse relations.

Asher (1993; 1997) develops a discourse structure in the DRT-approach that is not confined to the incremental composition of DRSs but also captures discourse relations between the sentences in the discourse:

SDRT is an extension of DRT that attempts to make clear in a precise and systematic way the interactions between semantic content and discourse structure. It provides a formal foundation for discourse structure in the tradition of Grosz and Sidner (1986) and Mann and Thompson's [= 1987, KvH] Rhetorical Structure Theory (RST), in which a text gives rise to a discourse structure that consists of propositions related by discourse relations. Further, SDRT shows how such a structure may be built up in an incremental and logically precise manner. Finally, SDRT offers a detailed integration of semantic and pragmatic phenomena relevant to the interpretation of discourse. (Asher 1999, 251)

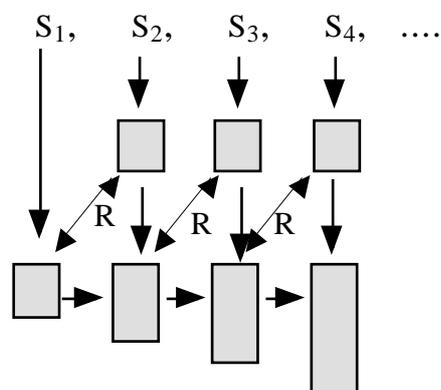
In order to develop such a theory, Asher revises the classical DRT of Kamp (1981) and Kamp & Reyle (1993). The classical version describes the dynamic meaning of a discourse by processing sentence for sentence. Since the meaning of each sentence is construed as a function from truth conditions to truth conditions, the truth conditional content of the whole discourse is reconstructed by the sequential application of these functions. Asher (1993, 256) notes that "the notion of semantic updating in the original DRT fragment of Kamp (1981) (...) is extremely simple, except for the procedures for resolving pronouns and temporal elements, which the original theory did not spell out. To build a DRS for the discourse as a whole and thus to determine its truth conditions, one simply adds the DRS constructed for each constituent sentence to what one already had. (...) This procedure is hopelessly inadequate, if one wants to build a theory of discourse structure and discourse segmentation." In classical DRT, a sequence of sentences $S_1, S_2, S_3, S_4, \dots$ is analyzed by the incremental construction of one discourse representation for the whole discourse, as illustrated in (20).

(20) Discourse construction in classical DRT



In SDRT, each sentence of a sequence S_1, S_2, S_3, S_4 , is first represented as a particular SDRS for that sentence, before the representation is merged with the already established representation, as in (21). The discourse representation of each single sentence is necessary in order to define the discourse relation R between the sentence and the discourse.⁵

(21) Discourse construction in *segmented* DRT



Asher (1993, ch. 7) defines several discourse relations, which are essentially borrowed from Rhetorical Structure Theory (RST), such as *causation*, *explanation*, *coherence*, *elaboration*, *continuation*, etc. These relations hold between the propositions expressed by the sentence under consideration and the set of propositions that are expressed by already established sentences in the discourse. There are two discourse relations that make reference to the internal structure of the sentences involved: *parallelism* and *contrast*, which are defined by Asher (1993, 285) as follows: "Parallelism involves a pairing of constituents in an SDRS and their parts such that each pair contains two semantically and structurally similar objects. Contrast also involves a pairing between constituents and their parts, in which at least some pairs contain structurally similar but semantically dissimilar objects." In order to describe these two discourse relations Asher (1993, 285) defines the notion of *theme*:

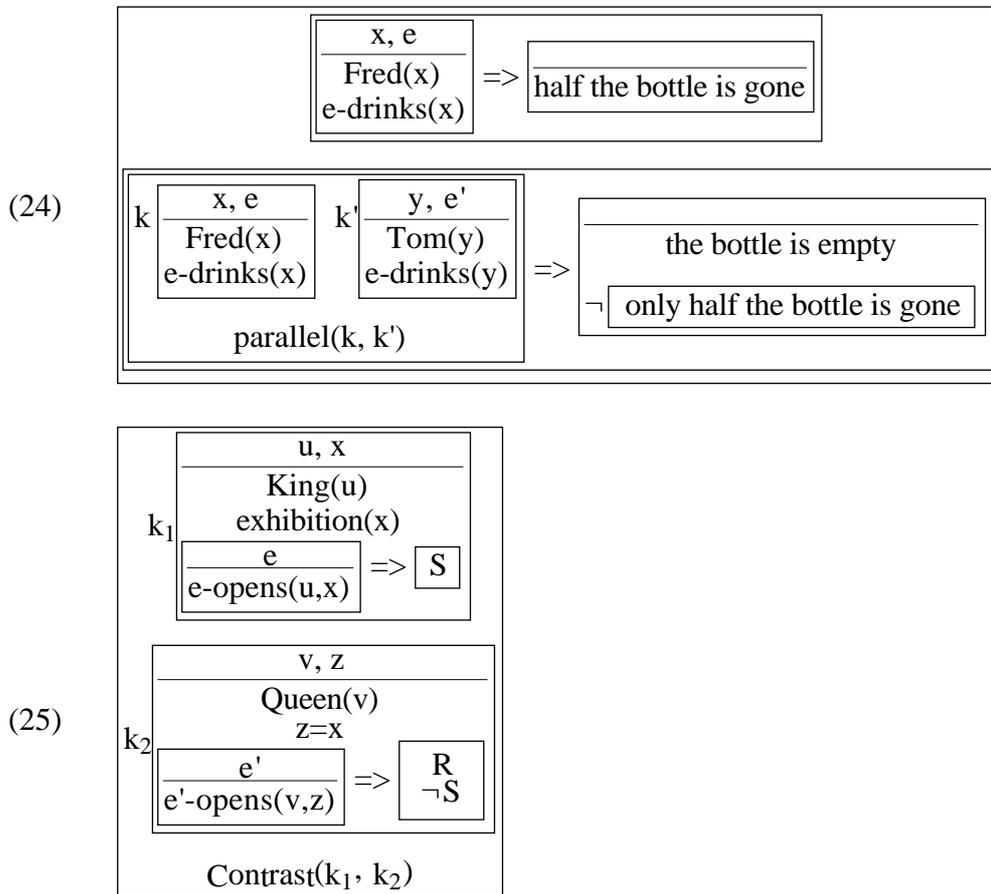
Echoing the distinction between topic and focus or given information and new, I shall isolate for each constituent a *theme*. Parallelism between two constituents is maximized when there is a common theme and it is as maximal as is compatible with informativeness. Contrast is maximally plausible when themes are complementary or even contraries.

The function of Asher's *theme* (roughly corresponding to the notion *background*) is illustrated by the following two examples, which Asher (1993, 284) ascribes to van der Sandt:

- (22) If Fred drinks, half the bottle is gone. If Tom drinks too, the bottle is empty.
 (23) If the King opens the exhibition, the newspaper will comment on his speech. But if the Queen opens it, they will comment on her robe.

⁵ The construction mechanism is more complex if the anaphoric relations are represented as well. In that case, the construction of the DRS for the particular sentence must be connected (or embedded) into the discourse DRS in order to license the linking of discourse referents. This aspect, however, will not be considered here.

In both examples the second sentence is dependent on the first. In (22), the second sentence says that if Tom *and* Fred drink, then the bottle is empty. In the second sentence in (23) it is said if the Queen opens the exhibition *and the King does not*, then the newspapers will comment on her robe. Asher (1993, 295f) assigns the SDRSs (24) and (25) to (22) and (23), respectively:



In both analyses, part of the representation of the first sentence is related to a part of the representation of the second sentence. In (24), the SDRS $\{x,e \mid Fred(x), e-drinks(x)\}$ from the first sentence is said to be parallel to the condition $\{y,e \mid Tom(y), e-drinks(y)\}$ of the second sentence. What is structurally the same in both SDRSs is the representation $x \{x,e \mid e-drinks(x)\}$ for *someone drinks*. Analogously, in (25) the SDRS k_1 stands in the relation of contrast to k_2 . Again, what is compared is something like $x \{x,z,e \mid exhibition(z) \ \& \ e-open(x,z)\}$ for *someone opens the exhibition*.

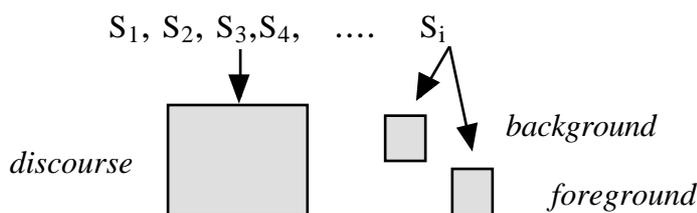
This short presentation of Asher's SDRT should have motivated the use of DRs in the description of discourse and discourse relations. Asher explicitly makes reference to representational structures in his model that serve as objects for the operations defined. He formally defines some of the discourse relations as embedding relations or isomorphy between *modified extended embedding trees* (MEE trees) of DRs. Even though we cannot go into the

details of his formalism,⁶ the examples should have motivated the idea that discourse relations are defined as operations on the representation of the background (Asher's *themes*).⁷

6. The Foreground-background semantics

My approach is based on the assumption that a sentence makes (at least) two kinds of contributions to the context: the ordinary or sentence meaning and the meaning that is already given by the discourse. These two contributions are not provided by a dichotomy of the sentence in focus-background, but by two construction mechanisms that translate the sentence into two representations at the level of discourse representation. I assume a DRT-like model sketched above with an extra set of construction rules for the background representations. The foreground is constructed from the material of the sentence in the common way a DRS is constructed. The background, however, is a DRS in which the focused expressions are not present; they are merely represented by designated variables. Background and foreground are both DRSs or representational objects at the intermediate level of discourse representation. Thus there are (at least) three objects when analyzing a sentence: the DRS for the previous discourse, the DRS for the background and the DRS for the foreground:

(26) DRSs for the discourse, foreground, and background



There are relations between each pair of DRSs: the relation between the discourse and the foreground concerns the rhetoric relationship mentioned above. The relation between the background and discourse is generally described in terms of givenness, and the relation between the background and the foreground serves as the domain over which discourse operators range. In the following sections, first the construction rules for the background-DRS

⁶ Asher (1999, 255) for example gives the following definition of his discourse relation "Parallel": **Definition:** For $\langle \sigma, \sigma' \rangle$ constituents of an SDRS \mathbb{K}_0 , $\text{Parallel}(\sigma, \sigma')$ is satisfied in \mathbb{K}_0 iff there are MEE trees σ and σ' for σ and σ' , respectively, and a tree isomorphism $\alpha: \sigma \rightarrow \sigma'$ such that for all nodes α of σ and there are themes P and P' of σ and σ' such that $\text{polarity}(\sigma, P) = \text{polarity}(\sigma', P')$.

⁷ In a different semantic approach to the "Information Structure in Discourse", Roberts (1996, 3) takes up the idea that the discourse is organized in moves: "There are two types of moves which players may make (...): What Carlson calls *set-up moves*, which are questions, and what he calls *payoff moves*, which are assertions. Note that moves, on the interpretation I will give them, are not speech acts, but the semantic objects which are used in speech acts: A speech act is the act of proffering [sic] a move. (...) I assume that there are two aspects to the interpretation of any given move: its *presupposed content* and its *proffered content*. I use the term *proffered* as a cover for what is asserted in an assertion and for the non-presupposed content of questions and commands." Even though discourse relations are reduced to the question-answer pairs, Roberts also assumes that a single sentence makes two distinct contributions to the discourse: material that is assumed to be accepted and material that is offered for acceptance. Roberts' *presupposed content* corresponds to Asher's *theme*, which is what here is called *background*, while her *proffered content* corresponds to the *foreground* use here.

are formulated, then the relation between the background and the discourse is described, and finally the sentence internal phenomenon of association with focus is captured by the relation between the background and foreground.

7. The construction of foreground and background

The foreground DRS is constructed according to the rules of DRT (Kamp & Reyle 1993). The background structure is constructed in the same way except for focused expressions, which are represented by a designated variable of the appropriate type. Due to the particular construction rules, the designated variable substitutes conditions, rather than discourse referents.⁸ This is even the case for proper names, which are introduced into the DRS by a discourse referent and a condition in which the name serves as predicate, as illustrated in (27). The foreground representation (27a) contains the two discourse referents x and y , and the conditions which link the discourse referents to Sam and to Fred, and the conditions that expresses the relation of talking between the two. The background representation (27b) contains the same structure except for the condition $Fred(y)$, which is replaced by $X(y)$.

<p>(27) Sam talked to FRED_F</p> <p>(27a)</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td style="text-align: center; padding: 2px;">x, y</td></tr> <tr><td style="padding: 2px;">Sam(x) Fred(y) x talks to y</td></tr> </table> <p style="text-align: center;"><i>foreground</i></p>	x, y	Sam(x) Fred(y) x talks to y	<p>(27b)</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td style="text-align: center; padding: 2px;">x, y</td></tr> <tr><td style="padding: 2px;">Sam(x) X(y) x talks to y</td></tr> </table> <p style="text-align: center;"><i>background</i></p>	x, y	Sam(x) X(y) x talks to y
x, y					
Sam(x) Fred(y) x talks to y					
x, y					
Sam(x) X(y) x talks to y					

The focused verb *talked* in (28) is represented in the background (28b) as the variable R over relations, while the focused VP in (29) is represented as the one-place predicate variable P . In the latter case the internal structure of the focused constituent is not preserved in the background representation.

<p>(28) Sam TALKED_F to Fred.</p> <p>(28a)</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td style="text-align: center; padding: 2px;">x, y</td></tr> <tr><td style="padding: 2px;">Sam(x) Fred(y) x talks to y</td></tr> </table> <p style="text-align: center;"><i>foreground</i></p>	x, y	Sam(x) Fred(y) x talks to y	<p>(28b)</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td style="text-align: center; padding: 2px;">x, y</td></tr> <tr><td style="padding: 2px;">Sam(x) Fred(y) x R y</td></tr> </table> <p style="text-align: center;"><i>background</i></p>	x, y	Sam(x) Fred(y) x R y
x, y					
Sam(x) Fred(y) x talks to y					
x, y					
Sam(x) Fred(y) x R y					

⁸ This is a structural difference between givenness and definiteness. However, one can also claim that definiteness is a subcategory of givenness. Allerton (1978), for example, distinguishes between givenness of linguistic items and givenness of the referent, which is linguistically reflected in pro-form and definiteness, respectively: Allerton (1978, 145) notes that "The difference between pro-form givenness and definite-givenness corresponds in large measures to Halliday and Hasan's (1976) distinction between 'substitution' and 'reference'."

- (29) Sam [talked to FRED]_F
- | | |
|-----------------------------------|-------------------|
| x, y | x |
| Sam(x)
Fred(y)
x talks to y | Sam(x)
x P |
| <i>foreground</i> | <i>background</i> |

The focused adjective *Dutch* in (30) is replaced by a predicate variable *X* in the background. Note that the definite article does not appear in the representation. Therefore, it can be concluded that focus semantics does not interact with the uniqueness condition of the definite article. One way to implement this is to assume with other discourse semantics (Heim 1982, Kamp 1981, Kamp & Reyle 1993) that the definiteness is a discourse pragmatic concept which is not expressed in the lexical meaning. It is operative while constructing the DRSs, for example, as an additional condition that there is only one Dutch professor. Such a condition could be understood as a locally accommodated representation (cf. Kamp & Reyle 1993, 297-299), which will be suppressed here:

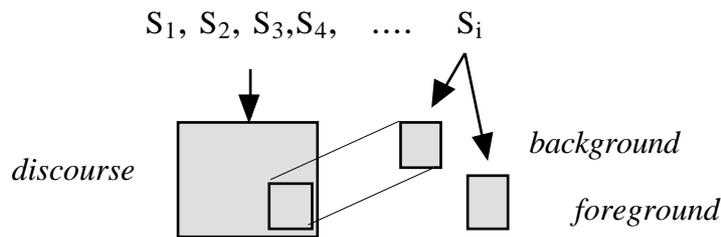
- (30) Sam talked to [the DUTCH_F professor]_{NP}.
- | | |
|--|--|
| x, y | x, y |
| Sam(x)
Dutch(y)
prof(y)
x talked to y | Sam(x)
X(y)
prof(y)
x talked to y |
| <i>foreground</i> | <i>background</i> |

8. Discourse structure, background, and givenness

The view of information structure enforced here allows for a new approach to the notion *givenness* introduced by Halliday (1967). He defines given as "anaphorically recoverable", while new is "textually and situationally non-derivable information", or "contrary to some predicted or stated alternative", or "replacing the WH-element in a presupposed question". With the discourse model developed so far, the description "anaphorically recoverable" can be captured: the background comprises the discourse-given material of the sentence. The representation of the background must be mapped onto a part of the already established discourse DRS, as illustrated in (31):⁹

⁹ For the direction of a formal account for this approach compare Asher (1993, 1999) and the definition of his discourse relation "Parallel" quoted above.

(31) Relation between discourse-DRS and background-DRS



This approach to givenness is representational and non-propositional: it is representational in that it follows one of the basic tenets of DRT, namely that anaphoric relations are relations between discourse objects rather than between denotations (or objects in the world). The same holds for givenness: it is a relation between discourse objects; it differs from anaphora in that it is defined as a relation between the conditions and not between discourse referents as in the case of anaphoric relations. The second point concerns the non-propositional definition of background. Givenness is substituted by the semantic concept of presupposition. However, Allerton (1978, 151) already notes the difference between these two concepts:

We may now perhaps appreciate how givenness differs from the notion of 'presupposed'. Givenness applies to sentence constituents including their component lexical items and to combinations of these; but it can also apply to whole sentences, when these are embedded. Presuppositions, on the other hand, apply to propositions. Propositions are always potential sentences, having the capacity for being true or false. (...).

In order to illustrate the difference between the representational approach to givenness and the presuppositional one, I briefly review Schwarzschild's (1997) attempt to accommodate Halliday's notion of givenness to a presuppositional treatment. Schwarzschild (1997) demonstrates the different steps one has to take to describe the representational view of *given* in terms of entailment. He starts with the following definition.

(32) An utterance is given iff it is entailed by prior discourse.

Schwarzschild (1997, 7) notes then: "The first problem that (13) [= (32)] runs into is that it is based on the notion of entailment, a notion that relates propositional utterances, but we want to apply the term 'given' to expressions of any type. (...) To remedy this let's assume a sort of type shifting operation that raises expressions of type t , by existentially binding unfilled arguments." If the phrase *green apple* has been mentioned, then he assumes that an utterance of *apple* is given, as in (33):

(33) $x(\text{green-apple}(x)) \text{ ENTAILS } x(\text{apple}(x))$

He calls the operation that allows us to generalize the notion of entailment "existential type shifting." He constructs the p-skeleton by substituting the F-marked constituents by designated variables, and then derives from that the existential closure over these designated variables. Schwarzschild (1997, 9) defines *given* in terms of entailment as follows:

- (34) An utterance U counts as **given** iff it has an antecedent A , and modulo λ -type-shifting, A entails the result of replacing F -marked parts of U with existentially bound variables.

The non-focused material in (35B) is given because the utterance (35A) entails in (36) the background structure of (35B).

- (35) A: John ate a green apple.
 B: No, John ate a RED apple.
- (36) John ate a green apple *ENTAILS* λY John ate a Y apple

This relation between the two utterances in (35) can be represented as in (37). (37a) is the DRS for the discourse so far, here only for the first utterance *John ate a green apple*, which is assumed to be established when the second utterance is interpreted. (37b) constitutes the background representation and (37c) the foreground representation of (35B).

(37a)	(37b)	(37c)						
<table style="width: 100%; border-collapse: collapse;"> <tr><td style="border-bottom: 1px solid black; padding: 2px;">x, y</td></tr> <tr><td style="padding: 2px;">John(x) green(y) apple(y) x ate y</td></tr> </table>	x, y	John(x) green(y) apple(y) x ate y	<table style="width: 100%; border-collapse: collapse;"> <tr><td style="border-bottom: 1px solid black; padding: 2px;">x, y</td></tr> <tr><td style="padding: 2px;">John(x) X(y) apple(y) x ate y</td></tr> </table>	x, y	John(x) X(y) apple(y) x ate y	<table style="width: 100%; border-collapse: collapse;"> <tr><td style="border-bottom: 1px solid black; padding: 2px;">x, y</td></tr> <tr><td style="padding: 2px;">John(x) red(y) apple(y) x ate y</td></tr> </table>	x, y	John(x) red(y) apple(y) x ate y
x, y								
John(x) green(y) apple(y) x ate y								
x, y								
John(x) X(y) apple(y) x ate y								
x, y								
John(x) red(y) apple(y) x ate y								

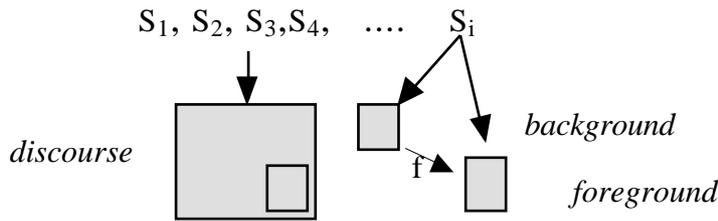
The background (37b) can be retrieved from the already established discourse (37a) without making reference to presuppositions. A purely structural relation between the two representations suffices (for an extensive argument see von Heusinger 1999, sect. 6.3.2).

However, if one prefers to link the sentence with the discourse by using presuppositions, the representational approach can be translated into the presuppositional one along the lines Schwarzschild proposes. In general, the existential closure of the background yields the presupposition.

9. Background-foreground interaction

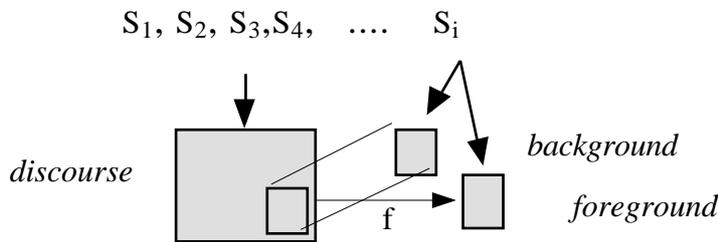
This section focuses on the relation between the background and the foreground, which can be understood in two ways: either as a relation between the background structure of the sentence under analysis, or as the whole content of that sentence, i.e. the foreground, as illustrated in (38).

(38) Relation between background DRS and foreground DRS



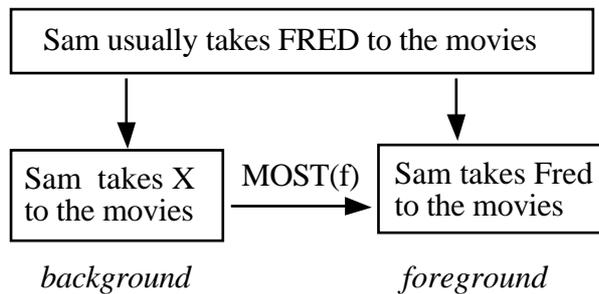
Since the background can also be understood as a structure that is provided by the already established DRS, the relation between background and foreground can also be understood as a relation between the discourse representation and the representation of the whole sentence, as illustrated in (39):

(39) Relation between discourse DRS and foreground DRS



In both cases a function f is assumed that relates the background to the foreground. Since the only difference between the background and the foreground representation is the use of designated variables in the background for focused expressions, the function f assigns conditions to the designated variables. I will assume that focus operators range over those functions rather than over denotational objects. According to this approach, the representation (7) from above, repeated as (40) is motivated:

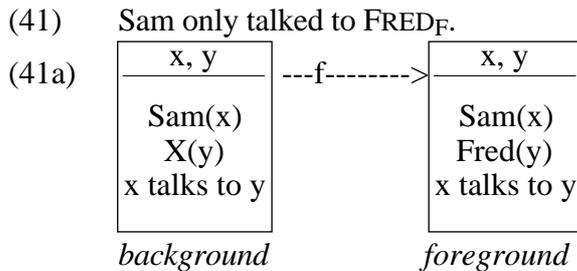
(40) Background-foreground representation of adverbs of quantification



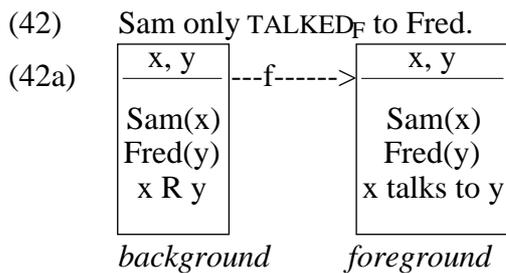
10. Association with focus

With this basic mechanism, it is possible to analyze association with focus with different operators. Focus-sensitive particles and adverbs of quantification are translated into operators that range over functions from the background onto the foreground. Sentence (2), repeated as

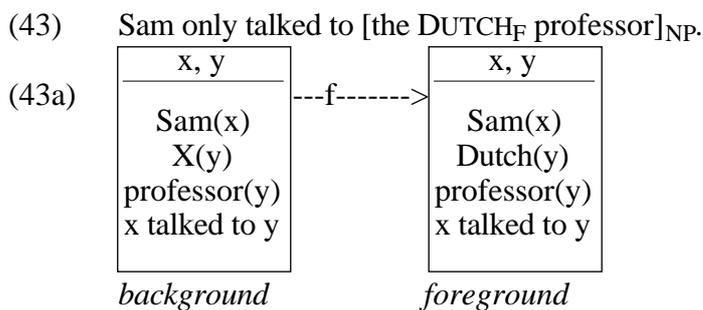
(41), is represented as background and foreground in (41a). The particle is not represented at either representation, but rather translated into an operator ranging over functions f from the background onto the foreground. The operator is defined as asserting that there is no function g specifying the underspecified background, but the function f that assigns the actual sentence (foreground) to the background. Since in this example the only difference between the two representations in (41a) consists of assigning the name *Fred* to the discourse referent y , the function can be reduced an assignment function with respect to the variable X :



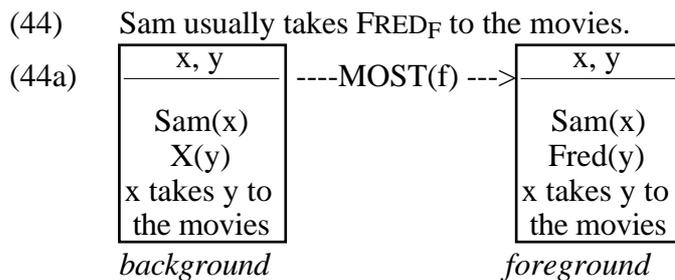
Analogously, sentence (3), repeated as (42), is analyzed as (42a), where the function that ranges over the variable R being the only difference between the two representations. Again, it is said that there is no other relation that hold of Sam and Fred other than the relation of talking:



Example (4) repeated as (43), is represented as in (43a), where the function ranges over the variable X , standing for the property of having a certain nationality:



Finally, the adverb of quantification in (5), repeated as (44), is translated into an operator *Most* that ranges over the function, which varies here only with respect to the value of X :



11. Some perspectives

The concept of a foreground-background semantics posits a challenge for semantic theories of information structure because the foreground-background semantics tries to integrate a wide range of phenomena. Discourse effects, such as information focus or discourse anchoring, could be accounted for by using the concept of background. On the other hand, the background played an essential role for the definition of discourse operators. Foreground-background semantics intends to span this wide field of semantics phenomena.

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