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approaches to unaccusativity:
A connectionist approach.

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Unifying syntactic and semantic approaches to unaccusativity: A connectionist approach

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It appears to be a universal property of intransitive verbs that only certain subsets are acceptable in particular syntactic contexts. Are the crucial properties of intransitives that govern their acceptability in these *diagnostic contexts for unaccusativity* semantic, syntactic, or both? Purely semantic, heavily syntactic, and a few mixed positions have been advocated in the literature. In this paper we examine a language, French, that exhibits a rich set of such diagnostic contexts (Section I); we describe in some detail a heavily syntactic approach and identify important weaknesses (Section II); we examine some purely semantic proposals and show their inadequacy (Section III); and finally we present a new approach that unifies the syntactic and semantic ideas within a novel, connectionist-based framework called Harmonic Grammar (Section IV).

I. The basic phenomenon

Unaccusativity phenomena in French provide a particularly challenging pattern of data. Legendre has identified ten diagnostic contexts, the most broadly applicable of which are the five illustrated in (1–5).¹

Object Raising (OR)

- (1) a. La neige est facile à faire *fondre*.
The snow is easy to make *melt*.
- b. *Les jeunes sont faciles à faire *méditer*.
Young people are easy to make *meditate*.

Croire "believe" constructions (CR)

- (2) a. Je croyais Marie déjà *sortie*.
I believed Marie to have already gone out.
- b. *Je croyais Marie *éternuée*.
I believed Marie to have sneezed.

Participial Equi constructions (PE): (the missing argument in the adverbial clause corresponds to the boldface main clause argument).

- (3) a. *Parti* avant l'aube, Pierre est arrivé à destination le jour même.
Gone before dawn, Pierre arrived at his destination on the same day.
- b. **Travaillé* toute la nuit, Pierre s'est endormi à 8h du matin.
Worked all night, Pierre fell asleep at 8 a.m.

Participial Absolute constructions (PA): (no coreferential link between the two clauses)

- (4) a. Les Dupont *partis*, toute la famille se mit à table.
The Duponts *gone*, the whole family sat down for dinner.
- b. *Le candidat *parlé*, l'audience se tut.
The candidate *spoken*, the audience turned quiet.

Reduced Relatives ("adjectival formation") (RR)

- (5) a. La neige *fondue* a formé de la boue.
The *melted* snow formed mud.
- b. *Son état *empiré* est alarmant.
His *worsened* condition is alarming.

II. The syntactic approach

The syntactic approach is founded on the following generalization: in many diagnostic contexts, there is a parallel between, on the one hand, the (a,b) contrast illustrated in (1-5) of the arguments of the contrasting classes of intransitive verbs, and, on the other, contrasts between the two arguments of a transitive verb, illustrated in (1-5c,d).

- (1) c. La vérité est facile à faire *dire* aux enfants.
The truth is easy to make children tell.
- d. *Les enfants sont faciles à faire *dire* la vérité.
The children are easy to make tell the truth.
- (2) c. Je croyais Marie *arrêtée* (par la police).
I believed Marie to be arrested (by the police).
- d. *Je croyais la police *arrêté* Marie.
I believed the police to have arrested Marie.
- (3) c. *Arrêtée* par la police, Marie a dénoncé ses amis.
Arrested by the police, Marie denounced her friends.
- d. **Arrêtée* Marie, la police l'a interrogée.
Arrested Mary, the police interrogated her.
- (4) c. La nouvelle constitution *approuvée* (par le congrès), le président renforça ses pouvoirs.
The new constitution *approved* (by congress), the president consolidated his power.
- d. *Le congrès *approuvé* la nouvelle constitution, le président renforça ses pouvoirs.
Congress [having] approved the new constitution, the president consolidated his power.
- (5) c. La personne *arrêtée* par la police n'a jamais été relâchée.
The person [who was] arrested by the police was never freed.
- d. *Le policier *arrêté* Ceaucescu a été fêté.
The policeman [who] arrested Ceaucescu was celebrated.

Arguing that the contrasting behavior in diagnostic contexts of the two arguments of a transitive verb is due to their different structural roles or grammatical relations, proponents of the syntactic approach to unaccusativity have postulated that the contrasts among intransitive verbs in diagnostic contexts arise from the same cause: different underlying grammatical relations of their arguments.

- (6) **(Syntactic) unaccusativity hypothesis** (RG: Perlmutter 1978, 1989, Rosen 1984; GB: Burzio 1986)

There are two classes of intransitives that differ *structurally*: the arguments of the two classes parallel the subject and direct object of transitives. Specifically, the arguments of one class of verb (RG: "unergatives"; GB: "intransitives") are deep subjects (RG: "initial 1s"; GB: "external argument"), while the arguments of the other class (RG: "unaccusative"; GB: "ergative") are deep direct objects (RG: "initial 2s"; GB: "internal argument").

On the syntactic account, the reason a diagnostic context accepts unaccusative verbs while rejecting unergatives is that it involves a construction with well-formedness conditions that require the argument of the intransitive to be an underlying direct object (or heading a 2-arc, in RG terminology). For the five French diagnostic contexts considered here, such well-formedness conditions are presented in (7–10) (Legendre, 1989a; (7) was proposed in Legendre, 1986).

- (7) **Condition on Object Raising (OR):**
An Object Raising structure is well-formed only if the raisee heads only 2-arcs in any clause below the raising predicate.
- (8) **Condition on *croire* unions (CR):**
Only a nominal heading a 2-arc at some level in the embedded clause can appear in *croire* unions.
- (9) **Condition on Participial Clauses (PE and PA):**
A participial clause is well-formed only if the argument (ultimately deleted in PE, realized in PA) of the participial verb is a "deep" object and a "surface" subject.
- (10) **Condition on Reduced Relatives (RR):**
A Reduced Relative is well-formed only if the "surface" subject is a "deep" object.

Note that a verb that is acceptable in one of these diagnostic contexts must be unaccusative, but that not all unaccusatives will necessarily pass each such test. In fact, intransitives vary greatly in how many of the five tests (1-5) they pass.²

(11)	<i>augmenter</i>	"increase"	passes 5 tests
	<i>arriver</i>	"arrive"	passes 4 tests
	<i>geler</i>	"freeze"	passes 4 tests
	<i>pleurer</i>	"cry"	passes 1 test
	<i>rougir</i>	"blush"	passes 1 test
	<i>aller</i>	"go"	passes 0 test
	<i>exister</i>	"exist"	passes 0 test

(It is interesting to note that the Italian counterparts of the last three verbs are all unaccusative, according to Rosen, 1984.) Far from an occasional failure of a putative unaccusative to pass all the tests, the data display a large number of such failures, comprising a complex pattern that wants explanation.

Among the major reasons for unaccusatives failing tests are several aspectual factors. (12) illustrates one such additional necessary well-formedness condition relevant to the French diagnostic contexts (Legendre, 1989a):

(12) **Aspectual restriction on Participial Absolutes:**

Only perfective verbs may appear in the PA construction.

In fact it has long been clear that the syntactic unaccusativity hypothesis (6) must be augmented with aspectual conditions in order to account for the full pattern of data presented by diagnostic contexts for unaccusativity. It is for this reason that we have characterized approaches such as Perlmutter (1978, 1989), Rosen (1984), and Burzio (1986) as "heavily" rather than "purely" syntactic.

But in fact there is need to strengthen the semantic component further in order to face the full complexity of the phenomenon: Semantic properties of the *argument* also can affect acceptability in diagnostic contexts. Illustrations of such effects in French are provided in the following table.

Verb	Argument	Test acceptability
<i>arriver</i> "arrive"	<i>Pierre</i>	-?OR
	<i>un malheur</i> "a disaster"	+?OR
<i>céder</i> "to give in"	<i>l'enfant</i> "the child"	+OR
	<i>la glace</i> "the ice"	-?OR
<i>disparaître</i> "disappear"	<i>l'enfant</i> "the child"	+?OR
	<i>la tache</i> "the stain"	+OR
<i>entrer</i> "enter"	<i>l'homme</i> "the man"	?OR, +CR, +PE, +PA, +RR
	<i>le train</i> "the train"	?OR, +CR, +PE, +PA, +RR
	<i>le vent</i> "the wind"	-OR, -CR, -PE, -PA, +RR
	<i>les marchandises</i> "the goods"	+OR, +CR, +PE, +PA, +RR

We conclude that any account of unaccusativity phenomena that strives for a reasonable degree of completeness must provide a major role for semantic/aspectual factors.

It is worth noting before moving on to consider purely semantic approaches that cross-linguistically there appears to be very little positive syntactic evidence for unergativity; while unaccusativity tests are quite abundant cross-linguistically, unergativity tests (diagnostic contexts accepting only unergative verbs) are extremely rare. As a result, the class of unergatives is often defined negatively, as those intransitives that fail to be picked out as unaccusative by the available tests. This may have the consequence of artificially increasing the appearance of a test-independent dichotomy of intransitives into two classes. In fact, in French, Legendre (1989b) has uncovered one unergativity test:³ the pronoun *on* allows two interpretations – the definite interpretation 'we,' and an arbitrary interpretation 'someone' – but they are constrained by (13), as illustrated in (14).

(13) **Interpretation of *on*:**

The arbitrary interpretation is restricted to deep subjects (unergative and transitive structures).

- (14) a. On lui a confié une tâche délicate. (transitive)
 Someone/we *entrusted him with a tricky task*.
 b. On a téléphoné à Pierre. (unergative)
 Someone/we *called Peter on the phone*.
 c. On avait été confié à l'Assistance Publique. (passive)
 We/*someone *had been entrusted to Child Welfare*.
 d. On s'est enfin tu. (unaccusative)
 We/*someone *finally shut up*.
 e. On est allé au cinéma. (unergative or unaccusative?)
 We/*someone *went to the movies*.

This unergativity test sheds some further doubt on the robustness of the unaccusative/unergative dichotomy, for it fails to positively identify as unergative an important verb – *aller* 'go' – that would be classified as unergative by virtue of failing all five unaccusativity tests (11).⁴

III. The semantic/aspectual approach

Given the apparently major role of semantic/aspectual factors in diagnostic contexts for unaccusativity, it is natural to consider a purely semantic account, which can be stated in a very general form as:

(15) **Semantic hypothesis (general):**

Semantic/aspectual considerations are sufficient, without positing structural differences among intransitives, to account for acceptability patterns in diagnostic contexts.

This hypothesis denies the uniform structural characterization of two subclasses of intransitives posited in (6), so unaccusativity ceases to be treated as a unified phenomenon: each diagnostic context singles out its own idiosyncratic class of acceptable intransitive verb/argument pairs, based on particular semantic/aspectual features.

The generality of (15) makes it almost impossible to refute, since there is an open-ended set of semantic/aspectual features that might be appealed to. In order to formulate a more specific and readily testable version of the purely semantic hypothesis, we consider some concrete existing proposals from other languages:

Unaccusativity test	Relevant semantic/aspectual features	Source
Dutch Impersonal Passivization	agentive vs non-agentive	Zaenen (1989)
Dutch Tense Auxiliary Selection	telic vs. atelic	Zaenen (1989)
Italian Tense Auxiliary Selection	activity vs. state, achievement, accomplishment	Van Valin (1990)
Acehnese Subject Cross-referencing	agentive vs. non-agentive	Van Valin (1990)

Taking these semantic/aspectual properties as a plausible starting point, we have:

(16) **Semantic hypothesis (specific):**

Whether an intransitive verb/argument pair is acceptable in a given diagnostic context is predictable from the verb's classification as Activity/Accomplishment/Achievement/State, or from its aspectual features (e.g. telicity), or from the semantic features of the argument (e.g. volitionality) or from the semantic features of the verb (e.g. verbs of motion).

To test this hypothesis, we examined the predictability from these semantic and aspectual properties of acceptability in the five unaccusativity tests OR, CR, PA, PE, RR (1–5) and the one unergativity test, ON (14). We studied a set of 355 intransitive verb/argument pairs, derived from a nearly exhaustive list of French intransitives. Some highlights of this study are summarized below; the first five are graphically represented in Figure 1, in which the percentages of verbs that pass or fail each test are shown by the lengths of bars which are white or black, respectively.⁵ Note that the last column of Figure 1 corresponds to the one unergativity test, ON, and is more-or-less anti-correlated with the other five columns; in qualitatively summarizing these data, we will use "unaccusative" as an abbreviation for "failing the ON test and passing the others" and "unergative" for the reverse.

Aspectual verb classes. Following Vendler (1967) and Dowty (1979), Van Valin (1990) characterizes a four-way distinction between Activity, State, Accomplishment, and Achievement verbs based on a set of criteria discussed in Dowty (1979). Dowty warned that these four classes have fuzzy rather than absolute boundaries, but Van Valin takes the criteria from Dowty as definitive. We have used a subset of the criteria mentioned in Dowty (1979) and Van Valin (1990), namely, criteria 1, 3, 4, 7, 8, 9 of Dowty (1979; p.60).⁶ For French, this characterization covers 25% of our data; the remaining 267 of 355 verb/argument pairs do not fit the patterns characteristic of any of the four classes. The data set contains 61 Activity, 16 State, 10 Achievement, and 1 Accomplishment verbs. (Accomplishment verbs are typically transitive verbs). Activity verbs do show a clear tendency to be unergative: all 61 fail the CR, PA, PE, and RR tests, and 81% fail while 16% pass the OR test (3% indeterminate), and 78% pass while 18% fail the ON test. The remaining 83% of verb/argument pairs (State, Achievement, Accomplishment, and Undetermined) do not show a clear pattern.

Superclasses. Various aggregations of these four classes into "superclasses" have been studied: Van Valin (1990) defines the Actor superclass as the union of the Activity and Accomplishment classes, and Undergoer as the union of States and Achievements; Zaenen (1989) and Van Valin (1990) define the Telic superclass as the union of Accomplishments and Achievements, and the Atelic superclass as the union of Activities and States. Like the four basic classes, these superclasses cover 25% of the data. There are only weak correlations between these superclasses and the tests, except for those that arise as an almost direct consequence of the one strong tendency of Activities to be unergative.

Telicity. Rather than treating Telic/Atelic as two superclasses including 11 and 77 verb/argument pairs, respectively, we can treat them as covering all the data by defining Telic or Atelic verb/argument pairs to be those for which it is unacceptable or acceptable, respectively, to assert that the action occurred 'for an hour.' Here there is a moderate one-way correlation: Atelic verbs are more likely to be unergative (e.g., OR: 34%+, 61%-; CR: 22%+, 78%-; RR: 21%+, 78%-; ON: 34%-, 64%+), but Telic verbs do not exhibit a clear pattern (e.g., OR: 53%+, 35%-; CR: 55%+, 40%-; RR: 55%+, 43%-; ON: 69%-, 28%+).

Animacy. Verbs taking animate arguments are much more likely to be unergative (OR: 22%+, 69%-; other unaccusativity tests: -15%+, -83%-; but ON: 42%-, 56%+) but those taking inanimate arguments are almost equally likely to pass or fail the tests (OR: 58%+, 35%-; CR: 45%+, 55%+; PA, PE, RR: -43%+, -55%-; ON does not apply to inanimates).

Agentivity. Agentivity shows the same pattern of correlations as Animacy, with verbs taking volitional arguments displaying a somewhat stronger tendency to be unergative.

It is interesting to note that the only reasonably clear predictions from purely semantic tests that come out of this exploration are those that entail unergativity; within the heavily syntactic approach, on the other hand, it is overwhelmingly conditions entailing unaccusativity that are found.

Our conclusion from this study is that prediction of acceptability in these diagnostic contexts can not be done on the basis of these aspectual and semantic properties, considered separately, with one exception: Activity verbs are reliably unacceptable in CR, PA, PE, RR. It is certainly possible that one could find combinations of these properties, or new semantic/aspectual properties, that would validate (15). Rather than pursuing this direction, we now present an alternative based on the hypothesis that semantic and aspectual properties *do* contribute to acceptability judgements, but in a way that is characterized by numerically graded preferences rather than hard rules. These *soft rules* are part of what we have called a *Harmonic Grammar*, which we describe below. In addition to these semantic/aspectual preferences, we assume that the grammar also recognizes a structural difference between two kinds of intransitive verbs, which parallels the structural difference between the two arguments of transitive verbs. But, as with the semantic/aspectual factors, we will assume that the rules in which such a structural distinction figure are soft rules.

IV. Integrating syntax and semantics: A connectionist account

Our goal here is to integrate (i) the structural parallel between transitives and intransitives central to the syntactic approach with (ii) the quantitative tendencies revealed through the semantic approach, to account for the full complexity of acceptability judgements in the French data: the full pattern of graded judgements of a set of 8393 sentences. These sentences involve 11 constructions⁷ in which 408 verbs are embedded: 183 transitives and 225 intransitives.

Our account can be looked at in a variety of ways. The first is as a connectionist network (for fuller discussion of an earlier version of this network, see Legendre, Miyata & Smolensky, 1990a) Each sentence to be judged is presented as an input pattern, and a graded acceptability value is produced as output. When the embedded verb is transitive, the sentence is represented by indicating which of the 11 constructions is used, whether the embedded verb's subject or direct object is the target of the construction, a featural description of the embedded verb, and featural descriptions of its two arguments. The features used for the arguments are Volitionality, Animacy, and Definiteness; the embedded verb is represented by six features that were learned by the connectionist network through back-propagation. The same representation is used for sentences involving embedded intransitives, except now the network makes a decision as to whether to place the features representing its unique argument in the same units that are used to represent an embedded transitive's subject or those used for its direct object. The decision rule is simple: the network picks that assignment of "deep grammatical relation" for the argument of the intransitive which produces the highest acceptability.

We have done very little tuning of or experimenting with this connectionist network to date, but the initial results are very encouraging. After training the network on all 8393 sentences and their acceptabilities using a revised version of the back-propagation learning algorithm, the network gets the sign of acceptability correct in all but 104 cases (1.2%), of which 90 involve embedded transitives (2.5%) and 14 involve intransitives (0.4%).

This account can be looked at in a second way, as a particular fragment of the grammar of French expressed within the *Harmonic Grammar* (HG) formalism (Legendre, Miyata, & Smolensky, in press). An HG account consists of a set of *soft rules* such as:

- (17) If the argument of *mourir* "die" is a deep subject, then subtract 2.6 from the Harmony of the structure.

Each HG rule consists of a grammatical or lexical constraint, together with a numerical cost that is incurred when the constraint is violated: this cost is subtracted from the well-formedness or *Harmony* of the structure. Soft rule (17) can be paraphrased as follows: "*Mourir* prefers its argument to be a deep direct object (it is unaccusative), but this preference is not absolute: it can be overridden by preferences of other sentential elements, at a well-formedness cost of 2.6." The numerical Harmony values are interpreted as graded acceptability judgements according to an arbitrarily chosen conversion scale (e.g., Harmony values between about 0.4 and 1.4 correspond to 'marginally acceptable').

The HG account of these data involve soft rules like (17) corresponding to lexical entries in the syntactic approach to unaccusativity, and others corresponding to soft versions of syntactic conditions such as (7-10); there are also other soft rules that involve purely semantic conditions, and finally others that involve direct interactions between syntactic and semantic properties. And all these rules interact via the fundamental principle of HG:

(18) **Harmonic principle**

Assign to an input the structural description with maximal Harmony.

Our account can be viewed in still a third way: as a higher-level description of a lower-level connectionist network governed by certain general connectionist representational and processing principles (for a full discussion, see Legendre, Miyata & Smolensky, 1990b). Central among these principles is one asserting that connectionist processing serves to build representations that maximize a certain numerical measure of well-formedness: Harmony (Smolensky, 1986). The central assumption of HG which links connectionism to grammar is that Harmony—the connectionist measure of representational well-formedness—can be interpreted at a higher level as a measure of linguistic well-formedness: acceptability. (For related harmonic approaches to phonology, see Lakoff, 1988; Goldsmith, to appear; Prince & Smolensky, forthcoming.)

V. Summary

We have argued that neither the heavily syntactic nor the purely semantic approaches to unaccusativity can be adequate as universal theories of the phenomenon, since they each fail in major ways under detailed scrutiny within one particular language, French. We have described a unified account in which both syntactic and semantic factors figure into a grammar defined as a set of soft rules or quantified preferences. By sensitively handling the strong interactions of all these preferences, this Harmonic Grammar treatment is capable of accounting for the rich complexity exhibited within a substantial body of French unaccusativity data.

Footnotes

1. The other tests are: cliticization of the embedded indirect object in causative *faire* constructions, parallel transitive structures, auxiliary selection, nominalizations, and stativity (see Legendre, 1989a, and *on* interpretation, Legendre 1989b).

2. The actual data is omitted here for lack of space; it is available in a longer version of this paper available to interested readers.

3. Postal (1986), Legendre (1990) discuss the occurrence of what they call *true* Impersonal Passive with unergative verbs. The fact that the construction is restricted to a small subclass of unergatives that select a subcategorized complement makes it a non-productive test for unergativity.

4. *Aller*, however, selects the perfect auxiliary *être*, usually considered a sufficient test for unaccusativity (Ruwet, 1988; Legendre, 1989). *Aller* can be viewed as very weakly unaccusative.

5. Left to right, the lengths of the five bars show the proportion of

verb/argument pairs of the specified type that, for a given test, were judged acceptable, marginally acceptable, indeterminate, marginally unacceptable, and unacceptable, respectively.

6. In the table on p. 60, Dowty lists the "for an hour" test as OK for accomplishments, but in the text (p. 56) he says that "accomplishment verbs take adverbials with *for* only very marginally." We adopted the conservative strategy of ignoring this criterion when defining accomplishment verbs. We tested Dowty's first criterion, non-stativity, with two specific tests described by Dowty (p. 55): the progressive and the imperative. We ignored this criterion, however, when defining achievement verbs, since it appears to be sensitive to the distinction between punctual and non-punctual verbs.

7. These constructions were the six unaccusativity diagnostics (1-5, 14), plus four of Dowty's criteria for defining the aspectual verb classes (the "for an hour," ambiguity with "almost," progressive, and imperative tests), plus another stativity test from Dowty (1979, p. 55), pseudo-clefting.

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