Handbook of Semantics

Chapter 6: Introduction to Discourse Semantics and Interface Semantics

6.1. Introduction

Individual words in natural languages have meanings that are structured per the syntactic structure of a sentence and combine to form a unit of meaning, the proposition, that corresponds to a sentence, as most people assume. Furthermore, most linguists who have attempted to model this phenomenon have used compositionality, which states that the meaning of all of it is a function of the meaning of the parts. Sentences, on the other hand, do not take place in isolation, nor are they interpreted in isolation (Muskens, 1996). Many words and semantic constructions of higher order have been found to be dependent on the discourse context for the specification of their meaning over the last 30 years, according to an impressive list of findings. To do respect to these insights, several speech interpretation theories have arisen.

The natural language syntax is represented by a deterministic, discrete, combinatory method that makes representations within an independent, informationally enclosed component of the language faculty (Fodor, 1983), which is represented by a lexical structure. A map is created between the result of the syntactic component and possible non-linguistic representation of many other cognitive segments at specific moments in the calculation. The interfaces are described as the points where two different systems communicate with one another. Features of the translation process from syntax to the conceptional-calculated structure that is liable for a model-theoretic explanation, the calculation of logical inferences, the depiction of intentions and concepts, and perhaps further functions are covered in recent studies of the syntax-semantics interface. The specifics of interface semantics will be covered in greater depth later in this chapter.

6.2. Discourse Semantics

The sensitivity of an expression's or construction's meaning to discourse context differs from Kaplan (1989) and his followers' well-known context-sensitivity attributed to demonstrative and indexical phrases. An expression is semantically assessed at an index or point of evaluation in standard Montague semantics, which comprises of a world, a time, and maybe other components as well. Many meaningful morphological or expressions markings, such as tense morphemes in many languages, can modify or shift these elements of assessment; for example, a sentence in the past tense, for whom the logical form for our purposes here is PAST (φ), will be true if and only if φis true at w and some t in the past of t when evaluated at w and some t in the past. The evaluation of indexical expressions, according to Kaplan, entails a different type of parameter, a context, which cannot be shifted by language elements. The rigidity of indexical and demonstratives is derived from the fixity of such settings, which is the fact that an indexical or demonstrative in a language such English has the same semantic meaning in every world (and time) of evaluation (Asher and Sablayrolles, 1995).

Conversation contexts, unlike Kaplanian contexts, vary or evolve as the discourse progresses, and new elements can serve to define the meanings of discourse-sensitive parts in subsequent continuations of the discourse. Consider the interplay between anaphoric pronouns such as the use of indefinite noun phrases (NPs) in earlier discourse.

➢ (6.1) a. A man entered the room. He drank a glass of orange juice.

b. A man entered the room. Then a young man entered. He drank a glass of orange juice.

The indefinite noun phrase a man offers a predecessor for the pronoun in the second sentence in (6.1a), and picking this antecedent as the pronoun's value gives it a specific semantic interpretation. The introduction of a second indefinite noun phrase, a boy, in the discourse context provided by the first line (6.1a), offers another antecedent and a second alternative interpretation of the pronoun he, that is not open to the pronoun's interpretation in (6.1a) (6.1a). As a result, the discourse background provided by the first sentence of (6.1b) has been changed in certain ways by the second sentence of (6.1b) (6.1a).

Another property of conversation contexts is that components for semantics may be accessible at one point in the growth of the conversation context and then disappear at a later point. Consider the case of anaphoric pronouns once more (Venhuizen et al., 2018).

➢ (6.2) a. Suppose a man walked in. Suppose he drank an orange juice.

b. Suppose a man walked in. Suppose he drank an orange juice. #Then he left.

The two statements from (6.1a) are encapsulated inside the range of the verb suppose in (6.2a). Although the pronoun he is used, it is possible to interpret it as referring to the man who (allegedly) enters the room. However, the second occurrence of the pronoun he in (6.2b), the one in the phrase Then he departed, cannot be the one in the sentence Then he left. Because of the way the conversation has progressed in (6.2b), the semantic meaning of the indefinite noun phrase is no longer available for the meaning of the pronoun in the third sentence to be determined (Asher, 2000).

This final feature is related to a third finding about the way logical and other operators structure speech contexts, which is discussed below. In the so-called donkey sentences, which were uncovered by Geach (1962), pronouns demonstrate that they can access the semantic meaning of an indefinite when used as the antecedent of a conditional.

➢ (6.3) If a man keeps a donkey, he beats it.

This poses problems for a compositional treatment of indefinites. (6.3) has the truth conditions of a universally quantified statement in which the universal quantifiers ranging over men and donkeys bind variables introduced by *he* and *it* respectively (Jayez and Rossari, 2004). That is, the logical form of such a sentence is as follows:

➢ (6.3) ' $\forall x(\text{man}(x) \rightarrow \forall y(\text{donkey}(x) \rightarrow (\text{owns}(x, y) \rightarrow \text{beats}(x, y))))$

Nevertheless, if indefinite NPs are to be translated as eternal quantifiers, providing a narrow nuclear context for such quantifiers, which does not include the consequent of the conditional, does not provide

the proper bound variable treatment of the pronouns, and giving these quantifiers a wide scope would result in incorrect truth conditions for the pronouns (Dehé, 2007).

These three findings suggest that discourse settings and semantic interpretation interact in a sophisticated way. While I've used anaphoric pronouns and indefinites to illustrate my points, the same principle applies to tense morphemes and temporal adverbs, which are likewise affected by discourse structure and were the inspiration for dynamic semantics in the first place (Kamp, 1979). Similar observations can be made about presupposition, as well as various types of anaphora or ellipsis. On either hand, there has been a lot of discussion regarding what elements influence semantic interpretation and which phrases are affected by discourse context. DRT (discourse representation theory), DPL (dynamic predicate logic), modernize semantics, and versions of continuation semantics are dynamic semantic theories that developed accounts of discourse contexts based on a close study of the connections of the logical operators and quantifiers familiar from first-order logic with linguistic contexts and semantic interpretation. Other theories of discourse interpretation, notably Grosz and Sidner (1986); Thompson and Mann (1987), accord discourse contexts a much richer, relational structure that involves discourse relations linking fundamental discourse units to other discourse units, as well as work on segmented discourse representation theory (SDRT) inspired by artificial intelligence. Discourse relations are not the same as conventional logical operators in that they express thematic, causal, structural, and temporal relationships between the semantic contents provided by fundamental discourse units, which are often connected with clauses. Lascarides and Asher (1993) argue that the interpretation of discourse context-sensitive expressions or morphemes like tense is sensitive to such structure as well as logical structure; Asher (1993) makes a similar argument about anaphors referring to propositions and ellipsis, following Hobbs (1977) earlier work on individual anaphors and definite descriptions. Other discourse context research focuses on the importance of different discourse entities as antecedents for anaphoric expressions – that is, which discourse entities are more likely to be antecedents for anaphoric statements.

Despite their variations in terms of discourse structure, all of these theories share a fundamental idea about semantics that can be found in Groenendijk et al. (1996). The text and its context are thought to be the unit of meaning. Every sentence is interpreted in relation to a context, which contributes to or updates the interpretation context. As a result, the meaning of a statement is naturally viewed as a relationship between contexts. Computer scientists and linguistics have developed sophisticated methods for modeling the impact of context on interpretation during the last 30 years. Various types of dynamic logics for programs and dynamic semantics are among these methods, and there is frequently a close relationship between them. The meaning of a natural language sentence is treated as a relation among both information states, an input information state, and an output information state, in different iterations of dynamic semantics, DRT, DPL, Update Semantics, as well as some versions of Situation Semantics. As a result, every sentence relates to an action on the input information state, similar to how program elements correspond to actions on the input computational state. The input information state

reflects the current discourse context's content, whereas they can use state represents the prior discourse context's content combined with the formula's content (Scheffler, 2009).

Let us take a closer look at this relationship concept. A discourse's interpretation is based on both a compositional semantics for sentences and what is known as a "binder" rule. Allow the sequence of a text's constituent sentences to serve as its structure (Rooryck, 2001).

When given a category of sentences S and a "combinator," such as ".", we can inductively define the category of texts T:

$$S \rightarrow T$$

$$T.S \rightarrow T$$

Consequently, text is composed of sentences, and text composed of a phrase is also composed of texts, where T is the meaning of a phrase whose meaning is to be given to the meaning of T, and the following is an example of an operation b: it takes a text meaning and combines it with a sentence meaning, and then provides a new text meaning that can be combined with further text meanings (Van, 1995):

- (6.4) $b: ||T||x\,||S|| \rightarrow ||T||$

In some form or another, all theories of discourse linguistics have a binder rule. In discourse semantics, the Stalnakerian semantics (Stalnaker, 1968) paradigm is likely the most straightforward model available. Theoretically, each sentence represents a set of possible worlds, and each discourse environment represents another set of possible worlds, according to Stalnaker. The set-theoretic intersection operation is denoted by the letter b. Even though this picture is appealing along with its simplicity and because of its direct connection with standard model-theoretic semantics and classical logic, it does not begin to do justice to the difficulties associated with understanding and interpreting intersentential anaphora or time tense in natural language (White, 2006). Consider, for example, the phenomenon of intersentential anaphoric reliance that has been found in the literature (6.1). In the context of a Stalnakerian semantics for discourse, the indefinite noun phrase does not have any recoverable semantic value that can be used to interpret the anaphoric pronoun; the natural idea that the pronoun in the second sentence of (6.1a) introduces a variable that is bound by the existential quantifier presented by the indefinite noun phrase in the first sentence does not combine coherently with a Stalnakerian semantics for discourse. The result has been that the majority of linguists who are interested in discourse semantics have come to accept some version of dynamic semantics, in which discourse contexts make values for variables available for anaphoric expressions to use. In the following section, I discuss three approaches to comprehending discourse settings that further expand this concept (Tomlin et al., 1997).

6.2.1. Discourse Representation Theory

Hans Kamp and Irene Heim published the first studies of discourse semantics in the early 1980s, in which they looked in depth at the behavior of anaphoric pronouns and discourse contexts, among other

things (Kamp, 1983). In this section, I will concentrate on Kamp's theory. DRT is a dynamic semantics developed by Kamp that defines a discourse context as a mental model of what has been stated, also known as a discourse representation structure (DRS). Incorporating a statement into a discourse context C stating that p is the merging of the contextually given DR and the DR for the given p. The operation b is a merge operation across DRSs, DRT's meaning representations, and DRT's meaning representations. DRSs are pairs of sets, the first element of which is a set of discourse referents that represent entities that the discourse is about, and the second element of which is a set of formulas over those discursive referents. DRSs are used in formalized discourse analysis to represent the relationships between entities (Asher, 1986).

6.2.2. Dynamic Predicate Logic (DPL)

The input and output states of the fundamental discourse equation in various variants of dynamic semantics differ (6.4). At a representational level, DRT, for example, contains the relational theory of meaning. Discourse Descriptive Structures, or DRSs, are used to represent the input and output states. DRT recommends that the updating and dynamics be built into the building of logical form, but not the interpretation of it. This makes DRT's semantics static and provably equal to a Tarskian semantics, but it also makes the logical form building extremely difficult (Vermeulen, 1993).

We introduced the main concepts of the dynamic semantics known as DPL in the relational version of DRT, where the meaning of a sentence is a relation among an input assignment and an output assignment, and b is the relational composition operation. Given a compositionality concept like the one used in MG, Groenendijk and Stokhof argue that we should get for the donkey sentence in (6.6), repeated below, the logical form in (6.7):

- (6.6) If a man owns a donkey, he beats it.
- (6.7) $\exists x(\text{man}(x) \wedge \exists y(\text{donkey}(x) \wedge \text{owns}(x, y))) \rightarrow \text{beats}(x, y)$

This complicates the compositionality principle until a non-standard translation for infinite NPs is provided, like DRT does. DPL presents a new semantics in which the formula (6.7) can capture the meaning of (6.6) and produce the same truth conditions as the first-order formula in (6.6). (6.6). DPL is inspired by systems of dynamic logic as they are utilized in the representations semantics of programming languages, as Groenendijk and Stokhof (1975) point out.

6.2.3. Continuation Style Semantics

Logics of composition and logical forms can be easily constructed for DPL or relational versions of DRT by employing a dynamicized version of the lambda calculus that is appropriate for the situation. The fact that this is happening is beneficial since it makes dynamic semantics more analogous to regular truth-conditional semantics. This allows us to follow normal semantics practice and use logical forms to give truth conditions, and therefore to be considered a fundamental component of semantics in general (Audebaud and Zucca, 1999). Open to interpretation, logical forms for meaningful clauses must

be produced by a theory of meaning composition, and similarly, logical forms for discourses must be produced by a theory of discourse structure. As a result, the shift away from compositional models of dynamic semantics is critical (Thielecke, 1997).

On the other hand, the composition logic and validity idea that emerge from such dynamic semantic frameworks are very non-standard in their formulations and applications. When objects are assigned to variables or any other equivalent in the lexical theory, types that include this assignment are considered to be part of the type system. Due to this, it is difficult to compare and contrast lexical entries in dynamic semantics with lexical elements in traditional theories such as MG. The use of more complex computer science methods known as continuations to construct contextually sensitive semantics inside the confinement of classical higher-order logic has, however, recently gained popularity among scholars (Streicher and Reus, 1998). Continuations make it possible to include dynamic semantics in higher-order reasoning in a faithful manner. Without going into technical details, the concept of continuations is to incorporate into lexical entries a "left" context parameter, which contains elements of discourse context relevant to interpretation, such as available discourse referents, as well as a "right" context parameter, which contains elements of discourse context relevant to interpretation, such as forthcoming discourse referents. For example, the trick is to get indefinites to "pass on" the discourse referents they introduce to following discourse while maintaining inside this context of classical logic, under which we end up with a proposition for a discourse that is classically valued. This is exactly what various variants of continuation style semantics are capable of accomplishing. In continuation style semantics, anaphoric expressions choose elements from the left context, whereas indefinites update the left contexts with an element, and the altered left circumstances are then passed on to the right contexts. In MG, continuation style semantics was used to construct the simpler lexical entries with a standard interpretation, which are comparable to those produced in MG (Selinger, 2001).

If you are working with DRT or DPL compositional semantics, you will encounter the introduction of "odd" types, whose residents include variables, assignments, and other "representational" features. As well as destructive assignment problems in DPL and variable clash problems in DRT or versions of DPL that use partial assignment functions, we have problems with variable collisions in DPL. When working in a completely compositional setting, it is difficult to avoid these issues. The methodologies developed by de Groote (2006); and Pogodalla (2008), provide a means of avoiding these difficulties. They provide us with a semantics that is entirely objectual for at least some dynamic ideas. The quantifiers and connectives can be interpreted according to a conventional, classical interpretation because they distinguish between the interactions between the discourse context and the logical operators, as well as the semantics of the logical operators. By complicating the lexical entries of expressions as well as the binder rule, the continuation-based discourse semantics of and are able to achieve this goal (Curien and Herbelin, 2000).

The implementation of resumption style semantics by de Groote will serve as a representative example, which I shall discuss in detail later. The goal behind De Groote's proposal is to make

continuations a fundamental attribute of all lexical objects. That is, for each term, we will have a context on the left I and a context on the right (o) to which it is sensitive.

- (6.8) $\lambda i \lambda o \phi$

An extra component of the concept is the requirement that the final product of a dialog be a proposition. An output context is defined as follows: (11) where prop is the kind of propositions to be produced.

- (6.9) $o = i \Rightarrow \text{prop}$

Once we have included the lexical entries for the verbs, we will have enough information to recreate the basic DRT fragment. Take note that certain determiners and proper names convey variables onto their appropriate contexts but take note as well that all of these variables are bound in the traditional meaning of first-order logic (see below). As a result, each of the terms in this section is closed and does not rely on a concept of assignment for its denotation. Furthermore, there is no requirement in the system to assume assignments, much less even discourse referents, as semantic values (Hofmann and Streicher, 2002).

6.2.4. More Elaborate Theories of Discourse Structure

So far, we have looked at discourse semantics theories that study how contextual information spreads through the logical structure of a conversation, as provided by first-order quantifiers and operators. We have also looked at how such accounts deal with anaphoric dependencies and expressions. While anaphoric phrases such as verb tenses, pronouns, and ellipsis constructions are the most obvious instances of discourse context-dependent interpretations, they are far from the only ones. According to theories that propose more elaborate discourse structures involving discourse relations, such as SDRT, all units of information that serve as constituents of discourse structure, specifically all clauses and parenthetical expressions, appositions, and non-restrictive relative clauses, have context-dependent interpretations. However, in order to make this idea a reality, we must revisit the model of discourse contexts (Moser and Moore, 1996).

Theories such as SDRT impart meaning to texts through a rich discourse structure, resulting in a more comprehensive representation of the context and definition of the binder rule. More specifically, the way combined with will occasionally be determined by specifics of the words' lexical entries. The fundamental premise of discourse semantics, such as SDRT, is that the way will join with will depend on the rhetorical or conversation function that has in the context of (Heerschop et al., 2011).

Discourse relations are several forms of relational speech acts. They are frequently, but not always, item by lexical semantics, the syntax/semantics interface, and compositional principles. They are metaphors (and cataphors). Except for the speech act type "response," which is a relational speech act, speech acts in Anglo-Saxon literature are normally regarded as unary features of utterances or sentences-in-context. The related aspect of several speech acts was overlooked in the mainstream image. Many relational "discourse" speech acts, or activities individuals perform with sentence contents in a discourse context, exist. Here is a brief and non-exhaustive list of possibilities (Hovy, 1993).

- They explain a prior opinion or explain why something occurred;
- They describe a story of what happened;
- They provide context for a certain occurrence;
- They go into greater detail about the characteristics of things they have already addressed, as well as an event or a plan;
- They explain the outcome of a formerly mentioned state or event;
- They correct themselves or others' discourse contributions;
- They provide questions whose responses will aid in the discovery of answers to previously posed questions;
- They offer insults and compliments, and say good-bye.

These specific relationships readily fall into general categories – narrative, causal, thematic, and structural similarities – that appear to be universal in their application. (Leth, 2020).

Every clause in a well-formed conversation generates a discourse constituent, which is related to the discourse context by one or more discourse relations. As a result, discourse constituents must be like speech acts. At the absolute least, we cannot associate a clause's contribution with a proposition or sentence content because the same sentence content can play distinct, contradictory rhetorical roles in different circumstances.:

- (6.10) Max fell. John pushed him.
- (6.11) John and Max were perched on the precipice of a cliff. Max was stuck in the back of the neck with a powerful punch. Max was knocked out. He was pushed by John. Max rolled down the cliff's edge.

This gives rise to the concept of a discourse context, as well as the contribution of a phrase to discourse as a relational structure comprising constituents and discourse relations among them. These structures are referred to as SDRSs in SDRT.

I will now explain why I'm introducing topic relations and structured conversation contexts. Content and prosody are affected by discourse interactions. I will offer a number of examples below of how SDRT's discourse relations and structured discourse contexts go beyond the predictions of traditional dynamic semantics for the domains for which these semantic theories were designed (Oliveira, 2010).

Let us consider first propositional anaphora. What is the referent of *this* in?

- (6.12) a. Three times, a plaintiff was passed in for a promotion.
  b. Another did not get a raise for five years.
  c. When compared to males doing the same work, a third plaintiff was paid less.
  d. But the jury did not believe this.

This question is not addressed by classical dynamic semantic theories. Nevertheless, if we look at the SDRT graph for this example, we can see that certain relations are coordination and some are subordinating (vertical lines).

Consider the right border of this graph: it contains only the content from the third phrase as well as the topic established for the entire discourse. Furthermore, only (26c) and the created topic provide connection points. SDRT and other theories that assume a densely organized discourse context point to an intriguing generalization: the conversation entities for anaphora resolution are located along the graph's right frontier.

This generalization holds true for anaphoric expressions that refer to specific people as well. Consider the following:

➢ (6.13) a. John had a beautiful evening last night.

b. He had a great meal.

c. He ate salmon.

d. He devoured lots of cheese.

e. He then won a dancing competition.

f. ??The salmon tasted great.

The SDRS graph for this instance is given in Figure 6.1.

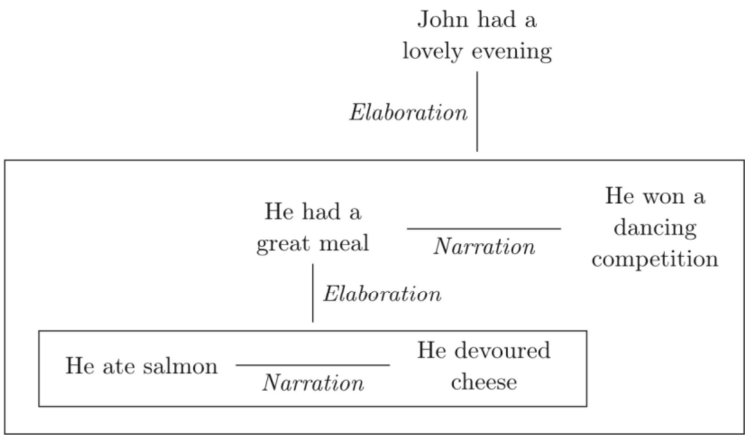

Figure 6.1. *SDRS graph for discourse structure of semantics.*

The graph's right frontier contains discourse entities related to John, the gorgeous evening, and the dancing competition, but not the salmon, rendering the continuation in (27f) difficult.

Many aspects of discourse meaning are influenced by discourse functions, including the resolution of anaphoric ellipsis and expressions, adverbial interpretation, presupposition, and temporal structure. To compute these interpretation components, we must first compute the discourse functions of discourse constituents.

At times a relatively small class of adverbs or adverbial phrases, referred to as discourse connectors or discourse markers by Knott (1998) and others, is sufficient to establish the discourse functions and therefore a method of combination in SDRT. Syntactic constructions can also provide crucial information about discourse structure and how a new phrase, or rather discourse constituent, must interact with the meaning of the text. However, the mechanism of combination will occasionally be determined by open class words such as verbs, their arguments, and their modifiers. To explain, consider the following:

- (6.14) a. John fell. He slipped.
  b. John fell. He got hurt.
  c. John fell. He went down hard, onto the pavement.

The second sentence in each of (6.14a–c) serves a particular rhetorical or discourse role, which is reflected in how SDRT combines its content with the discourse framework. SDRT might, for example, connect the discourse components denoted by the two sentences in (6.14a) by Explanation – John fell because he slipped. The constituents in (6.14b) are linked by Result, whereas the constituents in (6.14c) are linked by Elaboration. The rhetorical function in each example may be traced back to the meanings of the verb phrases.

In SDRT, each sentence introduces a speech discourse referent with associated content that is linked to its discourse context via one or more discourse relations. All of these instances use the same tenses but have intuitively different temporal patterns. These disparities cannot be explained by dynamic semantics. The discourse relations that connect the discourse elements obtained from the clauses in these mini discourses explain the varied temporal structures. These discourse relations define the rhetorical or discourse functions linked with the speech act. Explanation links the speech act a1, whose meaning is that John fell, with the speech act a2, connected with He slipped, in (6.14a); a2 explains why John fell. The speech act b2, initiated by the second sentence, is connected to the speech act b1, introduced by John fell, through Result in (6.14b). In (6.14c), the speech act c2, initiated by the second sentence, is linked to c1 via Elaboration. Each of these discourse relations puts a different set of time limitations on the events introduced by the sentences to which the relations are related: Explanation (a, b) implies that the eventuality in b occurs before the eventuality in a, while Result (a, b) implies that the eventuality in a occurs before the eventuality in b; Elaboration (a, b) implies that the eventuality in b is a subevent of the inevitability in a. This is consistent with intuition (Poesio et al., 2006).

6.3. Interface Semantics

Compositionality is a principle that is adopted by all significant concepts of the semantic-syntax boundary in one form or another. This notion states that the significance of complicated phrases is functionally dependent relative on the meaning of its important components and the way these sections are joined. Except for this stipulation, existing models of grammar differ significantly both in terms of their stance on the role of syntax in the design of the grammar and in terms of the semantic rules of

understanding that they permit. The inability to offer a uniform, generally applicable specification of the syntax-semantics interface makes it challenging to provide one. It is still possible to distinguish between two groups of techniques that are distinguished by their differing perspectives on how to deal with mismatches between semantics and syntax (or semantic mismatches). This type of context, which is prototypically illustrated by quantifier scope uncertainty in sentences such as a critic enjoyed every movie, is useful about the nature of the boundary due to syntactic parse fails to recognize individual a semantic understanding, needing the resolution of this struggle in one of the two mechanisms, as in A critic liked every movie (Borer, 1994; Bobaljik, 1995).

For example, lexicalized, monostratal models, for example, lexical-functional grammar (LFG), combinatory categorial grammar, categorial grammar, head-driven phrase structure grammar (HPSG), MG, and traditional MG, for example, builds both the syntactic and semantic representations at the same time, so that the input of a syntactic rule also acts as the input of a corresponding semantic rule at each level of the computation. They are characterized by the assumption that linguistic depictions do not have obscure structure, which allows them to keep the degree of abstractness in the object language expressions to a bare least. Surface-oriented, non-derivational approaches A semantic meta language augmented with type adjustment procedures or further rules of composition is often used to handle potential mismatches between semantics and syntax rather than by using syntax to fix the mismatches directly. A further advantage of theories in this lineage is that they frequently protect compared to overgeneration by restricting the application of rules of semantic to specified syntactic settings. As a result, for the lexicalized system, the investigation of the syntax-semantics boundary is mainly concerned with the investigation of semantic combinatory properties and their rules, rather than with the exploration of the nature of the relationship between these operations and the rules that generate obvious syntactic expressions (Bresnan, 1982; Brody, 1995).

In syntacto-centric systems, on the other hand, the syntactic component comes before model-theoretic analysis, which has two consequences. To begin with, primary syntactic procedures cannot be rendered semantically dependent without additional modifications (Chomsky et al., 1973). Second, communication among semantics and syntax is only possible at specific places of interaction that the semantic component can access. The abstract language representations known as LFs serve this interface function in derivational theories (logical forms).

Because LFs are assumed to be abstract things generated inside the syntactic element, they are bound by natural language grammar rules. In this sense, derivational models differ from lexicalized theories, which primarily deny the presence of obscure syntactic structure and procedures manipulating object language expressions. As a result, while there is no universally accepted definition of LF at the moment (see below), all LF-based approaches share a set of guiding, methodological principles: I a readiness to accept more abstractness in syntax than surface-oriented lexicalized methods, and (ii) a propensity to solve divergences among semantics and syntax, if they arise, during the syntactic origin rather than in the explanatory constituent. As a rule, categorial and derivational theories vary in that the

former accepts more abstractness in grammar, whilst the latter tends to allow more complication in semantics. The following parts go through the history and context of interface semantics (Chomsky, 1976, 1993):

6.3.1. The Use of Logical Form in Linguistics and Philosophy

Philosophers have been employing the phrase logical form to refer to a wide range of ideas that are just lightly related to the linguistic concept that inspired the word (Lappin, 1993; May, 1999; Pietroski, 2009). Logic forms, according to the broadest sense, bring to light underlying regularities in propositions, making obvious unifying logical features that had previously been obscured by what was thought intrinsic imperfections in plain language. One may only discover connections among first-order interpretations of general conditionals ([1b]) and quantification ([1a]) if one understands the logical form that underlies the translation into (1c).

➢ (1) a. Dogs are all awake.

b. *Dogs are always awake.*

c. œx[dog(x) ÿ awake(x)]

Logical forms, according to this perspective, are not part of the language used in the object, however, rather are representations that can only be defined by propositions and hence fit logic, wherever they are used to compute meaning relations and inferences. Menzel, Lappin, Peter, Preyer, and Pietroski are examples of works on the past of logical form (Chomsky, 2000, 2014).

Russell (1905) was the first to use the word "logical form" in a sense that was near to that of its present linguistic usage. When translating from natural language phrases into a regular formal language, Russell noticed that the translation sometimes exhibited invariant regularities, which suggested that there was a systematic relationship between metalanguage and object. Russel's theory of logical forms differs from past methods in that the link among form and meaning is organized in a systematic manner, which makes it more like present linguistic views. Several specific phenomena were taken into consideration by Russell, each with a distinct description and name. The surface string, for example, was thought to be represented by a formula like (2b) as its fundamental logical form (2a).

➢ (2) a. *The dog is awake.*

b. ›x[dog(x) v awake(x) v œy[[dog(y) v ¬x=y]] ¬awake(y)]]

The logical forms of the initial logico-philosophical incarnation were not made up of sentences or part of the object language.; rather, they have simply encrypted hidden characteristics of the proposition expressed by a sentence in their initial logico-philosophical manifestation. As a result, it was believed that the similarities between logical syntax and natural language were too idiosyncratic and irregular to allow for the establishment of a systematic mapping amongst them. For example, the syntax of (2a) and its logical representation (2b) vary in that the subject DP the dog is bracketed to the omission of the verb VP in the syntax, whereas there is no such grouping in the logical interpretation. The answer to

this question can be found in Frege's study of logical quantifiers as second-order qualities, as well as the -calculus, which is both discussed below (Church, 1936, 1940).

A major objective shared by all sufficiently accurate, compositional theories of language is the resolution of such inconsistencies between both the logical meta-language composition and constituent in natural language. Some representational systems models and syntacto-centric derivational are distinguished from lexicalized models by the fact that the latter uses the assumption that not all features of language meaning are phonetically characterized as a heuristic for conflict resolution (Collins, 2005):

- (3) *Abstractness Hypothesis*

Linguistic representations have things that are not real.

This hypothesis gained its most prominent form in derivational theories, with the assumption that grammar has a post-syntactic component that determines "components of meaning that are determined by grammar." To handle LF as a distinct level of argument, the Principle and Factors model (Chomsky, 1981) separated it from both syntactic and model-theoretic analysis. In uncluttered grammars, LF is integrated into the syntactic factor and determined by the point in the origination at which Spell-Out relates: LF consists of all processes that occur after Spell-Out and have no impact on pronunciation; as a result, LF has no impact on pronunciation.

Individual members of well-formed LF-representations and the class of all well-formed LF-symbols have come to be referred to as "LF," with no commitment to whether LF should be considered a distinct level of representation or not (Cooper, 1975, 1978, 2013).

Incorporating lower-case letters into an object language led to the belief that rational syntax of the technical understanding language is co-defined through natural language syntax, as articulated by the Transparent Interface Hypothesis (4):

- (4) *Transparent Interface Hypothesis*

In natural language, the syntax is also a factor in how interpretive properties are set up.

Because of this, the responsibility of establishing the rational syntax of an expression in derivation models can be delegated to the guidelines of natural language syntax are: that are applied to the expression. Adherents of LFs have made it a primary goal of theirs to demonstrate that such a division of labor among semantics and syntax does exist. Silent movement operations, elliptical nodes, unpronounced, pronouns variables, and variable binders are all analytic methods that can be used with (3) and (4). They include lexical decomposition in the object language, which is generally employed in conjunction with silent operators, and silent operators. The analytic techniques that can be used because of (3) and (4) are silent development operations and hidden structure of syntactic (Cresti, 1995).

As previously stated, the logico-philosophical heritage and modern generative grammars assign logical form to the core of what they do different roles, as demonstrated in the examples above. While logical types are similarity classes of attributes that exist in the logical meta language, the semantic notion defines sophisticated natural language objects that may be modified by the laws of grammar; the former is a concept that describes logical forms. Aside from the differences in their ontological

character, there is another distinction among modern notions of classical and the LF philosophical stance on the logical form. However, logical forms were originally intended to signify the logical skeleton of ideas on the base of which inferences could be drawn, LFs in generative semantics, however initially, were expressly designed not to encode meaning relations between words. The LFs, on the other hand, are simply syntactic entities that have not yet been allocated a model theoretical meaning. This is by the premise that syntax functions within an informationally enclosed system that does not take directions from external components (Bach, 1979; Diesing, 1992).

About the role of LF in existing models, it is necessary to make a few qualifying observations. Notably, the LF interface has the potential to deviate from the typical minimalist paradigm in at least two areas. As a starting point, there exist "flatter" variants of derivational grammars that do not assume that the distinction between covert and overt processes is a significant property of the model. These single output theories, in contrast to lexicalized theories, continue to recognize the existence of abstract, concealed information as a component of language representations. Although the origin is no longer divided into an invisible and a visible element, as was the case in earlier forms of minimalism, abstractness becomes a ubiquitous aspect of grammar because of this. Using such a conceptualization leads to the expectation of a systematic interplay between covert and overt processes in practice (Egg, 2012).

Second, there is increasing proof that the computations that transfer from semantics to syntax can be influenced by factors other than those inherent in the syntactic system itself. A recent investigation into this possibility has focused on areas where choices inside of central syntax that are related to the issue of model-theoretic explanation are either conversant by contextual aspects or by the result given by a non-domain exact logical system calculation logical implication (Feferman and Feferman, 2004; Reinhart, 2006).

6.3.2. Lambda Calculus

At least until the late 1960s, the general assumption was that the rigid methods of formal logic could not be applied to natural language semantics because they were incompatible with natural language. Combining two theories in Montague's work is what makes his work unique was what enabled the extension of formal rigor from logic to natural language. These results were – Frege and calculus's viewpoint of quantifier meanings as higher-order functions. Following the principle of compositionality as its primary heuristic rule, MG was the initial formal theory to treat natural language as the response of an interpreting function, which iteratively assigned meanings to complicated phrases in a recursive manner (Reinhart and Reuland, 1993).

Combining calculus with the Fregean theory of quantification in MG proved to be extremely useful in identifying compositional translation processes for complicated expressions that had previously only been treated when it comes to building, rules that have special meaning in previous logical analyzes. A minimal quantificational announcement like (5) could not, for example, be subjected

to a compositional evaluation as it was not feasible to allocate the quantificational determiner an understanding independent of the meaning of its usual noun sister dogs until that time (Riemsdijk and Williams, 1981).

➢ (5) *Every dog is awake.*

This was because pre-Fregean logic could only create first-order centers and so be short of the formal authority to describe to the two-place higher-order act signified by every. As a result, the meaning of the proposal conveyed by (5) could not be deduced compositionally from the meanings of its sections, a fact that was interpreted to show that natural language meaning computation comprises intrinsically non-compositional characteristics (Rullmann, 1995; Rizzi, 1996).

The -calculus was created in response to a similar situation in mathematics. Take into consideration the following function, which can also be represented as (6b):

➢ (6) a. $f = \{<1, 2>, <2, 5>, <3, 10>, <4, 17>,\ldots\}$

b. $f(x) = x^2 + 1$

c. $f = \lambda x[x^2 + 1]$

The function symbol cannot be isolated from the individual variable, which makes the conventional function notation less apparent (x in [6b]). An expression like $f = x^2 + 1$ isn't allowed. There is no way to talk about the function alone without a proper notational device. The -calculus bridged this gap by detaching the function from its variable, as seen in the diagram. The right-hand side of (6c) should be read as "the weakest function mapping x to $x^2 + 1$," which is, as expected, an explanation of the function f.

The -calculus, when applied to natural language semantics, provides a way of describing functions that is separate from their arguments, and may thus be employed to create proper connotations for sub-constituents like the quantificational determiner every. As seen in (7b), everyone is interpreted as a second-order two-place function that, when paired with the conventional word dogs, gives a Generalized Quantifier denotation, which characterizes every dog's semantic contribution ([7c]). GQs are used to represent a variety of functions, ranging from attributes to sentence denotations. The function transfers any property of each dog in the domain to 1 (or True) if it holds, and to 0 (or False) otherwise in the instance of (7c). The proper truth conditions for the proposition indicated by (7a) are then obtained by applying the GQ meaning (7c) to the established denotation ([7d])

➢ (7) a. *Every dog is awake.*

b. $f\text{every}_{,,} = \lambda P \lambda Q \text{œ} x[P(x)\ \ddot{y}\ Q(x)]$

c. $f\text{every dog}_{,,} = \lambda Q \text{œ} x[\text{dog}(x)\ \ddot{y}\ Q(x)]$

d. $f\text{every dog}_{,,}(f\text{is awake}_{,,}) =$

$= \lambda Q \text{œ} x[\text{dog}(x)\ \ddot{y}\ Q(x)](\lambda x.\text{awake}(x)) =$

$= \text{œ} x[\text{dog}(x)\ \ddot{y}\ \text{awake}(x)]$

To summarize, the -calculus offers a process for "splitting up" the connotations of complicated representations, whereas Frege's notion of quantification clarifies where the split should be applied,

along with how the components should be interpreted. These principles describe an iterative translation mechanism from natural language semantics to syntax that progresses compositionally, allocating a proper significance to every node in the syntactic tree at each step along the way. This transition is also mediated by LFs in derivational models, which is an important point to note (Ruys, 1992; Ruys and Winter, 2011).

6.3.3. The Model of the Grammar and Quantifier Scope

This part includes a study of several ways for establishing quantifier scope as well as an overview of the criteria that differentiate between grammar models that allow for LFs and those that do not.

6.3.3.1. Scope Ambiguity and Quantifier Scope

As stated by the concept of compositionality, the significance of any complicated utterance is just contingent on the meaning of its important elements and the way they are joined. As a result, the problem of logical quantifier in object position, as demonstrated by (18), cannot be resolved deprived of more developments in theory (Riemsdijk and Everaert, 2006; Shan and Barker, 2006):

- (18) *John liked every movie.*

The incompatibility between the object denotation and the meaning of the verb, which can be stated in terms of gaps among their logical types, is the source of the difficulty in understanding the sentence. Transitive connotes like denote two-place relations among persons according to their normal meaning, and as a result, they must be combined with a person designating term as their initial argument. When used with simplified quantifiers, like each movie, they denote second-order qualities, which are functions of type e, t, and t. Such functions need the properties to be provided as input. As a result, the verb meaning is seeking for an e-type reason, whereas the sister of each movie has to be in the realm of e,t>-type expressions, ensuing in a clash of type needs between the two.

Generally, most theories propose that a disagreement can be solved by implementing one of two tactics. According to the transparent LF technique described in (19), the object quantifier in each movie is raised above its initial location by applying the Quantifier Raising algorithm. QR is an operation that moves quantifiers and discreetly raises them into places where they can be interpreted, potentially crossing over with other operators in the process. According to this interpretation, the hint of every movie is regarded as an e-type variable attached by the -binder of the fronted quantifier ([19b]), which may then be coupled with the quantifier denotation to obtain the following explanation (Steedman, 2000; Steedman and Baldridge, 2011):

- (19) a. [Every movie$_2$ [John liked t_2]]
  b. [Every movie λ_2 [John liked t_2]]
  c. λQœx[movie(x) *ÿ* Q(x)](λx.John liked x) = œx[movie(x) *ÿ* John liked x)

So, the LF-method, by the general strategy mentioned in the introduction, overcomes the type conflict by implementing an abstract movement process, such as QR, which modulates the syntax to address the

type conflict. QR, in turn, might be driven using a common obligation that derivations produce semantically interpretable outcomes.

As an alternative, type shifting processes that change the significance of one of the expressions that cause a type difference can be used to give a compositional interpretation to (18). (every movie and like). In surface-oriented theories, such as MG and several modern editions of Categorial Grammar, this method is particularly popular because it avoids the use of underlying complexity or abstract representations. The higher-order types et and t can be used to map transitive verbs to the higher-order types et and t. In this way, the denotations of the verb and the denotations of the quantifier can be combined without changing surface constituency. Furthermore, it is feasible to change the significance of the object quantifier while keeping the significance of the verb constant. For a more in-depth examination of the treatment of opportunity in categorial grammar, see Jacobson, Hendriks, Szabolcsi, and Steedman, to name a few authors (Kamp et al., 2001).

It follows those phrases with structural ambiguity, for example (20), must be disambiguated before they can be presented to the semantic understanding function because compositionality also implies that every expression has a single meaning.

➢ (20) *Some critics liked every movie.*

Several approaches can be used to achieve disambiguation. The transparent LF technique, for example, allows for the placement of the object quantifier either within ([21a]) or beyond ([21b]) the range of the subject quantifier, resulting in two disambiguated LFs that result in two truth-conditionally each (May, 1977):

➢ (21) a. LF1: [A few critic$_1$ [every movie$_2$ [t_1 liked t_2]]]

LF1: [Some critic λ_1 [every movie λ_2 [t_1 liked t_2]]] Translation 1: ›x[critic(x) v œy[movie(y) ÿ x liked y]]

b. LF2: [Every movie λ_2 [Some critic λ_1 [t_1 liked t_2]]] Translation 2: œy[movie(y) ÿ ›x[critic(x) v x liked y]]

For quantified expressions, the LF evaluation creates a prenex normal form, which means that all quantifiers are in the same place come before the open preparation comprising their bound variables. In that way, scope relationships are turned into binding relationships among quantifiers and specific variables. This is how it works; this account is semantically like MG; the first concept of natural language quantification was a compositional one. However, MG represents a very distinct perspective on the relationship between syntax and semantics (Szabolcsi, 1997, 2010, 2011). Each time a sentence is computed, a syntactic object is made that is used in the sentence along with its corresponding interpretation, which is designed as a non-derivational categorial system. MG's implementation is based on the concept of rule-by-rule understanding, in which every input phrase causes the execution of a syntactic rule and its semantic partner rule at the same time. The rule of measuring-in, for example, is an operation that converts sentences including pronouns into quantified formulas or unbound variables. The syntactic element of quantifying-in places a quantifier directly in its prenex location ([22a]), even

as the semantic rule allocates a Tarskian model-theoretic analysis to the emergent structure, as seen in (22b):

➢ (22) a. [*some critic* α] *ÿ* *some critic* (λx. [$_{\alpha}$… x…]) (where; α is an open formula)

b. "There is a person who is a critic and who owns things λx. [$_{\alpha}$… x…]"

When you apply quantifying-in to (20) twice, you get two comparative scope bids. The surface scope reading is obtained by first quantifying the object and then quantifying the subject, whereas the inverted scope interpretation is obtained via reverse sequencing. Multiple derivational histories (analysis trees) relate to sentences with numerous quantifiers, not multiple grammatical representations. Therefore, MG generates outcomes that are semantically indistinguishable from those given by its descendent QR – even though these results are obtained through distinct methods. MG and further categorial theories come up with two different interpretations of (20) from the same surface representation. Derivational theories, on the other hand, separate the meanings at LF, so that each LF-tree functions as an order of single scope (Tarski, 1956).

Furthermore, variations in the syntactic side of the derivation between quantifying-in and QR can be seen. The quantifier must appear at the place of the coindexed variable, not in its prenex posture, according to the MG approach for representing scope. See, for example, Partee, Jacobson, Hendriks, and Partee (1997); Baldridge and Steedman (2011); and Szabolcsi (2011) for more in-depth discussions of scope in other variants of CG, for example, type-logical grammar, Flexible Categorial Grammar, and CCG.

Along with Quantifying-in, type shifting, and QR, there are many other ways to look at quantifier scope phenomena in the literature, including Quantifier Lowering; Scope Indexing; Cooper Storage; Semantic Reconstruction; syntactic reconstruction by copies; decomposition methods, which produce the quantificational determinative in a position beyond the quantifier restrictor; Game-theoretic accounts and underspecification. For an outline of these and other analytic tools for developing scope.

6.3.3.2. The Model of the Grammar (Evidence for LF)

As previously stated, there are a variety of analytical possibilities for scope ambiguity and coding scope, with derivational modes on one end and exclusively surface adapted, non-derivational, categorial concepts on the other. While the two groups are to a large extent incommensurable because of underlying changes in their axioms and experimental coverage, it is feasible to identify several diagnostics that aid in resolving among both the contending models. One or more of the criteria in (23) matches the profile of the most important of these:

- There are syntactic rules that apply to both covert and overt expressions;
- The syntactic ingredient believes functions that would or else be left to semantics;
- Hidden structure exists surface descriptions have obscure structure;