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INTRODUCTION TO SEMANTICS AND PRAGMATICS

1. Introduction to Semantics

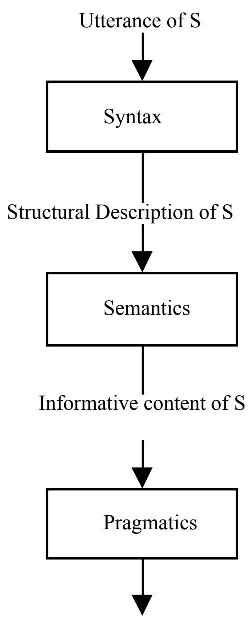
This chapter is devoted to basic concepts and problems trearted by formal semantics. I will first introduce the interface between semantics, syntax and pragmatics (§ 1.1), give basic concepts of formal semantics (§ 1.2) and event semantics (§ 1.3) and then finish with discourse semantics (§ 1.4). Section 2 introduces to pragmatics.

1.1 The syntax-semantics and semantics-pragmatics interfaces

There is a standard view of the linguistic division of work between syntax, semantics and pragmatics. This classical view can be summarized as follows (cf. Fig. 1.1, from [1]) :

- syntax is the input of semantics, that is, syntax provides as output a structural description of sentence S ;
- semantics is the input of pragmatics and the output of semantics is the informative content of S ;
- pragmatics is the last processing step, whose output is the action accomplished by the utterance of S.

Figure 1.1 Syntax, semantics and pragmatics.

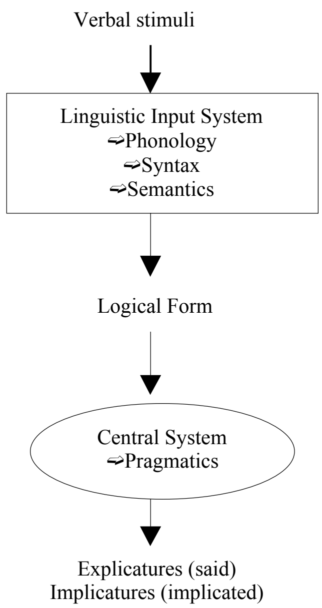


The classical division of linguistic work implies that each of these components is associated with specific types of rules :

- syntactic rules are rules of well-formation, whose function is to assign Structural Representations to sentences ;
- semantic rules are rules of interpretation assigning a denotation to sentences, i.e. a truth-value ;
- finally, pragmatic rules are rules of (full) interpretation assigning an action value (an illocutionary force) to the sentence uttered.

The classical view has been challenged recently by a new division of work : syntax and semantics belong to the Linguistic Input System, which is modular and yields Logical Forms (LF) as output, LF being a partial and linguistic interpretation of the sentence. Pragmatics belongs to the Central System of the Thought, that is, it is not modular, and has *explicatures* (what is said) and *implicatures* (what is implicated) as outputs. The aim of the pragmatic component is thus to provide a full interpretation of the utterance, as shown in Fig. 1.2 :

Figure 1.2 Linguistics and pragmatics



Within the classical or new division of linguistic work, semantics has specific relations to syntax and pragmatics. Syntax-semantics interface can be exemplified by ambiguity and interpretation of anaphora, whereas semantics-pragmatics interface concerns mainly disambiguation and inference.

1.1.1 Syntax-semantics interfaces : ambiguity and anaphora

Syntactic ambiguity occurs when one S-Structure maps with two D-Structures, as in (1), receiving the structural representations given in (2) and (3) :

(1) I saw that gasoline can explode.

(2) $[_{CP}$ I saw $[_{CP}$ that $[_{DP}$ gasoline$]$ $[_{VP}$ can explode$]]]$
‘I saw that it is possible for gasoline to explode’.

(3) $[_{CP}$ I saw $[_{CP}$ $[_{DP}$ $[_{D}$ that$]$ $[_{NP}$ gasoline can$]]$ $[_{VP}$ explode$]]]$
‘I saw that can of gasoline explode’.

In syntactic ambiguity, semantic information is encoded in the syntax, that is, gives the relevant information to compute the linguistic interpretation of the sentence.

Within semantic ambiguity, we have only one S-structure and one D-structure, but two Logical Forms. In this case, ambiguity is not caused by syntax, but by semantics which provides two different Logical Forms, as in (4), receiving interpretations (5) and (6) :

(4) Every man loves a woman.

(5) $\forall x[man(x) \rightarrow \exists y\ [woman(y) \wedge love(x,y)]]$
‘For any *x*, if *x* is a man, then there is a *y*, such that *y* is a woman and *x* loves *y*’.

(6) $\exists x \forall y\ [woman(x) \wedge man(y) \rightarrow love(y,x)]$
‘There is a *x*, such that for any *y*, *x* is a woman and *y* is a man and *y* loves *x*’.

Interpretation of anaphora is the second type of syntax-semantics interface, shown in (7) and (10). In these sentences, the anaphora (*his, he*) is not interpreted as the resumption of its antecedent (*every Englishman, every sprinter*), because such interpretations would incorrectly yield (8) and (11) instead of (9) and (12) :

(7) Every Englishman loves his mother.

(8) Every Englishman loves every Englishman’s mother.

(9) For any x such that x is an Englishman, x loves his mother.

(10) Every sprinter hopes that he will win.

(11) Every sprinter hopes that every sprinter will win.

(12) For any x such that x is a sprinter, x hopes that x will win.

The logical interpretation of (7) and (10) is not the result of a linguistic (syntactic) rule as “Replace every possible antecedent (*every sprinter*) by the corresponding anaphoric pronoun (*he*)”. It means that the quantification rules responsible for the correct interpretation of *every N* are not projected at the level of syntax, as we will see in the next section.

1.1.2 Semantics-pragmatics interface

Disambiguation is one of the main arguments for a semantics-pragmatics interface. The disambiguation problem can be stated as following : How will the hearer make the relevant choice when an utterance supports two or more interpretations ? Recall that linguistic interpretation says nothing about how such a choice is made. This implies that pragmatics has to make predictions about the match between context and interpretations. How does this work ? We can imagine that some interpretations are default interpretations, that is, more accessible without any other specifications. These default readings can be illustrated by the specific/generic contrast given in (13), which has the default and preferred specific reading (14) rather than the generic dispreferred one (15) :

(13) Jack bought *Libération* this morning.

(14) Jack bought one exemplar of *Libération*.

(15) Jack bought the Press Group publishing *Libération*.

Some preferred interpretations are not default ones, but the result of context preferences. For instance, Mary's answer would receive in ordinary circumstance a negative interpretation (she just want to have a good night of sleep), and a positive one in a marked context (she has to work all the night for instance) :

(16) Peter : Do you want some coffee ?
Mary : Coffee would keep me awake

(17) Mary does not want any coffee.

(18) Mary wants some coffee.

This last example shows that to get the positive or the negative answer reading, Peter has to make inferences. As inferences are based on contextual assumptions and can lead to false contextual implications, they are non-demonstrative. The two readings can be made more explicit in (19) and (20), where the results of inference (contextual implications) are by-products of contextual information (contextual assumptions) and utterances :

(19) Contextual assumption : Mary does not want to stay awake.
Utterance : Coffee keeps Mary awake.
Contextual implication : Mary does not want any coffee.

(20) Contextual assumption : Mary wants to stay awake.
Utterance : Coffee keeps Mary awake.
Contextual implication : Mary wants some coffee.

1.1.3 The domains of semantics and pragmatics

What is then the domain of semantics and pragmatics ? Traditionally, semantics deals with two basic topics, which are closely related : lexical semantics and compositional semantics.

- Lexical semantics is about representation of words meaning, defined as complex meaningful units. Lexical semantics is based on the hypothesis that word meaning is structured and context sensitive, that is, can vary with different contexts [2].
- Compositional semantics is about representation of sentences meaning, defined as compositional [3]. We will here hypothesize that sentence meaning underspecifies utterance interpretation, that is, gives no more information than linguistic encoded information [4].

Defining semantics as the domain of lexical and compositional meaning is not precise enough. We have to know what meaning is, that is, what meaning is about. In classical formal semantics, *meaning* is something that is not language and is defined by the relation of *denotation*. The denotations of expressions (lexicon, sentences) can be entities (terms), properties and relations (predicates), and states of affairs as eventualities or situations (propositions). However, the computation of semantic meaning is a necessary but not a sufficient condition for utterance interpretation, because utterance (full) interpretation implies not only the computation of what is said, that is, the proposition conveyed by the uttered sentence, but also the computation of what is communicated, that is, the proposition implicated by the utterance.

What then is pragmatics about ? First, pragmatics is about *contextual meaning*, that is, *meaning in use*, which includes *implicatures* or indirect meaning and *explicatures* or truth-conditional meaning. Another way of defining the scope of pragmatics is to represent meaning in use as the result of interactions between *linguistic knowledge* (LK) and *world knowledge* (WK), which implies that pragmatic meaning is computed through inferences, frames and scripts. The last property of pragmatics connects language (in use) and communication. We will see how general principles of communication (cooperation, relevance) play a role in the computation of meaning in use (§ 1.4).

1.2 Formal Semantics

Formal semantics is the sub-part of formal linguistics that deals with the description of linguistic meaning. Formal linguistics is based on two basic assumptions, called by Emmon Bach Chomsky's thesis and Montague's thesis, referring to the two main linguists and philosophers at the origin of formal syntax and formal semantics [5] :

- Chomsky's thesis : Natural languages can be described as formal systems.
- Montague's thesis : Natural languages can be described as *interpreted* formal systems.

Formal semantics is thus the domain of semantics that studies meaning within formal logical languages. Meaning is defined as a denotation relation between a linguistic expression and an entity of the world (meaning is something which is not language). In other words, words refer to objects (or individuals), and sentences are about events, states, processes, etc. A formal semantics assigns truth-values to sentences, meaning that a sentence is true if and only if its description is the case in the world. Truth-values belong to {0,1}, and the world is restricted to a situation called a *model*. Formal semantics is thus *model-theoretic semantics*.

1.2.1 Model-theoretic semantics

A model-theoretic semantics is a formal system containing an explicit set of syntactic rules and an explicit set of corresponding semantics rules.

A model M is an ordered pair <A, F>, where A is a set of individuals and F a function assigning semantic values (*denotations*) to basic expressions. A *basic expression* is a non-logical constant, whereas logical constants are the *logical connectives* (□, , □ , □ ,□). Semantic values (of any type of expressions) are denotations and defined relatively to A.

Here is a small model for a predicate language :

- A = {Chandler, Joey, Monica, Rachel}, that is, the set of individuals composed by Chandler, Joey, Monica and Rachel (some of the characters of *Friends*).
- Basic Expressions are *terms* and *predicates* (one-place and two-places-predicates) : terms are *c, j, m, r*, where *c, j, m, r* stands respectively for the (proper) names *Chandler, Joey, Monica and Rachel ;* one-place predicates are *W, S*, where *W* stands for *works* and *S* for *sleeps ;* two-place predicates are *K, H,* where *K* stands for *knows* and *H* for *hates*.

- F gives a denotation to every Basic Expression, that is, individuals for terms, sets of individuals for one-place predicates, and sets of ordered pairs of individuals for two-places predicates : F(*c*)=Chandler, F(*j*)=Joey, F(*m*)=Monica, F(*r*)=Rachel, F(*W*)={Monica, Chandler}, F(*S*)={Joey, Rachel}, F(*K*)={<Rachel, Monica>, <Joey, Chandler>, <Monica, Chandler>, F(*H*)=∅.

Let's now give the minimal required set of syntactic and semantic rules for a small formal predicate language allowing the computation of sentences (*formulas*) and meanings within this language. The syntactic rules are given by (R1) and (R2) and the semantic rules by (S1) and (S2) :

(R1) If *P* is a one-place predicate and *T* is a term, then *P*(*T*) is a formula.

(R2) If *R* is a two-place predicate and *X* and *Y* are terms, then *R*(*X*, *Y*) is a formula.

(S1) A formula (from R1) is true, if and only if (iff) the argument denotation belongs to the predicate denotation (formally, $[[P(T)]]=1$ iff $[[T]] \in [[P]]$).

(S2) A formula (from R2) is true iff the argument ordered pairs belong to the predicate denotation (formally, $[[R(X,Y)]]= 1$ iff $< [[X]], [[Y]]> \in [[R]]$).

What is the denotation of a formula ? Let's take the formula *K(r,m)*, which could be translated in English by *Rachel knows Monica*. The question is the following : is this formula true or false and how can we compute its truth-value ? Intuitively, this formula is true iff Rachel knows Monica, i.e. if the ordered pair <Rachel, Monica> belongs to the set of ordered pairs defining the denotation of the predicate *K*, i.e. F(*K*). Formally, $[[K(r,m)]]^M = 1$, iff $< [[r]]^M, [[m]]^M> \in [[K]]^M$. As $<[[r]]^M, [[m]]^M> \in [[K]]^M$, the formula is true, and $[[K(r,m)]]^M=1$.[1]

What then about complex formulas ? The principle of analysis if the following : the denotation of a complex formula depends on the denotations of its under-formula. Let's give a new syntactic and a new semantic rule, belonging to propositional logic, that is, the logic dealing with propositions :

(R3) If *F* and *G* are formulas, then $[F \wedge G]$ is a formula.

(S3) If *F* and *G* are formulas, then $[[F \wedge G]]=1$ iff $[[F]]=1$ and $[[G]]=1$.

What about the formula $W(c) \wedge K(m,c)$? Is it true or false ? It is true if each of its under-formula is true, that is, if *W*(*c*) and *K*(*m,c*) are true. We moreover know that $[[W(c)]]^M=1$, because $[[c]]^M \in [[W]]^M$, and we can affirm that $[[K(m,c)]]^M=1$, because $<[[m]], [[c]]> \in [[K]]^M$. Thus $[[W(c) \wedge K(m,c)]]^M = 1$.

1.2.2. Predicate calculus

Predicate calculus is a logical language introducing individual variables and quantifiers binding variables. In predicate calculus, quantifiers are introduced by quantification rules, given here in (R3) :

(R1) If □ is a one-place predicate and □ a term, then □(□) is a formula.

(R2) If □ et □ are formulas, then [□ □ □] is a formula.

(R3) If □ is a formula et *u* a variable, then □*u*□ is a formula.

(R3) introduces the universal quantifier ∀ (∀*u* means « for every *u* »). Quantified formulas are thus the results of a derivation, whose last step is the introduction of the quantifier through a rule like (R3). In order to derive a sentence like *Every*

[1] $[[\square]]^M$ stands for « the denotation of □ relative to M ».

student walks, where *student* is *S* and *walks* is *W* in our predicate calculus, we apply (R1) twice, then (R2) and finally (R3), as following :

1. $S(x)$, from (R1).
2. $W(x)$, from (R1).
3. $[S(x) \rightarrow W(x)]$, from (R2).
4. $\forall x[S(x) \rightarrow W(x)]$, from (R3).

In this language, quantifiers are introduced by syntactic rules, and thus do not belong to the set of basic expressions (they are *syncategorematic* expressions). If predicate calculus is used to express quantification in natural language, we should be able to justify the introduction of variables into natural language, as in (21) and (22) :

(21) Every Frenchman loves his mother.

(22) Every Frenchman beliefs that he is a grammarian.

The readings we propose are respectively given in (23) and (24) [6] :

(23) For every value of v_1 which is a Frenchman, v_1 loves v_1's mother.

(24) For every value of v_1 which is a Frenchman, v_1 believes that v_1 is a grammarian.

The justification of the introduction of variables in natural language is thus the following : quantification in natural language introduces covert bound variables that appear at the stage of derivation. Their treatment as syncategorematic expressions is thus justified.

We can now give a small predicate calculus for natural languages, where V_i stand for Intransitive Verb, V_t for Transitive Verb, *For* for Formula, *Neg* for Negation, *Conj* for Conjunction, *CN* for Common Noun :

($\mathcal{R}$1) If α is a V_t and β is a *N*, then αβ is a V_i.

($\mathcal{R}$2) If α is a V_i and β is a *N*, then βα is a *For*.

($\mathcal{R}$3) If α is a *Neg* and β is a *For*, then αβ is a *For*.

($\mathcal{R}$4) If α is a *Conj* and β and γ are *For*, then βαγ is a *For*.

($\mathcal{R}$5) If α is a *CN*, *u* a variable and β a *For* containing at least one occurrence of *u*, then β' is a *For*, where β' comes from β by replacing the left most occurrence of *u* by *every* α and every subsequent occurrence of *u* by *that* α.

($\mathcal{R}$6) *Idem* for *some*.

($\mathcal{R}$7) *Idem* for *the*.

Rules of quantification ($\mathcal{R}$5, $\mathcal{R}$6 and $\mathcal{R}$7) apply thus to formulas containing variables (if this were not the case, the quantification would be vacuous) and introduces both quantifier and *CN*. We will see in next section the role of *CN* in quantification, but the lack of such lexical information would produce, instead of sentence (25), sentence (26) :

(25) Some student works.

(26) Someone works.

The derivation of (25) passes through the following steps : 1. v_1 *works*, by ($\mathcal{R}$1), 2. *some student works*, by ($\mathcal{R}$6), which substitutes v_1 by *some student*.

How can we represent the syntactic derivation of a complex quantified sentence like (4) ? Let's repeat (4) in (27), which has two readings, given in (28) and (29). These two readings are described in derivations given in Fig. 1.3 and 1.4 :

(27) Every man loves a woman.

(28) $\forall x$ [*man*(x) $\rightarrow$ $\exists y$ [*woman*(y) $\wedge$ *love*(x,y)]]
‘For any x, if x is a man, then there is a y, such that y is a woman and x loves y’.

(29) $\exists x \forall y$ [*woman*(x) $\wedge$ *man*(y) $\wedge$ *love*(y,x)]
‘There is a x, such that for any y, x is a woman and y is a man and y loves x’.

Figure 1.3 First reading.

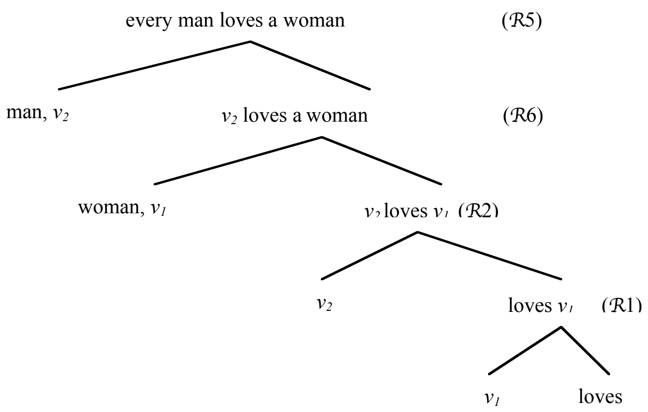
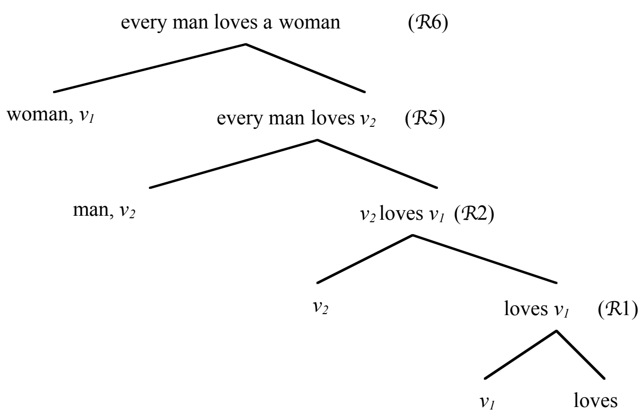


Figure 1.4 Second reading.



The difference in reading is thus a difference in the order of application of the quantification rules. Reading (28) has as order ($\mathcal{R}$6) then ($\mathcal{R}$5), whereas for (29) the reverse order stands. Note that these analyses do not say anything about the preferred reading. Both are structurally possible, syntactically and semantically.

1.2.3 Quantifiers interpretation

To interpret quantifiers, it is necessary to introduce a function that assigns a value to variables within the set of individuals defining the universe of discourse, that is, the set of individuals A. This function *g* is a function that attributes as denotation individuals to variables. The role of *g* is to restrict the interpretation of a variable to a specific (arbitrary) individual picked in A. In effect, a formula like v_1 *works* does not have to be true for all possible assignations of value *g* to the variable v_1.

What is relevant is to test the subset of individuals defined by the Common Noun introduced by the quantification rule, here the subset defined by the denotation of the *CN student*. The function of the introduction of a *CN* within the quantification rule now appears clearly : quantification introduces a relation between sets of individuals, that is, the set of individuals introduced by the Common Noun (its semantics is the same as for a one-place predicate) and the set of individuals denoted by the predicate. So the semantic interpretation of (30) is given by (31) :

(30) Every student works.

(31) ⟦student⟧ □ ⟦works⟧

The basic problem in a formal semantics for natural language is how to express sets within a formal language. Given that quantification is a relation between sets of individuals, a formal language expressing set relations would allow a formal representation of quantification in natural language. Fortunately, there is such a language (□-calculus), including a □□operator. The □□operator makes it possible to build sets from formulas, as shown by rule in (32) :

(32) If □ is a formula, then □*x*□ denotes a set.

Intuitively, the function introduced by the □□operator characterizes the set specified by □ relative to the variable *x*.

As □ is a functional operator, it allows the abstraction of predicates, that is, the formation of a set of individuals from a formula, as in (33) :

(33) If *A*(*x*)(*j*) is a formula (*John loves x*), then □*x*[*A*(*x*)(*j*)] is the set of individuals that John loves.

Two operations, within a formal language containing the □□operator, are responsible for the relations between sets and formulas :

- □*-abstraction* is the operation building sets from formulas : *A*(*x*)(j) □ □*x* [*A*(*x*)(*j*)].
- □*-conversion* is the operation building formulas from sets : □*x*[…*x*…](□) □ […□…] (replace all free occurrences of variable *x* in […*x*…] by □.).

How can we then assign denotations to sets relations defining quantification in natural languages ? First of all, let's recall the classical denotation of quantified sentences given by predicate calculus.

Table 1.1 Logical translations of quantified sentences.

English sentences	*Logical translations*	*English translations*
Every student works.	□x[S(x) □ W(x)]	For any *x* which is a student, *x* works.
Some student works.	□x[S(x) □ W(x)]	There is at least one *x* which is a student and *x* works.
No student works.	¬□x[S(x) □ W(x)]	There is no *x* such that x is a student and *x* works.

Let's take the sentence *Every student works.* Its meaning says that the property of working has the second order property of being true of every student. This property can be expressed by a variable of predicate *P*. In this case, if the formulas containing *P* are true, the quantified sentences are true.

- $\forall x[S(x) \rightarrow \boldsymbol{P}(x)]$
- $\exists x[S(x) \wedge \boldsymbol{P}(x)]$
- $\neg\exists x[S(x) \wedge \boldsymbol{P}(x)]$

What does this mean ? Simply that these formulas are true of all predicates which are true of *every students*. So we know something about the quantified expression (*all students*) : it is true of a set of predicates, denoted by the variable *P*. To get the value of the quantified expressions, we have to abstract over these formulas, as tab. 1.2 shows:

Table 1.2 Denotations of quantified *NPs*.

Quantified NP	*Denotations of quantified NP*	*English translations*
Every student	$\lambda P[\forall x[S(x) \rightarrow P(x)]]$	The set of predicates true of all students.
Some student	$\lambda P[\exists x[S(x) \wedge P(x)]]$	The sets of predicates true of at least one student.
No student	$\lambda P[\neg\exists x[S(x) \wedge P(x)]]$	The set of predicates true of no student.

As these formal expressions denote sets, we get now formal expressions of quantified expressions in natural language. To obtain a formula, we have to apply the value of the quantified expression to that of the predicate :

Table 1.3 λ-expressions for quantified sentences.

English sentences	*λ-expressions*	*λ-conversions*
Every student works	$\lambda P[\forall x[S(x) \rightarrow P(x)]](W)$	$\Rightarrow \forall x[S(x) \rightarrow W(x)]$
Some student works	$\lambda P[\exists x[S(x) \wedge P(x)]](W)$	$\Rightarrow \exists x [S(x) \wedge W(x)]$
No student works	$\lambda P[\neg\exists x [S(x) \wedge P(x)]](W)$	$\Rightarrow \neg\exists x[S(x) \wedge W(x)]$

What we get is the classical predicate-calculus interpretations. To find the value of the quantifier (*every, some, no*), we have to abstract a new predicate variable from the non-logical constant of the quantified *NP*. This new predicate variable takes as its value the set of properties associated to the Common Noun composed with the quantifier (*Q*) :

Table 1.4 Denotations of quantified *NPs*.

English quantifiers	*λ-expressions*	*English translations*
every	$\lambda Q[\lambda P[\forall x [Q(x) \rightarrow P(x)]]]$	The sets *Q* of sets *P* of predicates such that for every *x* being *Q*, *x* is *P*.
some	$\lambda Q[\lambda P[\exists x [Q(x) \wedge P(x)]]]$	The sets *Q* of sets *P* of predicates such that for at least one *x* being *Q*, *x* is also *P*.
no	$\lambda Q[\lambda P[\neg\exists x [Q(x) \wedge P(x)]]]$	The sets *Q* of sets *P* of predicates such that for no *x* being *Q*, *x* is *P*.

The next step is to show how we can build quantified *NPs* from quantified expressions and *CNs* :

Table 1.5 Denotations of quantified *NPs*.

Quantified NPs	*λ-expressions*	*β-conversions*
Every student	$\lambda Q[\lambda P[\forall x[Q(x) \rightarrow P(x)]]](S)$	$\Rightarrow \lambda P[\forall x[S(x) \rightarrow P(x)]]$
Some student	$\lambda Q[\lambda P[\exists x[Q(x) \wedge P(x)]]](S)$	$\Rightarrow \lambda P [\exists x[S(x) \wedge P(x)]]$
No student	$\lambda Q[\lambda P[\neg\exists x[Q(x) \wedge P(x)]]](S)$	$\Rightarrow \lambda P[\neg\exists x[S(x) \wedge P(x)]]$

Finally, the last step is to build quantified sentences from quantifiers, *CNs* and *VPs* (one-place predicates) :

Table 1.6 Denotations of quantified sentences.

Quantified sentences	*λ-expressions*	*β-conversions*
Every student works.	$\lambda Q[\lambda P[\forall x[Q(x) \rightarrow P(x)]]](S)(W)$	$\Rightarrow \forall x[S(x) \rightarrow W(x)]$
Some student works.	$\lambda Q[\lambda P[\exists x[Q(x) \wedge P(x)]]](S)(W)$	$\Rightarrow \exists x[S(x) \wedge W(x)]$
No student works.	$\lambda Q[\lambda P[\neg\exists x[Q(x) \wedge P(x)]]](S)(W)$	$\Rightarrow \neg\exists x[S(x) \wedge W(x)]$

Is it possible to derive syntactically quantified sentences, compose their logical forms and compute their truth-values ? As every expression of the formal language has an expression and a logical translation, it not difficult any to derive, translate and interpret quantified sentences. Here are the relevant derivation processes :

Table 1.7 Computation of semantic interpretations.

Syntactic derivations	*Logical translations*	*Semantic interpretations*
[*every*] ; [*student*] ; [*works*]	$\lambda Q[\lambda P[\forall x [Q(x) \rightarrow P(x)]]]$; S ; W	⟦*every*⟧ ; ⟦*student*⟧ ; ⟦*works*⟧
[*every student*] ; [*works*]	$\lambda P[\forall x[S(x) \rightarrow P(x)]]$; W	⟦*every student*⟧ ; ⟦*works*⟧
[*every student works*]	$\forall x[S(x) \rightarrow W(x)]$	⟦*every student works*⟧

1.3 Event semantics

Classical formal semantics aims to assign truth-values to sentences, that is, to propositions expressed by sentences. A proposition is thus the semantic content of a sentence evaluated as true or false. If some sentences like quantified sentences express propositions, lots of sentences describe events. An event is a type of state of affairs described in a sentence, located in time, having aspectual properties, i.e. bounded or unbounded, telic or atelic, accomplished or non-accomplished, terminative, continuative or inchoative.

Whereas classical logic does not represent time (reasoning is timeless), some proposals have been made to introduce temporal (*instants*) and event variables into predicate calculus ([7], [8]). For instance, a standard event semantic representation of (34), given in (35), introduces two variables, one for the event and the second for the time of the event :

(34) Brutus killed Cesar.

(35) $\exists e \exists t\ [kill(e) \wedge \text{agent}(Brutus,e) \wedge \text{patient}(Cesar, e) \wedge \text{happen}(e,t) \wedge (t < t_0)]$

‘There is an event *e* and an instant *t* such that *e* is *kill*, *Brutus* the agent of *e*, *Cesar* the patient of *e*, and *e* happens at *t*, and *t* occurred before t_0 *(now)*.’

Another way of introducing time in logical forms is given by intensional logic (a higher order logic), which indexes propositions relatively to moments and possible worlds. So (34) will receive as semantic interpretation (36) :

(36) $[\![$PAST[*kill*(*Cesar*)(*Brutus*)] $]\!]^{M,g,I,W}$= 1, iff the proposition [*kill*(*Cesar*)(*Brutus*] is true in a given model *M*, with respect to the function *g*, at a moment *i* and in a possible world *w*.

1.3.1 Time and tenses

These two classical ways of representing time within formal logic (either classical or higher order logic) encounter nevertheless serious problems in time representation, and in describing semantic interpretation of verbal tenses in natural languages. A trivial illustration is given by examples like (37)-(39) with English pluperfect, progressive past, and simple past :

(37) Mary had called.

(38) Mary was calling.

(39) Mary called.

If it is true that these sentences all state that the proposition *call(Mary)* is true at a past moment, the use of a logical past operator like (40) is not sufficient to grasp their meanings :

(40) PAST[*call*(*Mary*)]

The reason for this are the differences in meaning encoded by tenses relative to temporal reference (the time at which the event occurred) and the temporal relations between events they imply. This can be shown by the following discourses :

(41) John entered the room. Mary had called.

(42) John entered the room. Mary was calling.

(43) John entered the room. Mary called.

In these discourses, Mary's call happens before John enters the room (41), includes John's entering the room (42) and follows John's arrival (43). One important conclusion driven from these facts is that truth is not about sentences, but about discourses. Thus temporal information encoded by tenses is not truth-conditional : tenses encode relations between events represented in discourses.

The consequence is that defining temporal reference is tantamount to defining the moment of time (point, interval) true of the event, the temporal relations between events and the aspectual class of the event. For instance, the calling event is represented as unbounded in (42) and as bounded in (43), and the calling eventuality is represented as an activity in (42) and as an event in (41) and (43).

What are the possible aspectual classes for sentences describing eventualities ? Classical event semantics makes ontological distinctions between states (44), activities (45), accomplishments (47) and achievements (48) [9] :

(44) Mary knows John.

(45) Mary is running.

(46) Mary has built her house.

(47) Mary has reached the summit.

We will give further information about aspectual classes in § 1.3.2.3.

1.3.2 Intervals, Speech point, Reference point and Event point.

The delimitation of the temporal interval is also crucial for temporal reference determination. For instance, the length of the interval between the Event point (*E*) and the Speech point (*S*) is not encoded in a tense like *present perfect*. Though (48) and (49) have a structurally identical logical form, given in (50) and (51), they do not convey the same temporal information :

(48) I have had lunch.

(49) I have been to Tibet.

(50) PAST [*have_lunch*(*I*)]

(51) PAST [*be_to_Tibet*(*I*)]

In other words, the same information is semantically encoded, but the temporal interval [*E* ; *S*] is not pragmatically the same. So the determination of temporal reference includes the determination of temporal intervals between *S* and *E*, but imposes also another time location, the Reference point (*R*). Here are more precise definitions of these three temporal coordinates.

- *S* is defined as the time including or identical to the moment of the utterance. For instance, *now* encodes the temporal identity between *S* and *E* [*S*=*E*], whereas *today* encodes the inclusion of *S* in *E* : [$S \subset E$].
- *E* defines the moment (point or interval) in which the event happens. For instance, *yesterday* says that *E* is before *S* and the interval between *E* and *S* is one day : [*E*<*S*] $\wedge$ [*E* ; *S*] = one day.
- *R* is the moment of the time from which *E* is computed. *R* can be identical, precede or follow *S* or *E* : [*R*=*S*], [*R*<*S*], [*R*>*S*], [*R*=*E*], [*R*<*E*], [*R*>*E*]. For instance, in (52), *E* is identical to *R* and precedes *S* [*E*=*R*<*S*], whereas in (53), *E* precedes *R* which precedes *S* [*E*<*R*<*S*] :

(52) On Tuesday 26 of February, Jacques wrote his semantics courses.
R = Tuesday 26 of February
E = Tuesday 26 of February
S = Tuesday 5 of March

(53) When Max arrived, Mary had gone out.
E = the moment when Mary went out
R = the moment when Max arrived
S = the moment of the utterance

1.3.3 Aspectual classes

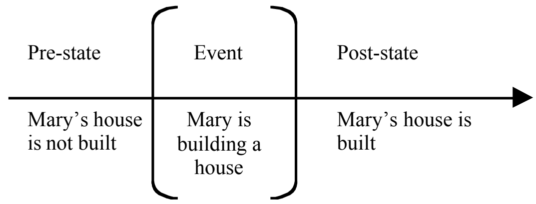
What are the basic aspectual classes expressed by sentences ? The basic aspectual classes are states and events. As we shall see, states and events are dynamically related.

Events are processes that happen in a period of space-time, defined by an initial and a terminal bound (the temporal interval defined by initial and terminal bound is the Event time) and are preceded by a pre-state and followed by a post-state. Let's take a classical example (of accomplishment) given in (54) :

(54) Mary has built a house.

In this example, the pre-state is the state where Mary's house is not build, the event is the building of a house by Mary, and the post-state the state where Mary's house is built. So what happens in event structure is a double relation between an event and states : first, the event destroys a pre-state and creates a new state (*resulting state*) ; second, the relation between the event and the post-state is causal. Fig. 1.5 gives an explicit drawing of the situation described :

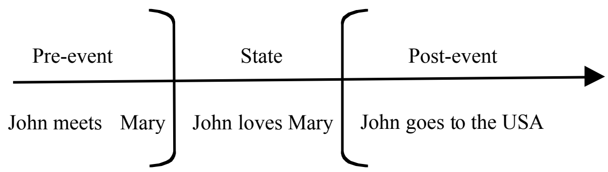
Figure 1.5 Structure of an event.



States have properties opposite to those of events, that is, are unbounded, have a duration in time, no initial nor terminal bounds, are homogenous and no change happens between the initial and the terminal bound if they have some. A state is preceded by a pre-event that creates it and followed by a post-event that destroys it. Example (55) is drawn in Fig. 1.6 :

(55) John loves Mary.

Figure 1.6 Structure of a state.



We can now give a more precise definition of aspectual classes. States are not directly opposed to events, but to processes.

- *States* are unbounded (they have no initial nor terminal bounds), atelic (they do not culminate, they have no intrinsic *telos*) and homogenous (no change occurs during a state). Examples of states are given in (56)-(58) :

(56) John is sick.

(57) John loves Mary.

(58) John knows Mary.

- *Processes* are intrinsically or extrinsically bounded, telic or atelic, homogenous or not homogenous, whether there are *activities* or *events*. So there are two types of processes, activities or events.

- *Activities* are atelic, not intrinsically bounded, homogenous, but contrary to states, they are dynamic (something happens during an activity). (59)-(61) are examples of activities :

(59) John is reading a book.

(60) John is running.

(61) Mary is pushing a cart.[2]

- *Events* are telic, bounded, non-homogenous, that is, composed of phases (initial, median and terminative) or sub-events. A classical example of event is given in (62) :

(62) Mary is drawing a circle.

Events are of two types, depending of the duration criterion : accomplishments and achievements.

- *Accomplishments* are telic, bounded, non-punctual and durative. (62) and (54) are typical examples of accomplishments.
- Finally, *achievements* are telic but punctual, as show (63) and (64) :

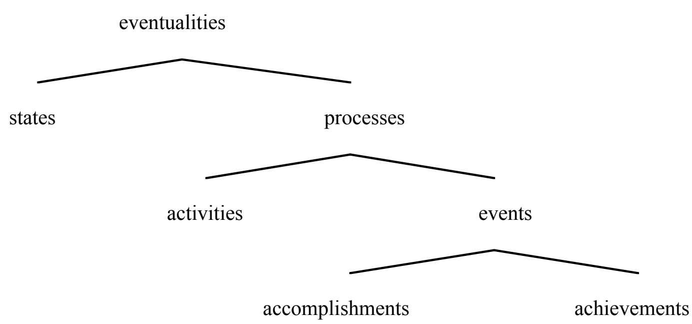
(63) Mary has reached the summit.

(64) Mary has won the race.

The given analysis of achievement implies that any moment preceding reaching of the summit or winning the race does not belong to the event. Achievements thus make a sharp separation between what happens before and after the event.

Fig. 1.7 gives a summary of the classical analysis of aspectual classes.

Figure 1.7 Typology of eventualities.



1.4 Discourse semantics

The main purpose of event semantics is the analysis of the eventualities described within sentences. Even if truth-conditions of eventuality sentences are discourse dependent, event semantics is not a theory of discourse. Nevertheless, discourse has

[2] In English, a crucial formal difference between activities and states is the progressive aspect. Whereas the progressive is possible with activities, the progressive form with states leads to different meanings (*John is being sick, John is loving Mary, John is knowing Mary*), that is, activity meanings.

been studied for about thirty years from the point of event semantics and classical formal semantics. What is called nowadays discourse semantics are *dynamic semantics* whose purpose is to give explicit interpretations of sentences relative to informations accessible from discourse, world knowledge and linguistic knowledge.

Discourse semantics are called *dynamic* because the state of the world in which sentences are interpreted changes along the discourse. This property of discourse semantics contrasts very strongly with classical formal semantics, like model-theoretic semantics : classical formal semantics are static semantics, i.e. they crucially depend of what the model says about the world. Discourse semantics takes into account a crucial property of discourse : information about the world can change throughout the discourse.

The principal types of dynamic semantics are File Change Semantics [10], Discourse Representation Theory [11], Segmented Discourse Representation Theory [12] and Dynamic Aspect Trees [13]. Even if these theories are dynamic, they all share the main hypothesis of formal semantics, that is, Montague's thesis : natural languages are interpreted formal systems.

One of the main topics developed by discourse semantics is Discourse Relations.

1.4.1 Discourse relations

A Discourse Relation (DR) is a relation between segments of discourse the extension of which is an eventuality. DRs determine the interpretation of a discourse segment relative to another one. They are limited in number and the main DRs are Narration, Explanation, Elaboration, Background and Result. Here are their definitions [14] :

- *Narration*(α,β) : the event described in discourse segment β is a consequence of event described in *a*.

(65) Max stood up. John greeted him.

- *Explanation*(α,β) *:* the event described in β explains why α's event happened.

(66) John fell. Max pushed him.

- *Elaboration*(α,β) *:* β's event is a part of α's.

(67) The council built the bridge. The architect drew up the plans.

- *Background*(α,β) *:* the state described in β is the « backdrop » or circumstances under which the event in α occurred.

(68) Max opened the door. The room was pitch dark.

- *Result*(α,β) *:* the event described in α caused the event or state described in β.

(69) Max switched off the light. The room was pitch dark.

DRs express thus temporal (Narration) as well as causal (Explanation) inferences. Typically, these inferences are defeasible. They are based on states of the world that can trigger or block them. Defeasible inferences are what logicians call *default inferences*. By definition, a default inference holds if no specific condition blocks it. In more general terms, discourse semantics is a default inference theory.

1.4.2 Defeasible inferences

Let's start with a basic classical inference rule, like *modus ponens*. Standard *modus ponens* given by propositional logic says that if the conditional proposition (P□ Q) and the antecedent of the conditional P hold, then the consequent Q holds. This rule is deductive : if the premises are true, the conclusion is true, whatever the content of P and Q is. This rule can be stated as following : P □ Q, $P \models Q$. For instance, if premises (70) and (71) are true, then conclusion (73) is also true, for a logical reason and the inference is valid.

(70) If you work, you will succeed.

(71) You work.

(72) You will succeed.

Thus, the conclusion holds if the premises are true.

Now, what about a defeasible inference rule like the *defeasible modus ponens*. This rule states that, if normally □ entails □ (□ >□) and □ are the case, then one can conclude □ (□ >□, □ $\approx$ □). For instance, if you know (73) and (74), you can conclude (75).

(73) Birds normally fly.

(74) Tweety is a bird.

(75) Tweety flies.

But this conclusion is not logically true : it is true iff Tweety is a bird that can fly (i.e. not a penguin). This example shows that defeasible inference rules do not warrant the truth of their conclusions. These reasonings are for this reason called *non-monotonic*.

Discourse semantics like SDRT [12] makes a crucial hypothesis : Discourse Relations are defeasible inferences. They hold unless there is contrary information that defeats them. If such contrary information is stronger, then the inference is defeated. One consequence is that default defeasible DRs are the less specific ones. In effect, if a DR is defeated, a more specific DR replaces it. For instance, Explanation is more specific than Narration and Elaboration is more specific than Narration. So Narration is the less specific DR.

Narration is defined by a defeasible Rule of Narration and a non-defeasible Axiom of Narration [14] :

- *Rule of Narration* : If the clause □ currently being processed is to be attached by a DR to the clause □ that is part of the text processed so far, then normally, *Narration(□,□)* holds.
- *Axiom of Narration* : If *Narration*(□,□) holds, and □ and □ describe eventualities e_1 and e_2 respectively, then e_1 occurs before e_2.

So, when a narrative discourse □.□ is processed, the first hypothesis is that Narration holds. This hypothesis can be defeated, but if no stronger information occurs, events are temporally ordered as the discourse presents them, and the temporal relation is *immediate* temporal precedence.

What are then the criteria for licensing or canceling a defeasible inference ? Defeasible inferences belong to Linguistic Knowledge (LK). A typical instance of LK is « segment □ follows segment □ ». In contrast, information allowing to defeat a defeasible inference belongs to World Knowledge (WK), as for example *Drawing* *a bridge's plans* is a part of *building the bridge*. The principle allowing the license of the cancellation of a temporal defeasible inference is the following *:* « use WK to check whether the inference allowed by LK holds ».

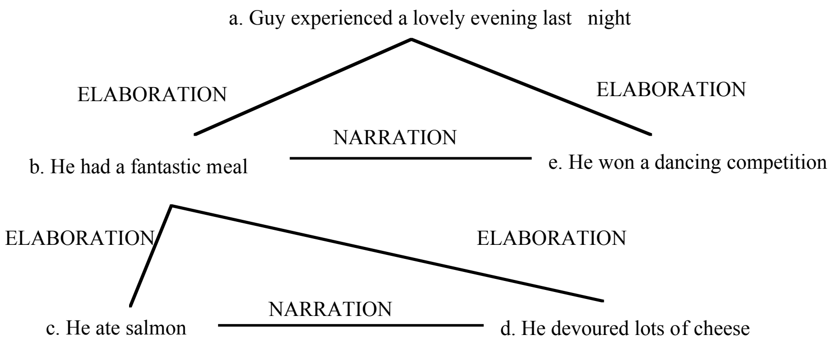
1.4.3 Discourse Structure

What is the function of Discourse Relations ? In discourse semantics, DRs are conditions for computing the interpretation of the current discourse segment and building up a *discourse structure*. So discourse structures are representations of relations between eventualities described within discourses. Let's take a classical example of discourse showing how the computation of Discourse Relations allow the computation of Discourse Structures [14] :

(76) (a)Guy experienced a lovely evening last night. (b) He had a fantastic meal. (c) He ate salmon. (d) He devoured lots of cheese. (e) He won a dancing competition.

What is interesting in this example is that Narration has to be blocked between (a)-(b), (b)-(c) and (d)-(e), in favor of Elaboration. Fig. 1.8 gives an explicit discourse structure for (76).

Figure 1.8 Discourse structure



I would like to conclude this brief introduction to discourse semantics by presenting a short fragment of a formal theory of discourse, Discourse Representation Theory (DRT). In DRT, the crucial information for discourse comprehension is stored in Discourse Representation Structures (DRS). A DRS-K is a box containing two types of information : (i) Discourse referents (U_k), as individuals (*x, y, z*), events (e_1, e_2, e_3) and the speech point (*n*) ; (ii) Conditions on *DRS-K* (Con_k), that is, specifications of referents and their relations. Conditions are predicates applied to individuals. A DRS-K is formally a 2-uple of discourse referents and conditions : $K = \langle U_k, Con_k \rangle$.

Let's take a final example, given in (77) [15], and its DRS in Fig. 1.9 :

(77) (a) Nicholas left Austin. (b) He flew to Toulouse. (c) There, he went to a restaurant with Sheila.

Figure 1.9 Discourse Representation Structures.

Nicholas left Austin	x y e1 n
	Nicholas(x) Austin(y) e1: leave(x,y) e1< n

He flew to Toulouse.	x z v e1 e2 n
	z : x e2: fly-to (z,v) Toulouse (v) e2< n e1< e2

There, he went to a retaurant with Sheila.	x z' w u t v e1 e2 e3 n
	z' = x Sheila(w) restaurant(u) t = v e3: go-to(z'⊕w,u) in(e3,t) e3 < n e2 < e3

The DRS will introduce first discourse referents (*x, y,* e_1 and *n*), and the conditions on these discourse referents : *Nicholas*(*x*)*, Austin*(*y*)*,* e_1 *:leave*(*x,y*)*,* $e_1<n$. Each new sentence introduces new referents, which are associated to previous referents if co-reference is the case. For instance, the new referent *z* (*he*) in (b) is identified to *x* (*Nicholas*). Finally, each event is related to the previous one by a temporal relation : $e_1<e_2$, $e_2<e_3$.

1.5 Conclusion

The purpose of this short introduction to formal semantics was to make accessible the main problems and domains of formal semantics. Contemporary semantic studies are principally interface studies, either with syntax or with pragmatics, and dynamic approaches to meaning. This last property makes the division of linguistic work crucial, especially with regards to pragmatics. Next section will develop the semantics-pragmatics interface.

2. Introduction to Pragmatics

Pragmatics is the study of language use and its object is meaning in use. The main hypothesis of contemporary pragmatics is that semantic interpretation is underspecified and must be enriched at the pragmatic stage. In this section, I will first give a brief survey of what pragmatics is and is not, and the types of pragmatic theories available on the scientific market (§ 2.1). Then (§ 2.2), I will discuss more precisely the semantics-pragmatics interface, with a special interest for the possible border between semantic and pragmatic meanings. Inference will be the third topic (§ 2.3) and I conclude this introduction by a crash-course on Relevance Theory (§ 2.4), one of most complete pragmatic theory today.

2.1 Pragmatics today

2.1.1.What is pragmatics ?

To answer this question, let's first say what pragmatics is not. Pragmatics is not the wastebasket of linguistics, a component of linguistics, nor a theory of discourse.

- Pragmatics is not a wastebasket, because pragmatic phenomena are not residual or without any link to linguistics. Disambiguation (the choice of the relevant interpretation within a context), pragmatic enrichment (the attribution of referents to referential expressions, of illocutionary forces to utterances, of propositional attitudes to the speaker), and inference are the main topics of pragmatics and are not residual phenomena.
- Pragmatics is not a part (a component) of linguistics : disambiguation, enrichment and inferences are not strictly linguistic phenomena, they imply interfaces between linguistic knowledge and encyclopaedic knowledge, as well as the attribution of mental states to others (a *theory of mind*, [16]). Pragmatic phenomena have thus not only a linguistic, but rather a cognitive side (speaker's intention and beliefs) and a communicative side (speakers' expectations and wishes).
- Pragmatics is not discourse linguistics : discourse linguistics makes the hypothesis that there are discourse structures and discourse rules. However, if it is true that a sentence is the compositional by-product of syntactic rules, it is doubtful that a discourse is the compositional by-product of utterances [16]. Indeed there is more to discourse interpretation than to utterance interpretation

What then is pragmatics ? Pragmatics is the study of language use *vs* the study of language, the study of the cognitive processes underlying utterances interpretation and the study of inferential aspects of verbal communication.

- Pragmatics is the study of language use, which implies a clear border between linguistics and pragmatics. In contemporary pragmatics, linguistics is restricted to phonology, syntax and semantics. The hypothesis is that linguistic interpretation of utterances is under-specified.
- Pragmatics is the study of the cognitive processes involved in utterance interpretation. Pragmatic aspects of meaning imply relations between language and human cognition, that is, the structure and property of natural languages and the language of thought (*mentalese*) [4].
- Pragmatics is the study of inferential aspects of verbal communication. The crucial relation here is between language and communication, and more precisely the model of communication involved in language use. Pragmatics defines communication as a mixed process, based on two models of communication, the code mode and the inferential model. Thus verbal communication implies both linguistic encoding and decoding processes and pragmatic inferential ones.

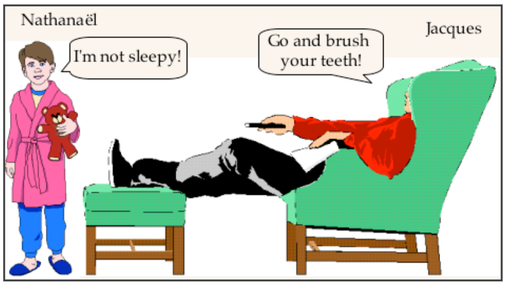
Let's take some examples to illustrates these aspects of pragmatic meaning :

• *Linguistic under-specification.* In (78), the interpretation of *they* as *the government* is not due to any linguistic rule, but is inferred on the basis on world knowledge. It implies a pragmatic enrichment and the access to assumptions about the world as « the government alone can increase taxes » :

(78) They are going to augment taxes.

• *Implicit communication*. In (79), how does Jacques understand that his son Nathanaël refuses to go and brush his teeth and to go to bed ?

(79) Jacques : Nathanaël, please go and brush your teeth.
Nathanaël : Dad, I'm not sleepy.



Jacques appeals to inferences based on beliefs. The crucial question is the nature of inference rules : are inferences rules based on social conventions or on general cognitive mechanisms ? If (79) seems to show the relevance of a social convention as *one brushes one's teeth before going to bed*, which kind of social convention can we appeal to explain the interpretation of the answer in (80) as an acceptation or a refusal ?

(80) Peter : Do you want some coffee ?
Mary : Coffee would keep me awake

Examples (79) and (80) explain why implicit communication is more relevant than explicit communication : implicit communication conveys in a more economical way more information than explicit communication. This explains why pragmatic inferences are non-demonstrative, that is, are not truth-preserving, cancelable (defeasible), deductive, have as premises beliefs (*contextual assumptions*) and are universal (not socially or culturally determined).

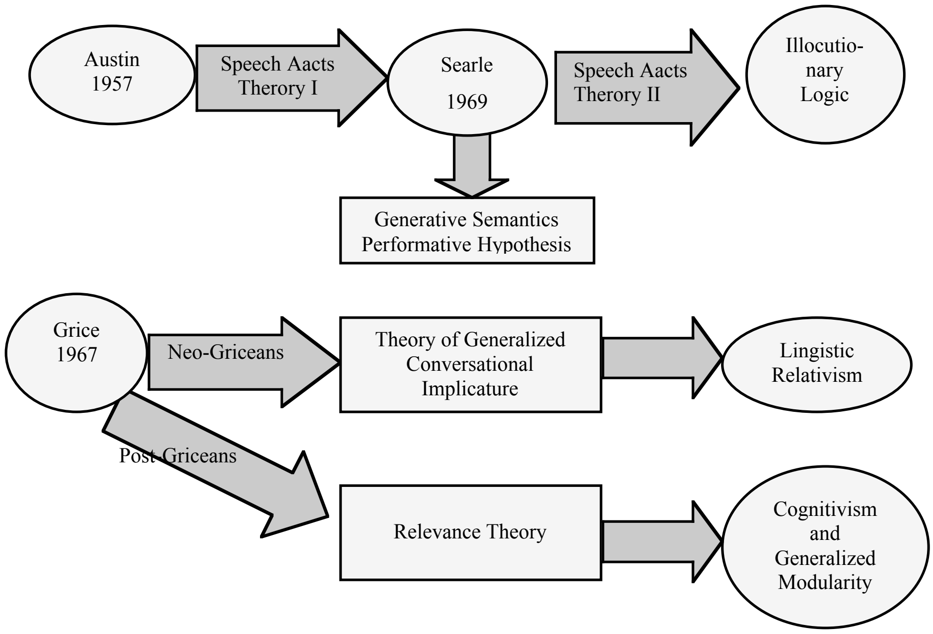
• *Utterance vs sentences*. Pragmatics has as its object *utterances* rather than *sentences.* Sentences are maximal units of linguistics, composed by grammatical and lexical morphemes and have meanings. On the hand, utterances are occurrences of specific sentences by a speaker in a particular setting and have senses in contexts. For instance, Nath's answer *I'm not sleepy* says that *Nath says that he is not sleepy* and implicates *Nath does not want to go to* bed and *Nath does not want to brush his teeth right now* via contextual assumptions as *one brushes one's teeth before going to bed* and *one goes to bed when one is sleepy*

In summary, pragmatics accounts for language use in communication, explains how inferences work in utterance comprehension, why non-literal communication is preferred to literal communication and why utterance interpretation is linguistically under-specified.

2.1.2 Types of pragmatic theories

Fig. 2.1 gives a brief history of pragmatics. The origin of pragmatic is Austin's William James Lectures (1957) [17], which exposed the first theory of speech acts, developed in 1969 by Searle [18] and later in a formal theory (illocutionary logic, [19]). Speech act theory is the basis of one of the most important hypotheses in generative linguistics, the Performative Hypothesis [20] at the origin of Generative Semantics (cf. [21] and [22] for histories of generative linguistics). The second origin of pragmatics is Grice's William James lectures (1967, [23], [24]), which gave rise to two main pragmatic frameworks, the Theory of Generalised Conversational Implicature [25] and Relevance Theory [26]. Whereas the first neo-Gricean paradigm adopts a new version of the Sapir-Whorf hypothesis (linguistic relativism), the second post-Gricean theory is a cognitive theory, following Fodor's hypothesis on the modularity of mind [27].

Figure 2.1 A brief history of pragmatics.



Gricean approaches to verbal communication are called *radical pragmatics*, because they make a clear-cut distinction between linguistic systems and processes and pragmatic mechanisms. Within this framework we can distinguish three types of principle-based theories : (i) Classical Gricean Pragmatics, based on the *Principle of Cooperation*, *maxims of conversation* and the notion of *implicature* [23], (ii) Neo-Gricean Pragmatics (the *Theory of Generalized Conversational Implicatures* [25]) and (iii) Post-Gricean Pragmatics, i.e. *Relevance Theory* [26].

• Gricean Pragmatics is based on the Principle of Cooperation : *Make your contribution such as is required, at the stage at which it occurs, by the accepted purpose or direction of the talk exchange in which you are engaged* [23]. The principle of Cooperation is said to be satisfied if the speaker respects or exploits conversational maxims. These maxims are the Maxims of Quantity (*Make your contribution as informative as required but not more*), the Maxim of Quality (*Make your contribution true*), the Maxim of Relation (*Be relevant*) and the Maxims of Manner (*Be clear : avoid obscurity, avoid ambiguity, be brief and be orderly*).

• Neo-Gricean Pragmatics is a first simplification of Gricean pragmatics. In Levinson's Theory of Generalized Conversational Implicatures [25], there are only two maxims, the maxim of *quantity* and the maxim of *minimization*, raised at the level of principles : the Q-Principle (maxim of quantity) claims that the speaker must give the strongest information with respect to the purpose of the conversational exchange, whereas the I-Principle (maxim of minimization) states that the speaker must say as little as necessary ; in this case, the hearer is allowed to understand more. When conflicts arise between implicatures, the I-Implicature is cancelled against a non-disputable proposition, and the Q-Implicature wins against the I-Implicature.

• Relevance Theory states that verbal communication is an ostensive-inferential process, implying both code and inference, and gives to context a crucial role. Context is not given but chosen, and defined as a subset of the mutual cognitive environment. Information in communication is processed through the Principle of Relevance, which says that the speaker has produced the most relevant utterance in the circumstances. Relevance is relative to cognitive effects (*the more cognitive effects, the more relevance*) and cognitive efforts (*the less cognitive efforts, the more relevance*). Relevance plays a role in both communication and cognition : speakers have expectations of optimal relevance and cognitive effects must balance cognitive efforts.

2.2 The border between semantics and pragmatics

2.2.1 The Classical *vs* Gricean views

The question of the border between semantics and pragmatics is very crucial, because the underlying question is the limit of linguistic processes. On the classical view, semantics takes charge of conventional or lexical, i.e. non-defeasible meanings, as semantic entailment and meaning postulates (for instance *John killed Mary* □ *Mary is dead*). On the classical view, pragmatics has in charge meaning in context, which is by definition non-conventional, the result of conversational implicatures. Typical examples of non-conventional meaning (*conversational implicatures*) are metaphors and irony.

The classical view has been challenged by the Gricean view. In the Gricean view, the semantics-pragmatics border is not linked to the difference between conventional meaning and meaning in context. Indeed, Grice defines a type of implicatures linked to the form and meaning of words, called *conventional implicatures*. In (81)-(83), words like *even*, *therefore*, *but* are responsible for specific meanings (*Bill is not expected to like Mary, there is a semantic entailment between being an Englishman and being brave*, and *there is a semantic contrast between having children and being a researcher*) :

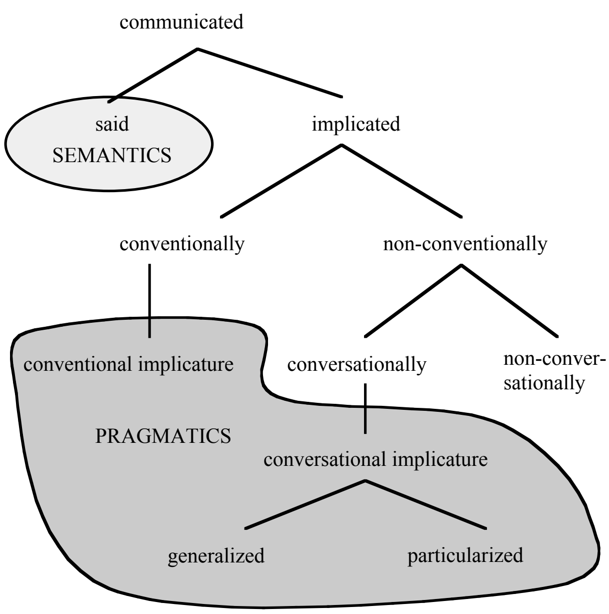
(81) **Even** Bill likes Mary.

(82) John is an Englishman ; he is, **therefore**, brave.

(83) Anne has four children, **but** she is a research fellow.

The border between semantics and pragmatics passes through the difference between truth-functional meaning (*what is said*) and non-truth-functional meaning (*what is communicated*). Pragmatics is thus defined as follows : pragmatics = meaning – truth-conditions. Fig. 2.2 shows the specific domains of semantics and pragmatics.

Figure 2.2 Typology of implicatures.



2.2.2 Conventional and conversational implicatures

In the Gricean view, the domain of pragmatics is thus restricted to implicatures. As Fig. 2.2 shows, there are two types of implicatures, i.e. two types of pragmatic meanings : conventional implicatures and conversational implicatures.

• *Conventional implicatures* are triggered by specific expressions, but their meaning is *detachable* (the implicature is attached to a specific word), *non-cancellable* (you cannot negate a conventional implicature) and *non-truth-functional* (the content of the implicature does not play a role in the truth-conditions of the sentence). In (81), *even* triggers at least two conventional implicatures, given in (84) and (85) :

(81) Even Bill likes Mary.

(84) Other persons than Bill like Mary.

(85) Among these persons, Bill is the less expected to like Mary.

Clearly, these meanings do not contribute to the truth-conditions of what is said, that is the proposition (86) :

(86) Bill likes Mary.

- *Conversational implicatures* are the result of the application of one conversational maxim and can be triggered by a linguistic expression (*generalized conversational implicature*) or not (*particularized conversational implicature*). The conversational implicatures are *non-conventional* (they are the results of conversational maxims), *non-detachable* (the implicature is attached to a meaning), *cancelable* (implicatures can be cancelled) and, as conventional implicatures, *non-truth-functional*. A typical generalized conversational implicature is the temporal meaning of *and* ('and then'), as in (87) :

(87) Max pushed John and John fell.

2.2.3 The pragmatic exclusive meaning of *or*

The border problem between semantics and pragmatics can be illustrated by the exclusive reading of *or* (only one disjunct is true, not both). In logic, *or* has an inclusive reading (*P or Q* is true if one disjunct is true or both). This is problematic, because the pragmatic meaning of *or* is exclusive, as in (88) :

(88) *On a menu* : Cheese or dessert.

Tab. 2.1 and 2.2 give the truth tables for inclusive and exclusive *or* :

Table 2.1 Truth table of inclusive (logical) *or*

P	Q	P Q
1	1	1
1	0	1
0	1	1
0	0	0

Table 2.2 Truth table of exclusive (pragmatic) *or*

P	Q	P □ Q
1	1	0
1	0	1
0	1	1
0	0	0

What is the explanation for this divergence in meaning ? Is *or* ambiguous between its logical meaning and its pragmatic meaning ? Is the linguistic meaning of *or* radically different from its logical one ? Pragmatics has given a very interesting answer to this question : *the exclusive meaning of or is pragmatically derived from its logical inclusive meaning*. In other word, *or*-semantic meaning is inclusive, and *or*-pragmatic meaning is exclusive. The explanation is the following : the exclusive meaning is the result of a *scalar implicature*. A scalar implicature is based on a *quantitative scale*, which allows two types of relations : (i) the upper-bound term implies the lower-bound term ; (ii) the lower-bound term conversationally implicates the negation of the upper-bound one. If *or* belongs to a quantitative scale with *and* (<*and, or*>), one can predict that (89) is an entailment ('$\Vdash$'), whereas (90) is a scalar implicature ('+>') :

(89) *Cheese and dessert* $\Vdash$ *Cheese or dessert*

(90) *Cheese or dessert +> not(cheese and dessert)*

The formal demonstration is the following : *or*-exclusive meaning has the same truth-conditions as the conjunction of *or*-scalar implicature and *or*-disjunctive meaning. So *or*-exclusive meaning ($\oplus$) is pragmatic, as shown in (91) and in tab. 2.3 :

(91) $(P \oplus Q) \leftrightarrow \neg(P \wedge Q) \wedge (P \vee Q)$

Table 2.3 Truth table for scalare implicatures.

P	Q	$P \wedge Q$	$\neg(P \wedge Q)$	$P \vee Q$	$\neg(P \wedge Q) \wedge (P \vee Q)$	$P \oplus Q$	$(P \oplus Q) \leftrightarrow \neg(P \wedge Q) \wedge (P \vee Q)$
1	1	1	0	1	0	0	1
1	0	0	1	1	1	1	1
0	1	0	1	1	1	1	1
0	0	0	1	0	0	0	1

2.3 Inferences

Pragmatics has to say something about inference, because pragmatic meaning is mainly inferential. In this section, inference will be defined as a logical process including premises, conclusions and rules (§ 2.3.1). Semantic inference like presupposition will be the object of next section (§ 2.3.2) and finally the status of implicature as inference will be raised (§ 2.3.3).

2.3.1 Logical inference

Logical inferences are valid inferences : an inference is valid if the truth of the premises entails the truth of the conclusion. In logic, such an inference is said to be *truth-preserving*. Logical validity is a matter of logical form, not a matter of content. For instance, (92) is an example of valid inference, whereas (93) is an invalid inference :

(92) All *A* are B.
All *B* are *C*.
Therefore all *A* are *C*.

(93) No *A* is a *B*.
No *A* is a *C*.
Therefore no *B* is a *C*.

Inferences are triggered by inference rules, which ensure the validity of inferences. In logic, there are two types of inference rules : *deductive* rules and *inductive* rules. Inference rules of classical logic are deductive (they are truth-preserving contrary to inductive rules) and are of two types : *eliminative* rules and *introductive* rules. A deductive rule is *eliminative* if it eliminates in its output a logical connective contained in the input of the rule. An eliminative rule provides new information, i.e. a *non-trivial* implication. A deductive rule is *introductive* if it introduces in its output a logical connective. An introduction rule allows redundancy or iteration, i.e. a *trivial* implication.

Modus ponendo ponens is an elimination rule, and *and*-introduction an introduction rule :

(94) *Modus ponendo ponens* (*if*-elimination)

Inputs	(i) *if P, then Q*	
	(ii) *P*	
Output	*Q*	

(95) *And*-introduction

Inputs	(i) *P*
	(ii) *Q*
Output	*P and Q*

Deductive rules (either eliminative or introductive) can be analytic or synthetic. An *analytic rule* has only one premise as input, whereas a synthetic rule has two premises as inputs. *And*-elimination is an analytic rule, and *or*-elimination a synthetic rule.

(96) *And*-elimination

Input	*P and Q*
Outputs	(i) *P*
	(ii) *Q*

(97) *Modus tollendo ponens* (*or*-elimination)

Inputs	(i) *P or Q*	(i) *P or Q*
	(ii) *not-P*	(ii) *not-Q*
Outputs	*Q*	*P*

One relevant question is the nature of pragmatic inferential rules. We can predict that if the results of pragmatic inferences are non-trivial implications, it should be produced by synthetic deductive elimination rules. This is the hypothesis of Relevance Theory (§ 1.4.4).

2.3.2 Semantic inference

The typical example of semantic inferences is *presupposition.* Semantic presupposition is defined as follows : a statement *P* presupposes a statement *Q,* iff in all situations where *P* is true, *Q* is true and in all situations where *P* is false, *Q* is true. The classical example of semantic presupposition is (98) and its negation (99), which both presuppose (100) :

(98) The King of France is bald.

(99) The King of France is not bald.

(100) There is a present King of France.

In (98) and (99), the definite description *the King of France* presupposes the existence and the uniqueness of the King of France.

The semantic (truth-functional) definition of presupposition defines presupposition as a special case of semantic entailment. Semantic entailment is defined as follows : *P* semantically entails *Q* ($P \models Q$), iff every situation that makes *P* true, makes *Q* true. Semantic presupposition can now receive a truth-functional definition : a sentence *P* semantically presupposes a sentences *Q,* iff (i) $P \models Q$ and (ii) $\neg P \models Q$. This definition seems very convenient, because it makes a clear-cut distinction between semantic inferences like presuppositions and pragmatic inferences like implicatures. Unfortunatelly, semantic presupposition raises an unsolvable problem. Under the definition of semantic presupposition, a presupposition is always true. Here is the demonstration ([28], [29]).

1. *P* presupposes *Q*.

2. Therefore, *P* entails *Q* and ¬*P* entails *Q*.

3. (a) every sentence *P* has a negation ¬*P*.

   (b) *P* is true or *P* is false (Bivalence).

   (c) *P* is true or ¬*P* is true (Negation).

4. *Q* must always be true.

Is this formal demonstration empirically correct ? In fact, the prediction of the semantic definition of presupposition is false, because a presupposition can be false, as (101) shows. If (98) and (99) presuppose (100), (101) negates it :

(101) The King of France is not bald, because there is no King of France.

These observations have led to a new definition of presupposition. Presuppositions can be false and share this property with conversational implicatures. Thus presuppositions and implicatures are *non-truth-functional aspects of meaning.* We can show this parallelism between implicature and presupposition by comparing (102) and (104), where the scalar implicature (103) and the presupposition (105) are defeated.

(102) Anne has not three children, she has four children.

(103) Anne has exactly three children.

(104) John doesn't regret having failed, because he succeeded.

(105) John failed.

The new definition of presupposition is thus *pragmatic*. On this definition, presupposition is not any more a property of sentences, but relative to a set of background beliefs defining the context :

"*A proposition P is a pragmatic presupposition of a speaker in a given context just in case the speaker assumes or believes that P, assumes or believes that his addressee assumes or believes that P, and assumes or believes that his addressee recognizes that he is making these assumptions, or has these beliefs.*" [30]

For instance, the background beliefs (pragmatic presupposition) (107)-(108) will be responsible for the readings (109)-(110) of sentence (106) :

(106) My cousin is no longer a boy.

(107) My cousin is a male human being.

(108) My cousin changed his sex.

(109) My cousin is now a male adult.

(110) My cousin is now a woman.

2.3.3 Pragmatic inferences

While conventional implicatures are triggered by particular words and are not cancelable, conversational implicatures are triggered by conversational rules. For instance, (111) implicated conversationally (112), *via* the maxim of relevance :

(111) John has a rendez-vous with a woman.

(112) +> The woman is not his wife/mother/sister.

Conversational implicatures are thus the results of applying the Principle of Cooperation and the conversational maxims. In drawing pragmatic inferences, the hearer assumes the speaker is cooperative and rational. Assuming speaker's cooperation is assuming that he respects or exploits the conversational maxims (Quantity, Quality, Relation, Manner). Let's take an example based on the respect of the maxims of quantity. The maxims of quantity says that the speaker must give the strongest information ('*Make your contribution as informative as is required*', '*Do not make your contribution more informative than is required*' [23]).

What does happen in (113) ? This utterance implicates (114) : if the speaker is cooperative, he must respect the first maxim of quantity and thus give the strongest information :

(113) The flag is white.

(114) +>The flag is entirely white.

The question is how such an implicature is computed ? Grice [23] gives the following description of how implicatures are processed :

1. The speaker (*S*) has said that *P*.
2. There is no reason to think that *S* is not observing the maxims.
3. *S* could not be doing this unless he thought that *Q*.
4. *S* knows (and knows that the hearer (*H*) knows that he knows) that *H* can see that he thinks that the supposition that he thinks that *Q* is required.
5. *S* has done nothing to stop *H* from thinking that *Q*.
6. *S* intends *H* to think, or is at least willing to allow *H* to think, that *Q*.
7. And so, *S* has implicated that *Q*.

This description can apply to examples as (113). But what about scalar implicatures and more generally generalized conversational implicatures, that is, conversational implicatures triggered by specific words ?

Scalar implicatures are based on quantitative scales. Formally, a *quantitative scale* is an ordered set of predicates $<e_1, e_2, e_3...e_n>$, such that if A is a sentential frame and $A(e_1)$ a well-formed sentence, then $A(e_1)$ entails $A(e_2)$, $A(e_2)$ entails $A(e_3)$, etc. [29]. Exemples of quantitative scales are <*all, most, many, some, few*>, <*and, or*>, <*n,…, 5, 4, 3, 2, 1*>. A *scalar implicature* receives the following definition : given any scale of the form $<e_1, e_2, e_3...e_n>$, if a speaker asserts $A(e_2)$, then he implicates $\neg A(e_1)$, if he asserts $A(e_3)$, then he implicates $\neg A(e_2)$ and $\neg A(e_1)$, and so forth.

Scalar implicatures are Generalized Conversational Implicatures (GCI). A GCI is a conversational implicature triggered by a specific linguistic expression, but is cancelable. For instance, in (115), (a) implicated (b), (c) entails (d) and (d) entails (a) :

(115) (a) Some of the students were at the party.

(b) Not all the students were at the party.

(c) Some, in fact all, of the students were at the party.

(d) All of the students were at the party.

Is it possible to find a general explanation about how implicature are processed ? There seems to be a general procedure of licensing pragmatic inferences [28] :

1. Draw all potential inferences (implicatures, presuppositions).
2. Check their compatibility with mutual knowledge before drawing the actual inference.

Pragmatic inferences have to be triggered within a precise order, to avoid contradictions. This order is the following [28]:

1. The entailments of the uttered sentence *S*.
2. The clausal and scalar conversational implicature of *S*.
3. The presupposition of *S*.

So, in (116), its potential presupposition (117) is not actual, because the following explanation (*because*-clause) entails (118), which is contradictory with the potential presupposition '*succeed*(x) □ *not*(*fail*(x))'. This explains why (116) is not a contradiction, and why presuppositions can be cancelled : they are cancelable as any other pragmatic inferences.

(116) John doesn't regret having failed (not-*P*), because he succeeded (*Q*).

(117) John failed (*P*).

(118) John succeeded (*Q*).

Thus (Neo-)Gricean pragmatics defines implicatures as inductive inferences : the inductive property of implicatures explains their cancelability.

2.4 Relevance Theory

Relevance Theory (RT) [26] is a Post-Gricean theory that diverges on some important points from Gricean and Neo-Gricean approaches. RT does not refer to the principle of cooperation and any conversational maxims, but reduces all pragmatic principles and rule to the Principle of Relevance. Secondly, RT does not share with (Neo-)Gricean theories the hypothesis that inferences are the results of inductive rules. Thirdly, RT is a cognitive approach of verbal communication and gives a cognitive and communication definition of relevance.

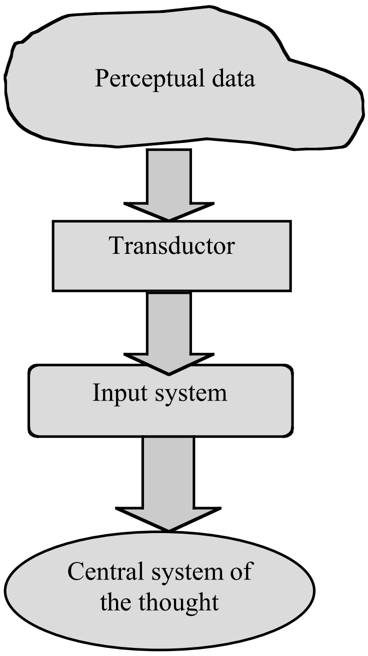
2.4.1 Pragmatics and human mind working

The main hypothesis of RT is that processes implied in pragmatic interpretation are not language specific. On the contrary, they are general and universal, not culturally determined, all human beings share them, and, for the simplest of them, human beings share them with superior mammals. The vision of human mind in RT is hierarchical [27] :

1. Perceptual data are processed within transducers, which are translated into a format accessible to input systems.
2. The perceived translated data are processed within a specialized modular input system, producing the first coded interpretation.
3. The central system of the mind completes the first coded interpretation by comparing other information already known or simultaneously given by other input systems and draws inferences.

Fig. 2.3 gives an iconic interpretation of the hierarchical treatment of information by the mind :

Figure 2.3 A hierarchical treatment of information



Before applying this hierarchical model of the mind to language interpretation, it is worth to give some information about modules and the central system of the thought [27].

- What is a module ? A module is an input system, which is domain specific and informationally encapsulated. The operations a module triggers are automatic, mandatory, fast and have shallow outputs.
- What is the central system ? The central system of the thought is complex and non-specialized, working out the interpretation of data and reasoning used in daily life as well as the production and the interpretation of complex and subtle reflections specific to scientific researches and artistic activities.

What could be the relationship between such a theory of mind and linguistic theory ? RT hypothesizes that linguistics corresponds to an input system specialized in the treatment of linguistic data and pragmatics belongs to the central system. Moreover, RT claims that the study of utterances pragmatic interpretation could shed a light on the working out of specific processes of the central system.

What is the precise articulation between linguistic and pragmatic processes ? The linguistic input system yields a partial coded interpretation from which the central system works to yield a full interpretation of utterances. Thus the interpretation of utterances is a mixed process : the code corresponds to the linguistic part of the interpretation and the inference to its pragmatic counterpart. So one of the main task of pragmatics is to explain processes by which this completion works.

2.4.2 From logical form to propositional form

The first task of pragmatics is to explain how linguistic interpretation is completed as a full interpretation, including the determination of what is said and implicated. Let's begin with the output of the linguistic input system.

The output of the linguistic module is a *logical form*. In RT, a logical form is an ordered string of *concepts*. A concept is the mental counterpart of a linguistic item. It is through concepts that information necessary for building contextual assumptions is accessed. So inferential processes have access to information yielded by input systems and encyclopaedic knowledge : the linguistic input system yields a logical form, whose concepts (their addresses) enable the access to encyclopaedic knowledge. The encyclopaedic knowledge is stored in long-term memory, which contains a set of information about the world. Long-term memory is completed by two other memories : short-term memory, which contains a limited number of item (3 to 7) used in the current process, and mid-term memory, which contains the results of recent processes.

In RT, utterance interpretation is an inferential process whose premises are the logical form of the sentence uttered and the *context*. The information in the context comes from long-term memory, i.e. concepts in logical form, short-term memory, i.e. immediately perceptible data drawn from the situation or the physical environment, and mid-term memory, i.e. data driven from the interpretation of preceeding utterances. Now not all of these information can belong to the context, that is, the set of contextual assumptions used as premises in the inferential process. The actual context is a small part of the cognitive environment for an individual at a given time, that is all the information accessible to an individual at a given time from short-term, mid-term and long-term memories. Last but not least, a context is not given, but constructed utterance after utterance.

What is now the relation between concepts and contexts ? Logical form contains the addresses of concepts that are necessary to access long-term memory. So access to encyclopaedic information is possible through the addresses of the concepts. More generally, a concept has three types of entry :

- a logical entry, containing information about logical relations a concept entertains with other concepts ;
- an encyclopaedic entry, containing information about objects corresponding to concepts ;
- a lexical entry, corresponding to the linguistic counterpart of the concept.

To sum up, the construction of the relevant context is directly dependant on information stored in memory. Concepts plays a crucial role in accessing information in long-term memory, whereas the other types of memories yield information coming from the physical environment and the interpretation of previous utterances.

2.4.3 Cognition and relevance

How is the central cognitive process driven ? The aim of the cognitive process is to achieve the intention communicated by the speaker through his utterance. The identification of intention in communication is thus crucial. RT makes a distinction between two types of intention : informative intention and communicative intention.

- The *informative intention* is the speaker's intention to bring to his audience the knowledge of a give information.
- The *communicative intention* is the speaker's intention to bring to his audience his informative intention.

So, the recognition of the speaker's information intention, i.e. the set of assumptions he wants to communicates, passes through the recognition by the addressee of his communicative intention. As communication implies speaker's intention recognition, communication is not simply a code process. RT defines communication as an ostensive-inferential process. In *ostensive-inferential communication*, a speaker brings about his audience his intention to make manifest to him an information. The ostensive side is what the speaker does, that is, showing his communicative intention, whereas the inferential side is what the audience does, that is, infering speaker's informative intention.

RT moreover claims that human cognitive activity aims the construction and modification of the representation of the world by an individual and communication plays role in that process, for instance by adding new information to old ones. Now, for cognitive activity to be relevant, it is not sufficient to build and improve the representation of the world : this representation must also be true. So an information is relevant if it has a minimal cognitive effect, for instance if it brings about a new information and it is true.

Relevance is the core concept of RT. RT claims that it is possible to reduce Grice's conversational maxims to one maxim, the maxim of relevance. Being relevant for a speaker supposes to give the required quantity of information (maxims of quantity), to tell the truth (maxims of quality), to speak clearly and without ambiguity (maxims of manner). But RT makes a stronger claim : not only are all maxims implied by the maxim of relevance, but communicative and cognitive processes are governed by a unique principle, the *principle of relevance*. The principle of relevance is a general principle implied by the notion of ostensive-inferential communication and is at the basis of inferential processes. It states that *every utterance communicates the presumption of its own optimal relevance*. So the principle of relevance underlies the working out of interpretive processes, as soon as these processes are about acts of ostensive-inferential communication.

How does relevance play a role in ostensive-inferential communication ? The act of ostensive-inferential communication warrants relevance. As the ostensive property communication implies hearer's attention, the hearer is naturally expecting that what the speaker wants him to communicate is worth processing. This expectation of relevance is thus the result of what communication is : an ostensive-inferential process. But expectations of relevance can be disappointed, if no effects or too weak effects are drawn. In order to balance the expectation of relevance, RT defines relevance as implying both cognitive efforts and cognitive effects :

- *cognitive efforts* are those efforts necessary to the processing of the sentence and the creation of context ;
- *cognitive effects* are conclusions drawn from the inferential process : they are contextual effects.

We can now give a motivated definition of *relevance* :

- *ceteris paribus*, the less cognitive efforts the processing of an utterance requires, the more relevant the utterance is ;
- *ceteris paribus*, the more cognitive effects the processing of an utterance produces, the more relevant the utterance is.

Cognitive efforts are those efforts caused by the length of the utterances and the words uttered, the accessibility of context, i.e. the formation of contextual assumptions, and the complexity of the deductive rule used. Cognitive effects are of three types :

- the addition of a new information drawn as a conclusion (*contextual implication*) ;
- the strengthening of an old information ;
- the eradication of an old information, when contradiction arises between an old and a new information.

How is the context chosen ? One of the premises of the context is given by the utterance, and corresponds to its logical form. The other premises are driven from different origins : the encyclopaedic knowledge (long-term memory), perception (short-term memory) and the interpretation of preceding utterances (mid-term memory). But the important point is that information building the context are those that produce enough effects for the utterance to be relevant. So the selected context is the relevant one.

If relevance is relative to the contextual effects obtained during the interpretive process, the question of the stopping of the interpretive process arises. RT gives a simple answer to this question : the interpretive process stops when sufficient cognitive effects are obtained to balance cognitive efforts. This process can thus be short and costless if sufficient effects arise quickly and easily.

Now, how can the addressee be sure that what he gets (contextual effects) corresponds to speaker's informative intention ? Nothing can guarantee it, because verbal communication is not a code process, but an ostensive-inferential one. But what the addressee knows is more than nothing : the first interpretation which comes to his mind is *the interpretation consistent with the principle of relevance,* that is, the interpretation which is governed by the addresse's presumption of optimal relevance.

2.5 Conclusion

In this section, we have introduced basic concepts of pragmatics. Pragmatics today is a new discipline, connected to linguistics (syntax and semantics), cognitive sciences, but also to philosophy of language and mind, computational sciences and anthropology. The Gricean approach to pragmatics, either Neo- or Post-Gricean, is certainly, with the Chomskian revolution in formal linguistics, one of the greatest change in language sciences during the last century. Moreover, no linguistic engineering application will be satisfying unless a minimal of pragmatics is taken into account.

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