Processing auxiliary selection
with Italian intransitive verbs*

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Abstract

For intransitive verbs in languages with a choice of perfective auxiliaries, off-line acceptability judgments conform to a semantically based Auxiliary Selection Hierarchy (ASH) (Sorace 2000, 2004). According to the ASH, inherently telic verbs regularly selecting auxiliary BE appear to be core exemplars of unaccusative syntax, while atelic verbs of agentive activity regularly selecting HAVE are core exemplars of unergative syntax. Non-core verbs that are inherently neither telic nor agentive allow either auxiliary to degrees depending on context and on distance from telic and agentive poles. ASH effects have not yet been investigated in real-time language processing. This paper demonstrates ASH effects on processing of Italian auxiliaries essere *'be' and* avere *'have' in on-line comprehension and production. For native speakers reading Italian sentences, total reading times display the ASH effect: a stronger advantage for correct over incorrect auxiliaries with aspectually prototypical core verbs than with peripheral exemplars. In word production, the ASH effect appears when visually presented auxiliaries prime production of participles corresponding to infinitive stimuli. The pattern of results conforms to linguistic markedness and suggests how the ASH may be reflected in the real-time processing of auxiliaries.*

1. Introduction

While judgments of linguistic acceptability are the primary empirical data for much of syntactic theory, the psychological instantiations of syntactic facts are often left to investigation of quite different aspects of human language ability, those involved in comprehension and production. With the advent of more rigorous methods of investigation of acceptability judgments, however, (Bard et al. 1996; Cowart 1997; Schuetze

1996), experimental syntax has begun to bring the two approaches together. One phenomenon that is well supported by rigorous studies on acceptability judgments is gradience in the choice of perfective auxiliaries to accompany intransitive verbs (Keller and Sorace 2003; Legendre 2006; Legendre and Sorace 2003). This paper asks whether gradience is reflected in speakers' production and comprehension of the same verbs. Our findings indicate that the linguistic and psycholinguistic facts are well aligned.

2.   Linguistic accounts of split intransitivity

The term "split intransitivity" refers to the existence of two types of intransitive verbs, differentiated by a number of syntactic characteristics that have been extensively described in the linguistic literature. The best-known is the choice of auxiliaries in the compound tenses of Romance languages: members of one set of intransitives co-occur with the "E" auxiliary, the equivalent of English *be*, as in the French example (1a) below, while members of the other set co-occur with the "A" auxiliary, the equivalent of English *have* (1b).

(1)   a.   *Elle est <u>arrivée</u>.*
            she is arrived
            'She has arrived'
      b.   *Ils   ont   <u>travaillé</u>.*
            they have worked
            'They have worked'

The distinction appears, albeit in a less clear-cut way, in other constructions, too. In Italian, for example, certain intransitive verbs pattern with transitives, as in (2) below, where intransitive verbs like *arrive* (2a) and transitives (2b) can be used with the clitic *ne* in Italian, though other intransitives like *work* (2c) cannot.[1]

(2)   a.   *Di studenti   stranieri, ne   sono   <u>arrivati</u> tanti.*
            of students   foreign   of-them are   arrived many
            'Many foreign students have arrived'
      b.   *Di bicchieri, ne   hanno <u>rotto</u>   tanti, i bambini.*
            of glasses   of-them have   broken many, the children
            'The children have broken many glasses'
      c.   **Di operai   stranieri, ne   hanno <u>lavorato</u> tanti.*
            of workers foreign   of-them have   worked many
            'Many foreign workers have worked'

In non-Romance languages like English, the resultative construction, which is acceptable with passive transitive verbs (3a), subdivides intransitives. Barred with many intransitives whose translations would use A auxiliaries (3b), the resultative can appear with certain intransitives whose Italian translations would use E auxiliaries (3c).[2]

(3)   a.   *The toast was burnt black.*
      b.   **The clown laughed hoarse.*
      c.   *The lake froze solid.*

  Linguistic accounts of these phenomena have evolved over the last 30 years from models that privilege either the syntax or the lexical-semantics of verbs to models that focus on the interaction between them. The seminal proposal known as the Unaccusative Hypothesis (Burzio 1986; Perlmutter 1978; Rosen 1984) splits intransitive verbs into two subsets — unaccusatives and unergatives — which have distinct syntactic and semantic properties. Intransitive verbs as a class have single arguments. Because the single argument of unaccusative verbs shares many syntactic properties with direct objects of transitive verbs (compare (2a) with (2b), (3a) with (3b)), the hypothesis treats the argument as an underlying direct object. In contrast, the single argument of unergative verbs shares syntactic behavior with the subject of transitive verbs and is treated as a subject at all levels of representation. The syntactic distinction is related to certain semantic characteristics of these verbs: as we might expect from the object–subject distinction, ''patienthood'' tends to correlate with unaccusativity and ''agentivity'' (having a subject which is truly an agent) with unergativity (Dowty 1991; Perlmutter 1978). The alignment between syntactic and semantic properties is, however, not consistent (Rosen 1984): some verbs with similar semantics have different syntactic behavior across languages (for example, *blush* is unaccusative in Italian and unergative in Dutch), and some verbs would be classified as both unaccusative and unergative by the same diagnostic within a single language (for example Italian *fiorire* 'blossom' can take either the E auxiliary, *essere*, or the A auxiliary, *avere*).

  These cases have inspired two kinds of elaborations of the Unaccusative Hypothesis. Some accounts are purely semantic (Bentley 2006; Bentley and Eythórsson 2003; Dowty 1991; Van Valin 1990), denying any role to syntactic factors in the determination of unaccusative–unergative differences. Others describe the interaction of syntactic and semantic aspects of split intransitivity. The general conclusion here is that although most syntactic diagnostics of split intransitivity tend to distinguish semantically coherent subsets of verbs (Levin and Rappaport Hovav 1995), some syntactic characterization of these verbs is necessary to account

for phenomena not easily reducible to purely semantic explanations, such as the similarity between unaccusatives and passives illustrated above. Exactly how lexical semantic or aspectual representations underlying individual verbs are mapped onto the syntactic facts also needs explaining.

Three main proposals for the syntactic/semantic relationship have been advanced. One, known as the "projectionist" approach (Legendre and Sorace 2003; Levin and Rappaport Hovav 1996, 2005; Sorace 2004), maintains that the lexical semantic properties of a verb deterministically specify the classification of its arguments as objects or subjects, and that this in turn produces the syntactic behavior associated with unaccusativity or unergativity (Hale and Keyser 1986, 1993; Levin and Rappaport Hovav 1992, 1994, 1995). For English at least, Levin and Rappaport Hovav (1995) propose a small number of linking rules which map lexical semantic components of verb meaning (such as [immediate cause], [directed change] and [existence]) onto positions at the argument structure level of syntactic representation. Inconsistencies of syntactic behavior across verbs in a semantic set are attributed to the verbs' slightly different meanings, which support different lexical semantic representations, each with its own regular argument structure realization.

A second proposal is broadly "constructionist" (Arad 1998; Borer 1994, 1998; McClure 1995; van Hout 1996, 2000). It regards unaccusativity and unergativity as clusters of properties derived from the syntactic configurations in which verbs appear, which in turn determine their aspectual interpretation, that is, their interpretation in terms of categories of actions and states which subclassify the verbs in many languages. Thus, in contrast to the projectionist view, the lexical entry of intransitive verbs does not specify whether the argument is a subject or an object. Instead any verb is free to enter into more than one syntactic configuration and consequently to receive multiple aspectual interpretations.

A third proposal (Cennamo and Sorace 2006; Keller and Sorace 2003; Sorace 1993a, 1993b, 1995a, 1995b, 2000, 2004, forthcoming) identifies the critical semantic components as belonging to the set of features that determine verb aspect. Sorace and her collaborators propose that aspectual differences underlie an Auxiliary Selection Hierarchy (or "ASH") for monadic verbs,[3] illustrated in Table 1. As the rightmost column of the table shows, the extremes of the ASH consist of maximally distinct "core unaccusative" and "core unergative" verbs, while there is a gradation to intermediate "peripheral unaccusative" and "peripheral unergatives" from those poles. The terms "core" and "peripheral" do not refer to gradients of unaccusativity/unergativity of verbs — since these are syntactic configurations that cannot have intermediate states — but

Table 1.   *The auxiliary selection hierarchy for Italian verbs (after Sorace 2000)*

Semantic category	Example	Auxiliary	ASH type
Change of location	cadere *fall*	E *essere* be	CORE UNACCUSATIVE
Change of state	nascere *be born*		
Continuation of pre-existing state	sopravvivere *survive*		⇓
Existence of state	esistere *exist*		PERIPHERAL UNACCUSATIVE
Uncontrolled process	brillare *shine*		PERIPHERAL UNERGATIVE
Controlled process (motional)	correre *run*		⇑
Controlled process (non-motional)	lavorare *work*	A *avere* have	CORE UNERGATIVE

rather to their differential likelihood of allowing multiple syntactic behavior. In this view, the primary distinction separating the unaccusatives from the unergatives is aspectual telicity (goal-directedness), with only core unaccusative verbs possessing that feature inherently and therefore being more likely to show consistent telic uses than peripheral verbs. Thus, verbs of change of location, most of which are inherently telic, display more consistent unaccusative behavior than most verbs denoting change of state, which do not entail any end-point. Where Italian change of state verbs are telic (*nascere* 'be born' and *morire* 'die'), they prefer *essere* more categorically than those denoting indefinite change (*crescere* 'grow').[4] Stative verbs, which are incompatible with the notion of change and so have no goal or end-point, are the least consistently unaccusative in their behavior. A secondary distinction, agentivity (having a genuinely volitional subject), separates core unergatives (e.g., *lavorare* 'work') from peripheral unergatives (e.g., *circolare* 'circulate') with the latter denoting non-agentive, non-volitional processes. Thus, the ASH distinguishes at its unaccusative and unergative extremes core verbs which are inherently specified for telicity and agentivity, respectively. As Table 1 shows, these are verbs of change of location (e.g., *arrive*) at the telic unaccusative pole and of agentive non-motional activity (e.g., *work*) at the unergative.

Unlike earlier treatments of aspect and split intransitivity, the ASH is framed in terms that speak to both syntax and semantics. It helps to account both for variability and for consistency in the behavior of intransitive verbs. In contrast to the constructionist view, where context is always critical, the ASH account associates core verbs with syntactic behavior which is generally insensitive to non-lexical properties contributed by the remainder of the sentence predicate. On the other hand, peripheral verbs,

which are neither telic nor agentive, do seem to behave according to the constructionist observation, with syntactic behavior depending on the properties of the predicate in which they appear. Verbs characterized as peripheral by the ASH are not only more variable in their choice of auxiliary within a language (Levin and Rappaport Hovav 1995; McClure 1995; Sorace 2000); they are also the verbs which select E in some languages and A in others. In fact, Sorace, and her colleagues (Sorace 1995a; 1995b; Sorace and Shomura 2001) show that other less clear-cut syntactic manifestations of split intransitivity, such as *ne*-cliticization in Italian (Burzio 1986; Perlmutter 1978) and quantifier floating in Japanese appear to be sensitive to the same hierarchy that is seen in auxiliary selection.

In summary, both constructionist and projectionist approaches are inherently unable to capture the gradient and systematic variation that characterizes split intransitivity. In contrast, the ASH has the explanatory advantage of predicting both cases where the results of split transitivity are built into a verb on semantic grounds and cases where contextual details determine the verb's behavior. This distinction is supported by evidence from the acquisition of Italian and French as second languages (Sorace 1993a, 1993b, 1995a, 1995b) but, most pertinent for our current purposes, it forms the basis of a series of experimental studies on intuitions that give us the behavioral fingerprint which this paper will rediscover in on-line processing. The ASH therefore provides us with the basis for making interesting hypotheses about the comprehension and production of intransitive verbs appearing with different auxiliaries.

3.   The ASH fingerprint in linguistic intuitions

Using a classical psychophysical technique, magnitude estimation (Bard et al. 1996), Sorace and her colleagues have demonstrated that speakers of several languages are sensitive not only to split intransitivity but also to the core–periphery distinction. Magnitude estimation allows judges to use the full power of the set of positive numbers to express their impressions of the relative acceptability of sentences containing "correct" and "incorrect" auxiliaries. Sentences containing intransitive verbs are given higher magnitude estimates of linguistic acceptability with the correct than with the incorrect auxiliary, as any theory defines "correct" and "incorrect". Preferences for the correct auxiliary over the incorrect are significantly stronger for prototypical core verbs than for peripheral verbs in native judgments of Italian (Bard et al. 1996; Sorace 1993a, 1993b, 1995a, 1995b), Dutch (Sorace and Vonk 1998), and German (Keller and

Sorace 2003). Thus, the intuition data have a behavioral fingerprint: a core–periphery distinction in strength of intuitions about the major reflex of split intransitivity, the choice of auxiliary in the compound tenses.

These behavioral data, however, are based on global judgments produced after a sentence has been fully read and considered. They do not provide information on the source of the ASH effects. In particular, they tell us little about the processing events that lead to the expression of judgments about the acceptability of one auxiliary or the other with any given verb type and in any given context. In order to investigate the origins of the ASH, we need to establish at what point the language processor uses syntactic and semantic information that is made available by the verb and/or by the context in which the verb appears. Given the options for representing split intransitivity linguistically, the source of native speaker judgments might be lodged in any of several representations. The present study used comprehension and production techniques that should be sensitive to each.

We might begin by supposing that the critical issue is the syntagmatic relationship between auxiliary and lexical verb, and that intuitions might therefore be accessing a set of subcategory-based processing strategies. We know that lexical verb sub-categorization information can be used very quickly (Boland et al. 1995; Frenck-Mestre and Pynte 1995, 1997; Tabossi et al. 1994; Trueswell et al. 1994). In auxiliary selection languages, either auxiliaries or intransitive verbs might be subcategorized for the appropriate pairing. More or less in line with the projectionist syntactic claims, encountering an intransitive lexical verb may permit the parser to project a structure that includes the appropriate auxiliary as well as the underlying agent or patient. Since the auxiliary usually precedes the verb, however, prediction could run in the other direction: when an auxiliary is encountered, a verb of an appropriate class with a structure of the appropriate type may be expected.

Whether lexical or auxiliary verbs do the projecting, this line of argument implies that participants in judgment studies were reacting to local difficulties in processing auxiliary + V stimuli. Early syntactic effects are of course possible, albeit difficult to interpret unambiguously (for a recent example, see the early parsing effects for gender agreement violations in Betancort et al. 2004; for a discussion of the interpretations of such effects, see Boland 2004), and in some views, construction of syntactic representations has priority in sentence comprehension. If acceptability judgments are actually the judge's assessment of his or her own processing difficulties, then we would predict that the standard reading time techniques designed to reveal processing difficulties will also show the ASH fingerprint. If we arrange for sentence onsets to be identical and

semantically neutral across the whole intransitive series, then syntax-based effects could appear quite early in processing, when the auxiliary and lexical verb are in view but the sentence completion has not yet been encountered. If intuitions tap early syntactic processing, first pass eye-tracking times for correct auxiliary–verb pairs should be faster than those for incorrect, with the advantage for the correct combination greater for core verbs than for peripheral verbs of either type.

Alternatively, if split intransitivity phenomena are based on delicate semantic gradations of agentivity or telicity, there should be a critical role for the processes that compute sentence semantics from word meaning and syntactic structure, processes which cannot be completed until the whole sentence has been encountered. In this case, judges in magnitude estimation studies were reflecting a more global process which included initial contact with the verb's semantics and any eventual mismatches between the likely aspectual status of the lexical verb, the implications of the auxiliary, and the remainder of the sentence (for examples of aspect assignment with transitive verbs see (Todorova et al. 2000; Townsend et al. 2005). If intuitions reflect these semantic processes, later stages of processing should show the ASH fingerprint, with total reading times increasing for incorrect over correct combinations and more markedly so for core verbs than for peripheral.

It is also possible that the distinction is not represented in the processes which build syntactic or semantic representations of individual sentences, but rather as a relationship between entries in the mental lexicon. Under this view, judgments of acceptability are reflections of lexical associations. Of course, lexical relationships may enhance sentence processing because they mark likely sequences. This is precisely the implication of a study by Macdonald and Shillcock (2004) which shows that higher transitional probabilities between individual words yield lower first fixation durations. Syntagmatic relationships between auxiliaries and lexical verbs should have this capacity. Alternatively, the relationships between lexical items may have a semantic basis. Persistent collocation is known to be a good indicator of semantic relationship (Deerwester et al. 1990; Landauer et al. 1998). Any semantic associative relationships could be both available for judges in linguistic intuition tasks and influential in the course of sentence processing. Two lexical representations of the ASH fingerprint are plausible.

The first of these lexical associations seems to resemble the findings of Macdonald and Shillcock (2004) in proposing that lexical verbs may be associated with their sentence surroundings. The relationship between participial forms and auxiliaries in the compound tenses could be recorded as a simple matter of frequency of E-to-participle or A-to-

participle pairing. Again, since core verbs are virtually exclusive in their use of a particular auxiliary while peripheral verbs are variable, it is possible that the ASH effect on intuitions reflects stronger participle-to-auxiliary association in core verbs and weaker associations in peripheral. The language production literature (Levelt 1992; Levelt et al. 1999; Roelofs et al. 1998) distinguishes a representation for an individual word form, the lexeme, which is not directly related to the overall syntactic or semantic characteristics of the word, but which might be associated with forms often in construction with the word form itself. Since only participles collocate with auxiliaries to form compound tenses, the ASH intuitions might derive from lexeme–lexeme connections.

The second possible association would place the relationship at a more abstract level, represented by links between what the language production literature calls the lemma, or word as an abstract unit of the linguistic system, and its semantics or its grammatical category features. Aspect features, which are semantic in origin, would quite naturally be represented as linked to verb lemmas in the mental lexicon and would allow for a core-periphery distinction based on the relative strengths of links from particular lexical verbs to [+telic] or [+agentive] features. If intuitions tap lemma–feature associations, then associations between verbs and their auxiliaries should not be restricted to participial forms of the verbs. Indeed, since the lemma has the role of the central representation of a word in the language system, lemma–feature relationships should make the ASH fingerprint available in production as well as perception.

To test for a lexical locus of split intransitivity, we use a word production technique developed by Balota et al. (1989). Working with pairs of open class word associates presented at various lags between word onsets (or Stimulus Onset Asynchronies), Balota et al. showed, first, that conventional prime–target pairings of associates (*organ–piano*) reduced speakers' latencies for reading the second word aloud (relative to, for example, *anchor–piano*). They then demonstrated that the priming effect had a semantic basis: they preceded homophone primes with words related to one or other of their senses and tested the latency to reading a target word associated to only one of those senses (*music–organ–piano* vs. *kidney–organ–piano*). When the first word of the triple was related to the wrong sense of the second word (as in *kidney–organ–piano*), the priming effect on the third word disappeared. Balota et al. explained the effect in terms of a relationship between lexical access and speech production: they proposed that if a word's semantics are activated, it can be accessed faster and uttered sooner.

The Balota et al. paradigm allows us to ask whether intuitions about auxiliary selection are represented in associations between intransitive

verbs and their usual auxiliaries. If more persistent pairings lead to stronger associations, the correct auxiliary will prime relative to the incorrect, and the priming effects will be stronger for core verbs than for peripheral. If judgments exploit the lexeme used in compound tenses, the past participle, then only the production of past participles should be faster with preferred than with dispreferred auxiliaries, and the past participles of core verbs should show the effect more strongly than their peripheral counterparts. If the associations are based on the semantic features which are implicated in the ASH, then the lemma is likely to be involved, and forms other than the participle should show ASH effects.

4.   Experiment 1: Sentence processing

It is well established that eye-movements during reading can be used as a sensitive on-line marker of syntactic processing. The rich trace left by the reader's eyes makes it possible to distinguish between "early" and "late" effects in sentence interpretation. Despite the lack of a precise model of the mapping between specific cognitive processes and eye movements in sentence comprehension (Clifton et al. 2007; Pickering et al. 2004), the distinction between early and late effects is often regarded as corresponding to that between the initial parse of a sentence and subsequent reinterpretations. On this assumption, eye-movements allow us to determine not only whether but also when during sentence processing the information provided by intransitive verbs exerts its influence. If the ASH pattern appears for time spent viewing a verb and auxiliary before later parts of the sentence are explored, the result would indicate a relationship between immediate parsing decisions and ASH intuitions, perhaps due to an initial general categorization of verbs following E as unaccusative and verbs following A as unergative. In other words, early increases in reading time might result from local anomalies involving particular combinations of incorrect auxiliaries and verbs. The ASH would predict these effects to be stronger for core members of the two verb classes. If the ASH pattern appears for time spent viewing the verb and auxiliary when later parts of the sentence have also been viewed, then it may involve interpretation of the whole sentence — hence the calculation of sentential aspect from the combination of AUX, lexical V, and any following adverbials or prepositional phrases. Late effects may thus reflect compositional anomalies involving the predicate in which the verb appears; according to the ASH, these effects would be more pronounced for peripheral unaccusatives and unergatives.

In Experiment 1, native speakers of Italian read sentences containing core and peripheral intransitive verbs with correct and incorrect auxiliaries. Both early and late effects on reading were examined via the recording of eye-movements.

4.1. *Method*

4.1.1. *Participants.* Sixteen native speakers of Italian, including men and women, aged 20 to 24 years, participated in a single 30-minute session for payment. All were newly enrolled at the University of Provence for a short course in French. None were at all fluent in French, according to self-report and scores on entrance examinations to the course. To avoid effects of native language attrition (Tsimpli et al. 2004) only participants who had had little contact with the second language were selected for the studies reported here. None had ever resided in a French speaking country for more than three weeks.

4.1.2. *Materials and Design.* Thirty-two Italian verbs were used. They were evenly divided by Intransitive Type (16 unaccusative, and 16 unergative) and by ASH Type (half of each Intransitive Type were core verbs, half peripheral). Verbs were classified as core or peripheral on the basis of previous acceptability judgment studies: core unaccusatives were inherently telic verbs of change of location or change of state; peripheral unaccusatives were stative verbs; core unergatives were verbs of controlled non-motional activity, while peripheral unergatives were verbs denoting less agentive activities. All verbs were monadic: none had transitive alternants. The verbs used in Experiment 1 are indicated with asterisks in Appendix A.

The verbs were controlled as far as possible for average frequency per cell, with most items moderately or very frequent. There were no significant differences in frequency by Intransitive Type ($F(1, 28) < 1$), ASH Type ($F(1, 28) = 1.2$, $p > .20$), or their interaction ($F(1, 28) < 1$). Verbs were also controlled group-wise for length of participle in letters. Though unaccusatives were on average slightly shorter than unergatives, (6.43 vs 7.50 letters) this difference was neither dependable ($F(1, 28) = 3.15$, $p = .09$), nor relevant to the critical contrasts between auxiliaries by ASH Types. There were no dependable length differences by ASH Type or by ASH Type within Intransitive Types ($F(1, 28) < 1$).

Each verb appeared as main verb in a pair of Italian sentences which were identical except for the auxiliary, which was a form of *essere* for one member of the pair, and a form of *avere* for the other. *Essere* was the correct choice for unaccusatives and *avere* for unergatives.

To control for the effect of sentence context, the same sentence phrasal structure was used for all eight conditions defined by Intransitive Type (unaccusative vs. unergative) × ASH Type (core vs. peripheral) × Auxiliary (correct vs. incorrect). For each structure, two structurally identical versions with different lexical items were devised for the onset of the sentence. Examples (4) and (5) below provide examples. The full set of materials is found in Appendix B.

Because auxiliary choice for verbs of indefinite change and stative verbs may vary with animacy of the surface subject, all surface subjects were conceptually animate. In each case, the post-verbal portion of the sentence included two phrasal segments in order to assure that the early reading times for the auxiliary and verb were not contaminated by "wrap up" processes at the end of the sentence. These latter phrases were selected to avoid influencing the interpretation of those peripheral verbs, particularly verbs of manner of motion, which are sensitive to compositional telicity (compare *Maria è corsa a casa* 'Maria IS run home' vs., *Maria ha corso velocemente* 'Maria HAS run fast'): these verbs were always presented in atelic contexts. Finally, all sentences were pretested for naturalness on native speaker informants who did not participate in the main experiment.

(4)   Version A
   a.   Unaccusative core:
   Secondo Repubblica *il Presidente*   {*è*/**ha*} *caduto*
   According to *Repubblica* the President   {is/has} fallen
   mentre giocava a tennis.
   while playing tennis.
   b.   Unaccusative periphery:
   Secondo Repubblica *il Presidente*   {*è*/**ha*} *durato*
   According to *Repubblica* the president   {is/has} lasted
   in carica per troppo tempo.
   in post for too-much time.
   c.   Unergative core:
   Secondo Repubblica *il Presidente*   {*ha*/**è*} <u>*riflettuto*</u>
   According to *Repubblica* the president   {is/has} thought
   a lungo sul da farsi.
   about what to do.
   d.   Unergative periphery:
   Secondo Repubblica *il Presidente*   {*ha*/**è*} <u>*ceduto*</u>
   According to *Repubblica* the president   {is/has} yielded
   alle richieste dell'ONU.
   to the UN's requests.

(5)   Version B
    a.   Unaccusative core:
    Secondo Panorama il ministro   {*è/*ha*} <u>*caduto*</u>
    According to *Panorama* the minister {is/*has} fallen
    mentre sciava a Cortina.
    while skiing at Cortina.
    b.   Unaccusative periphery:
    Secondo Panorama *il ministro*   {*è/*ha*} *durato*
    According to *Panorama* the minister {is/*has} lasted
    in carica più del previsto.
    in post more than predicted.
    c.   Unergative core:
    Secondo Panorama *il ministro*   {**è/ ha*} <u>*riflettuto*</u>
    According to *Panorama* the minister {*is/has} reflected
    sulle sue responsabilità.
    on his responsibilities.
    d.   Unergative periphery:
    Secondo Panorama *il ministro*   {**è /ha*} <u>*ceduto*</u>
    According to *Panorama* the minister {*is/has} yielded
    alle pressioni del suo partito.
    to the pressure from his party.

In the present experiment, each participant read a single list of sentences, encountering each verb and each sentence onset only once. To achieve this last restriction, 8 different lists were created with 2 verbs per each of the eight conditions, for a total of 16 experimental sentences per list. In addition, 4 warm-up sentences preceded the list and 32 filler sentences of varying syntactic structures were presented randomized within the list for a total of 52 single sentences per list. Filler sentences included strings of a variety of structures, some fully correct, some semantically anomalous, and some bearing syntactic violations of different types.

4.1.3.   *Eye Movement Recording.*   The dependent variable of interest is reading time, which should reflect the acceptability of the auxiliary if impressions of acceptability derive from syntactic or semantic processing. Eye movements were recorded with a standard Dr. Bouis oculomotor device. Sentences were presented individually on a single line of a monitor linked to a PC. The participant was seated with his or her head restrained by means of a chin-rest and bite-bar, 60 cm. from the monitor so that 3.25 characters subtended 1 degree of visual angle. Horizontal eye-movements were recorded from the right eye every 5 ms.

A trial started with a fixation cross to the left of where the first character of the sentence would be displayed. The participant's fixation on this cross-triggered sentence presentation. Calibration of the system was performed at the outset and thereafter every four sentences by means of an array of five digits spaced evenly across the display screen. Participants were instructed to take breaks prior to a calibration, but to refrain from all movement while reading. Eye-movement data were analyzed off-line and any trials contaminated by head movements were discarded.

4.1.4.   *Task and Procedure.*   Participants were requested to read each sentence for comprehension, and to indicate via a press on a button-box placed in front of them whether the sentence was acceptable or not. The critical source of unacceptability was the incorrect auxiliary (*essere* for unergatives and *avere* for unaccusatives) which, the ASH predicts, should disrupt reading more for core than for peripheral verbs. Disruptions should be more immediate for core verbs presented with the incorrect auxiliary and more dependent on an evaluation of the sentential context for peripheral verbs.

4.2.   *Results*

4.2.1.   *Analyses.*   Sentences were divided into four regions, corresponding to 1) the sentence onset up to three character spaces before the auxiliary, 2) the critical region extending from three characters prior to the auxiliary to one character space following the main verb, 3) a six character region following the critical region, 4) the sentence ending. An example is provided in (6) below. Secondary analyses were also made for the lexical verb alone.

(6)   /$_1$Secondo Repubblica il Presiden$_1$/$_2$te é caduto $_2$/$_3$mentre$_3$/$_4$
       giocava a tennis$_4$/.

The auxiliary and verb were treated as a unit for both oculomotor and psycholinguistic reasons. From an oculomotor standpoint, the auxiliary consisting of only a single letter (è) in half the critical stimuli was unreliable as a unit of analysis, because short regions have a high probability of being skipped. From a psycholinguistic standpoint, the auxiliary is likely to be interpretable semantically and in some cases syntactically only when considered in conjunction with the lexical verb. Hence, the logical unit of analysis was indeed the auxiliary plus main verb. The region following this critical region was of interest as it could reveal spill-over effects.

Sentence onset and ending were analyzed as controls for incidental differences in sentence versions.

Reading times were examined in two ways. First, all fixations coming from the left of a given region prior to exiting the region were cumulated as a measure of first pass gaze duration in the region. First pass gaze can reflect early, local processing, or at least processing without benefit of subsequent material. Second, total reading times were the sum of all first pass fixations and all subsequent fixations within a defined region. This measure is perhaps the best indicator of processes which can exploit the structural and semantic contents of the rest of the predicate, in so far as they help to compose an aspectual interpretation for the verbs

Mean reading time measures were entered into a factorial repeated measures ANOVA, with Intransitive Type (unaccusative vs. unergative), ASH type (core vs. peripheral) and auxiliary (correct vs. incorrect) as variables.

4.2.2. *First pass gaze durations.*   There were no effects before or just following the critical region ($F_1 < 1$, for all three variables). At the main region of interest, i.e., the aux + verb region, the only effect to reach significance was Intransitive Type ($F(1, 15) = 4.90$, $p < .04$): Unergative verbs were processed more slowly than unaccusative (881 ms vs. 793 ms respectively). When this region was reduced to include only the main verb, the same main effect was observed (unergatives 514 ms vs. unaccusatives 442 ms, $F(1, 15) = 6.49$, $p < .02$). There was no significant auxiliary effect (correct vs. incorrect) or ASH effect (auxiliary × ASH status). Thus, first-pass reading times do not display the behavioral fingerprint of judgments about the Auxiliary Selection Hierarchy.

4.2.3. *Total reading times.*   At the main region of interest, the auxiliary + verb region, several effects were observed. Unergatives (1482 ms) were still read more slowly than unaccusatives (1210 ms) ($F(1, 15) = 10.97$, $p < .01$). Now peripheral verbs (1445 ms) were read more slowly than core verbs (1248 ms) ($F(1, 15) = 7.67$, $p < .01$). There was very nearly a significant auxiliary effect, with overall reading times in the aux + verb region tending to be longer for incorrect auxiliary-verb pairs (1431 ms) than for correct (1262 ms) ($F(1, 15) = 4.11$, $p < .06$). When the region was reduced to include only the lexical verb, the same effects were observed, with longer processing times for unergative than for unaccusative verbs (892 vs. 753 ms; $F(1, 15) = 6.27$, $p < .02$), for peripheral than for core verbs (878 vs 767 ms, $F(1, 15) = 4.66$, $p < .05$) and for verbs following incorrect than correct auxiliaries (878 v 767 ms, $F(1, 15) = 4.19$; $p < .06$).
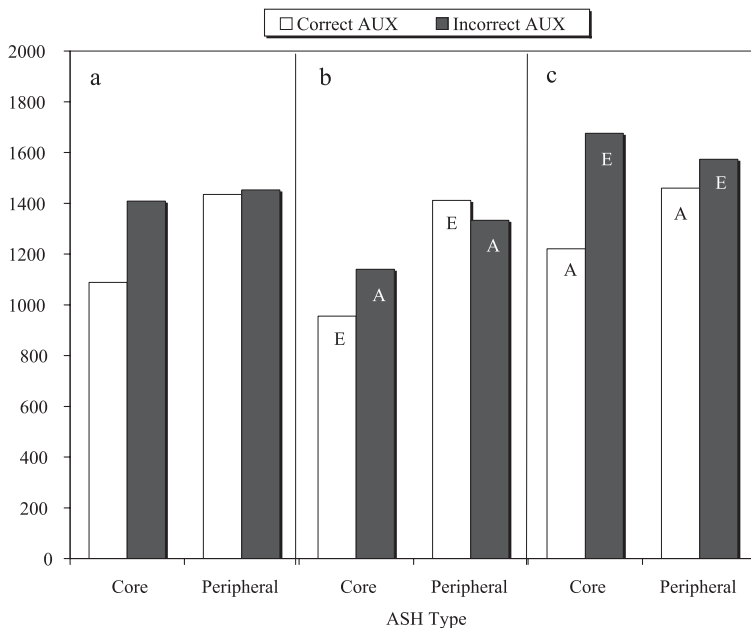
Figure 1.   *Effects of auxiliary (correct vs. incorrect) and ASH Type (core vs. peripheral) on total reading time for critical Aux + V regions (Experiment 1): a. Overall; b. Unaccusatives; c. Unergatives; bars are labeled by auxiliary*

Most importantly, as Figure 1a shows, the critical region displayed the behavioral fingerprint found in grammaticality judgments, an Auxiliary by ASH Type interaction obtained when the region comprised the auxiliary + verb ($F(1, 15) = 4.79$, $p < .04$): total reading times were significantly longer for core verbs with the incorrect auxiliary than with the correct auxiliary (1408 vs. 1088 ms, Tukey HSD, $p = .01$), whereas for peripheral verbs no significant difference in reading times was observed as a function of the auxiliary (1453 for incorrect auxiliary vs. 1435 ms for correct). The same interaction tended towards significance when the region comprised only the verb itself ($F(1, 15) = 3.21$, $p < .09$), with the same pattern of means: for core verbs, 882 ms following incorrect auxiliaries vs. 652 ms following correct auxiliaries; for peripheral verbs 873 ms following incorrect vs. 882 ms following correct.

4.3.   *Discussion*

The results for reading sentences are straightforward. First pass reading times do not reveal grammaticality effects of the auxiliary, let alone the

effect of the Auxiliary Selection Hierarchy on the grammaticality effect. Total reading times for lexical verbs, and to a greater extent for lexical verbs and their auxiliaries, do show the ASH fingerprint. Thus, we have no evidence for effects in common between early processing and acceptability judgments, but we do have some indication that later processing shows the same kind of effect as judgments. Total reading times, of course, include regressions to the critical region from points following it in the sentence, when syntactic or semantic analysis of the predicate might have inspired an attempt at repair. As far as we can tell from reading times, then, whatever inspires judgments about these verbs is related to our ability to interpret them in context rather than as independent syntactic units comprised of the auxiliary and lexical verb.

At first sight, this pattern seems to contradict our expectation of a processing difference between a local anomaly for core verbs with the incorrect auxiliary and a compositional anomaly for peripheral verbs with the incorrect auxiliary. However, as recent studies have pointed out (Boland 2004; Boland and Blodgett 2001, 2002; Clifton et al. 2007; Pickering et al. 2004), the correlation between eye movement and stages of sentence processing is not straightforward; in particular, first pass effects (or lack thereof) cannot always be equated with early syntactic processing. The absence of first pass effects could be due to the fact that violations of auxiliary selection, even with core verbs, are not the same type of anomaly as the violations that typically give rise to first pass effects (e.g., subcategorization violations or morphological agreement in case-marking languages). If, as Boland (2004) argues, first-pass times are more likely to be affected by constraints that control structure-building, our results indicate only that auxiliary selection, even with core verbs, does not belong to this type (Pickering et al. 2006).

5.   Experiment 2: Word reading and production

The design used by Balota et al. (1989) and described earlier offers a way to examine local associations between auxiliary and verb forms. Balota et al. found both priming effects, where the associate precedes the target, and cueing effects, where the associate follows the target and signals the participant to utter it. The former are usually taken to be effects of association on access of the target word form. The latter were described as assembly effects, because they were seen in the duration of the response word rather than in the delay to producing it. Balota et al. make it clear that both effects have the same source: semantically related cues speeding access to a word's lemma so that, ultimately, the phonological form of the word may be more efficiently assembled.

We use the prime/cue technique with auxiliary verbs as prime/cue stimuli and with two forms of lexical verbs as target stimuli, the past participle in experiment 2a and the infinitive in experiment 2b. In all cases, the participants were to utter the participle form in response. Thus, the results were not contaminated by forcing participants to utter ungrammatical sequels to primes: *è cadere (Aux + infinitive) is ungrammatical, even if è caduto (Aux + past participle) is perfectly correct.

The ASH fingerprint should once more be found in an interaction between the effects of Intransitive Type (unaccusative v unergative), ASH type (core v periphery) and Auxiliary. Whether the printed stimulus was a participle or an infinitive, we would expect faster responding for unaccusatives (*caduto* 'fallen'; *durato*, 'lasted') after the correct E auxiliary *è* ('is') than after the A auxiliary *ha* ('has') and shorter tokens of the participle with the E auxiliary cues than with the A auxiliary cues. We would expect the opposite pattern of auxiliary association for unergatives (*riflettuto*, 'reflected'; *ceduto*, 'given in'). Finally, we would expect a stronger auxiliary effect for the core unaccusatives (*caduto*, *cadere*) or unergatives (*riflettuto*, *riflettere*) than for their peripheral counterparts (*durato*, *durare*; *ceduto*, *cedere*).

Priming from Aux to V should indicate an effect on access to the word in the mental lexicon. If the association is via the participle lexeme, we should find stronger effects when the participant simply reads the participle presented (as in Experiment 2a), though there may also be priming where the participle form must be assembled via its links to the infinitive (as in Experiment 2b). If the ASH effect is based on the lemma, however, then we might expect weaker effects in word naming (2a), where lemma access is unlikely to be obligatory, and stronger effects where the infinitive target has to be transformed into the participle response (2b). Here the speaker would appear to be exploiting links between the visible infinitive, the lemma common to both infinitive and participle lexemes, and the participle lexeme which has to be uttered as a response.

Note that the cueing conditions create a situation which is unlikely to be involved in the expression of impressions about intransitive verb sentences: participants in acceptability judgment experiments are not normally asked to utter a mis-ordered version of the sequence of words which they judge. The purpose of these conditions is to serve as a control. Since it is necessary to utter the target verb forms in both paradigms, a priming result with a cueing result might be attributable to assembly processes common to both. A priming result without a corresponding cueing effect is more likely to be reflect the relationships preceding the assembly of production routines.

5.1.   *Method*

5.1.1.   *Participants.*   All participants were native speakers of Italian studying temporarily at a British university. All were paid a small fee. As in Experiment 1, no participant had been in the second language environment for more than 3 months at the time of testing or had previously lived in a country where the second language was spoken. Initially two groups of 18 participants were run, one for each experiment. For Experiment 2a, an additional 3 participants were run to replace one whose data were lost because of an experimenter error, one who failed to follow instructions, and one whose mean RT was more than two standard deviations above the grand mean of all reaction times for the experiment. For Experiment 2b, one additional native speaker was run to replace a participant whose mean RT was more than 2 standard deviations above the grand mean.

5.1.2.   *Design and materials.*   The materials were of two kinds. The first were the *target verbs*, 36 Italian verbs, 9 per cell of the Intransitive Type (unaccusative vs. unergative) × ASH Type (core vs. periphery) design. They included the 32 verbs used in Experiment 1 (See Appendix A). The remaining materials were *prime-cue words*, either third person singular forms of the auxiliaries *essere* (*è,* 'is') or *avere* (*ha,* 'has') or a control word, a neutral conjunction (*ma,* 'but'). Each target verb and each prime-cue word appeared alone and centred on the computer screen. Stimuli appeared in two orders. In the priming condition (as in example (7)), each prime-cue word preceded its target. In the cueing condition (example (8)), it followed the target. In either case the SOA was 400 ms, 650 ms, or 900 ms.

(7)   Priming condition:
       Screen 1: è
       Screen 2: caduto
       Required response: caduto
(8)   Cueing condition:
       Screen 1: caduto
       Screen 2: è
       Required response: caduto

All participants encountered all 36 participles (9 per Intransitive Type × ASH Type cell), assigned by Latin Square to combinations of SOA (3), prime-cue word (3), and order (2) conditions, with the proviso that a given combination of target verb and prime-cue word appeared at the same SOA in each order.

5.1.3.   *Procedure: Experiment 2a.*   In the prime condition, participants were asked to treat the prime word as an indication that the target was imminent and then to read the target participle aloud as soon as it appeared. In the cue condition, they were asked to ready themselves to read the target participle aloud but not to do so until the cue word appeared. All participants experienced both the prime condition and the cue condition but in separate blocks. Appropriate instructions and practice items were provided immediately before each block.

5.1.4.   *Procedure: Experiment 2b.*   The procedure was as in 2a except that the visible verb forms of target verbs were all infinitives (as in examples 9 and 10 below) and the instruction was to provide the corresponding participle.

  (9)   Priming condition:
        Screen 1: è
        Screen 2: cadere
        Required response: caduto
 (10)   Cueing condition:
        Screen 1: cadere
        Screen 2: è
        Required response: caduto

5.2.   *Results*

5.2.1.   *Experiment 2a.*   Data for erroneous responses were omitted. ANOVAs by subjects were performed on two dependent variables. First, reaction time to begin speaking was measured by voice key from the presentation of the second word in a pair, i.e., from the target in the prime condition and from the cue in the cue condition. Reaction times more than 2 s.d. above and below the mean were trimmed to 2 s.d. above or below the mean respectively. Second, response duration was measured. The metrical structure of Italian bars final vowel lengthening in participles but promotes devoiced final vowels, whose durations might not regularly be measured. Accordingly, we report response durations from the onset of the participle to the closure of the final consonant of the stem. These are consistent with results based on full participle lengths where the latter could be obtained.

  As in Balota et al. (1989) trials with the irrelevant prime *ma* 'but', increased variance in response times without producing an outcome significantly different from either auxiliary cue. Accordingly, *ma* trials are

omitted from the analyses reported here. All analyses crossed Auxiliary (correct vs. incorrect), ASH Type (core vs. peripheral), Stimulus order (prime vs. cue) and SOA (400, 650, 900 ms). Analyses were done separately by Intransitive Type (unaccusative and unergative). ASH Type was a repeated measure by participants and a grouping variable by items.

As in Balota et al.'s study there were overall effects for SOA, showing that shorter RTs followed both longer target-to-cue delay (for unaccusatives 599 (400 ms), 509 (650 ms), and 489 ms (900 ms), $F(2, 32) = 24.83$, $p < .000001$; for unergatives 601, 508, 473 ms, $F(2, 32) = 27.40$, $p < .000001$) and longer prime-to-target delays (for unaccusatives 572, 537, 534 ms, $F(2, 32) = 4.21$, $p = .02$; for unergatives 558, 530, 517 ms, $F(2, 32) = 6.21$, $p = .005$). There were no significant interpretable interactions with Auxiliary, Intransitive Type, or ASH Type on either dependent variable in either priming or cueing conditions. Either past participles of intransitive verbs are not directly associated with the auxiliaries that often co-occur with them or the task of reading participles aloud does not access any representation which taps such associations. In either case, there is no trace of the pattern found in intuitions.

5.2.2. *Experiment 2b.* Dependent variables were analyzed as in Experiment 2a. There were no relevant effects in the cue condition. In the priming condition, however, as Figure 2 shows, the behavioral fingerprint of the ASH appeared. Participants produced participle responses from core unaccusative infinitives significantly faster after the correct auxiliary (660 ms) than they did after the incorrect auxiliary (763 ms), while peripheral verb production was unaffected by preceding auxiliary (767 ms after correct vs. 758 ms after incorrect auxiliary) (Auxiliary × ASH Type: $F(1, 15) = 6.02$, $p = .027$, Newman Keuls, $p < .05$). No significant effects were found for unergatives.

5.3. *Summary of Experiment 2*

The pattern of results in Experiments 2a and b suggests that lemmas are involved in the representation accessed in making judgments of acceptability. Experiment 2a showed no evidence of association between participial forms and their usual auxiliaries. Experiment 2b showed evidence, albeit incomplete, of a relationship between lemmas and preferred auxiliaries and of the ASH effect. Only core unaccusatives produced faster RTs when preceded by the correct (E) than by the incorrect (A) auxiliary.

The mechanisms of phonological assembly do not seem to be involved: both experiments required assembling the same forms for pronunciation,
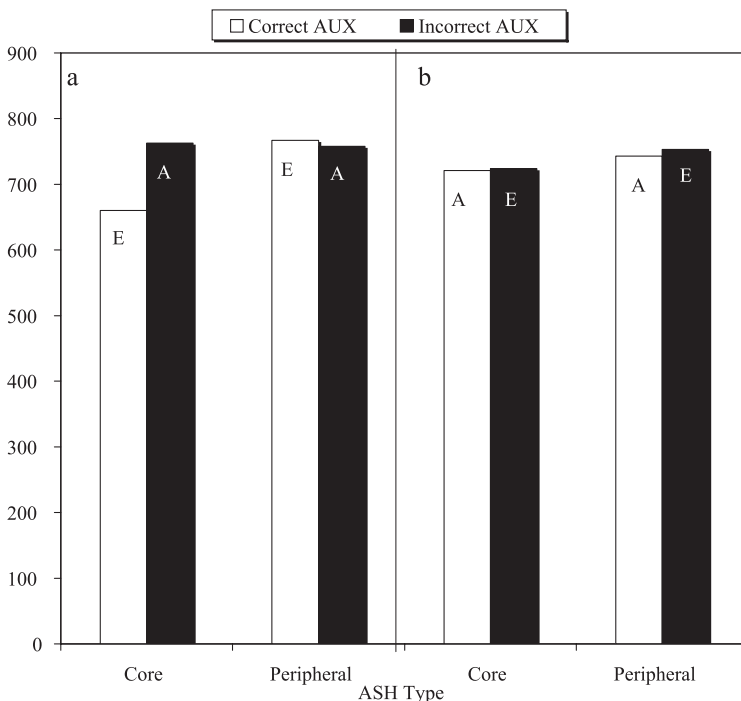
Figure 2.   *Effects of auxiliary (correct vs. incorrect) and ASH Type (core vs. peripheral) on priming paradigm reaction times for two types of intransitive verbs (unaccusatives vs. unergatives) (Experiment 2b): a. Unaccusatives; b. Unergatives; bars are labeled by auxiliary*

but the one which required only assembly, Experiment 2a, gave no ASH effect, and neither showed assembly effects on response duration in the cueing conditions. Thus the process of accessing a more abstract representation of the word, as in Experiment 2b, seems to be necessary to achieve any effect of grammaticality.

The question arises as to why only unaccusatives showed the ASH fingerprint. The core unaccusatives, despite our attempts at controlling for word frequency, were the most frequent verbs, but ANOCOVAs with word frequency as a covariate showed the same patterns as ANOVAs on raw data, so that frequency was unlikely to be the explanation for the limited results. As Figure 2a shows, the ASH effect on reaction times is due to accelerated responding for core unaccusative verbs after the appropriate E-auxiliary, rather than to slow responding after the inappropriate A-auxiliary, which does not differ from the remaining cells. That is, the E-auxiliary primed core unaccusatives, while the A-auxiliary did not prime core unergatives.

6.   Discussion

The work reported here searched for the processing correlates of the results found in linguistic acceptability judgments of auxiliary selection with intransitive verbs. Native speaker intuitions show a difference in the strength of preference for the "correct" auxiliary with intransitive verbs that depends on the aspectual character of the verb as defined by the Auxiliary Selection Hierarchy: core unaccusatives, with maximally telic meanings, give rise to strong preferences for the E-auxiliary over the A-auxiliary, while core unergatives, with maximally atelic agentive meanings, elicit strong preferences in the opposite direction. Intransitive verbs whose meanings are neither strongly telic nor strongly agentive support weaker preferences or none at all. We sought an analogous interaction in on-line processing, testing the syntactic or semantic phases of sentence processing, the access or production of word forms, and the access of the verbs as a whole. In so far as we found such effects, the ASH is confirmed by processing as well as by judgments of acceptability.

Where we found the effects is particularly informative. There were no grammaticality effects at all for early eye fixations, for the task of reading word forms aloud or for cued responding. The interaction of core and periphery with grammaticality appeared twice: as a late effect in sentence reading and in the production of participles from infinitive forms of the same verbs.

The fact that we found the behavioral fingerprint of linguistic intuitions in total reading times suggests that semantic representations of aspect are very likely to be involved in ASH effects. Early reading effects would have indicated that the effect was independent of sentence context, but early reading effects were not found. Late reading effects, which were found, could reflect both late-registering syntactic effects and the computation of many parts of sentence semantics. There is evidence that the composition of aspectual information does continue throughout the reading of a sentence and uses world knowledge and lexis as well as syntax (Pickering et al. 2006; Todorova et al. 2000; Townsend and Bever 2001; Townsend et al. 2005). Thus, the comprehension evidence is not compatible with the ASH assumption of gradient variation in dependence on context within the classes of unaccusative and unergative verbs.

The production studies implicate in this process the part of a word's mental representation which is directly linked to its abstract semantic features. Since no larger syntactic constructions are involved in the production task, we are likely to be dealing with lexical representations. Because verb participles were not primed by suitable auxiliaries or inhibited by unsuitable, the lexeme for the participle does not support the fingerprint

relationship. Because the production of participle responses to infinitive stimuli, the task most likely to involve lemma access, showed the crucial priming effect, the lemma should be implicated. Because there were no cueing effects on phonological assembly of participles, the ASH finger-print in production reflects some more abstract representation of the target verbs. With lexemes eliminated, only verb lemmas are available as candidates. Thus the lemma representations of lexical verbs with their links to meaning-based grammatical features seem to be responsible.

How might the core-periphery distinction be realized if the critical representation is the aspectual specification of verbs? The distinction might be as simple as a difference in strength of association from a particular lemma to the appropriate aspectual feature. Readers' decisions on sentence aspect will be more nearly complete on encountering a core verb but more open to the influence of the following phrases after a peripheral verb. Only core examples should therefore induce early commitment to aspect and re-analysis in the face of incorrect combinations of auxiliary and verb. Peripheral examples may have aspectual preferences but these will be weak enough to allow for major effects of subsequent context.

The asymmetrical effect in Experiment 2b, however, suggests a limitation. The E-auxiliary primes production of core verbs used with it, but the A-auxiliary does not. Two questions arise here. First, why is there a restricted ASH effect in the production paradigm? Second, why do Experiments 1 and 2 show different patterns?

The first question seems to have something to do with the notion of markedness either in a linguistic or a statistical sense. Since the E-auxiliary is linked to telicity, the aspectual feature which is the primary determinant of split intransitivity, a special role for items strongly associated with telicity is comfortable from the point of view of linguistic theory. But a more complete explanation includes the fact that the A-auxiliary might be associated with all manner of aspectual characteristics and with any constructions whose surface subject is an underlying subject — in effect, with all transitive verbs of the language and with unergative intransitives. The E-auxiliary is appropriate only with any constructions in which the surface subject is either an underlying object (for unaccusative intransitives and for passive transitive verbs) or is co-indexed with the other NP argument (for reflexives or copulas).

Confirmation of the privileged relationship between *essere* and telicity comes from two experiments conducted by Vinson et al. (2005) on compositional telicity provided by temporal adverbials in context. In giving acceptability judgments on nonce verbs, native Italian participants were more likely to accept sentences expressing telic events (indicated by means

of temporal adverbials such as *in tre ore* 'in three hours') when the sentence was presented with *essere* than when it appeared with *avere*. No corresponding preference for atelic events (indicated by means of the adverbial *per tre ore* 'for three hours') was obtained when the sentence was presented with *avere*. In completing past-tense sentence fragments after seeing present-tense context sentences using nonce verbs in clearly telic (*in un'ora* 'in an hour') or clearly atelic contexts (*per un'ora* 'for an hour'), participants showed the same asymmetry: they used *essere* significantly more often in telic than in atelic contexts, while there was only a tendency for *avere* to be more frequent in atelic than telic contexts.

Though the experimental paradigms do not overlap, the results of Vinson et al. show the same strong link between *essere* and telicity but only a weak link between *avere* and atelicity. The asymmetry finds a natural explanation within the assumptions of the ASH, since telicity is the primary factor underlying split intransitivity: unaccusatives are a positive instantiation of telicity, whereas unergatives can be defined negatively by the absence of telicity.

In more general psychological terms, the effect seems to be consistent with the fact that relationships among linguistic entities function by facilitation rather than by inhibition: if two abstract representations collocate, each encourages choice of the other. Moreover, we assume with dominant models of language production (Levelt et al. 1999) that speakers must find the lemmas to represent the lexical concepts which they wish to express. That is, speakers have the problem of activating the correct word and selecting it from among similar items that also have semantic and syntactic links with the concept. Appeal to the relationship between the A-auxiliary and agentivity would make this task no easier: too many classes of lexical verb and too many individual verbs would thereby become strong competitors in the process of supplying the correct lemma. Appealing to the relationships between the E-auxiliary and lexical verbs might be more helpful: It would promote a much smaller set of candidate lemmas, those for telic intransitive verbs, transitives verbs which are commonly reflexive, and the like. The restricted set of possibilities may well encourage efficient language production. Indeed, there are several other domains in which efficiency of processing can account for asymmetrical priming patterns (Shillcock and Bard 1993; Tanenhaus and Lucas 1987): In each case, priming a small set of candidates is useful because, all else being equal, favoring that set decreases the effective set of competitors and increases the chance of an early correct choice. Priming a large set of competitors under the same circumstances is counter-productive.

To return to our second question, why do we fail to find this same asymmetry (Figure 2) in sentence reading (Figure 1)? Figures 1b and 1c

break down the total reading time results by Intransitive Type, though there is no significant interaction between Intransitive Type and the ASH fingerprint. They show that the priming effect for core unergative verbs is numerically not weaker but stronger than the analogous effect on unaccusatives. This pattern, we suggest, is consonant with a long-standing claim that initial processing choices follow only one of the patterns available in our materials, the one assigning agenthood to the subject (Fodor and Inoue 2000) and coincidentally, transitivity to the verb. This first-pass tendency would contribute reanalysis time to our late reading effects. If both the Aux and the lexical V can encourage reanalysis, we can explain why unergatives show a larger effect in sentence processing than in production. In all cases, the critical verbs are not actually transitive, so that some re-interpretation should be needed. What varies is the consistency of the indications that reanalysis of surface subject will be necessary. All sentences presented with E would immediately signal that their surface subjects are not necessarily agents, while A auxiliaries do not demand reanalysis. Next, unaccusatives will additionally ask for reanalysis, because their surface subjects are underlying objects. Unergatives are ex hypothesi accepting of surface subjects as true subjects. Thus the sequence of (incorrect) E auxiliary and unergative verb is the only one in our materials first to encourage and then to discourage reanalysis. The resolution of this conflict may account for the fact that incorrect unergatives received the longest total reading times in the experimental design. In this way syntactic processes could serve to magnify the Auxiliary effect for core unergatives relative to the one we see for core unaccusatives, the class that shows the larger Auxiliary effect in production. At the very least, the difference between reading and production may be less extreme than it initially appeared.

7.   Conclusions

The present results give us reason to believe that the ASH bears on more than judgments. It provides generalizations which underlie on-line processes in comprehension and production. How can the ASH be psychologically represented so that on-line and off-line behaviors follow from it? Certainly the intuitions about auxiliary selection appear to have a semantic basis that is likely to involve the relationship between abstract representations of verbs and their aspectual features. The core intransitives, with strong unitary relationships to an aspectual feature, show the most dependable processing effects for grammaticality of auxiliaries. The peripheral intransitives, with multiple aspectual interpretations, fail to

display such effects. But the difference between production and perception suggests that native speakers judging sentences they read might be performing a subtler activity than merely consulting the aspectual connections of the lemma. All the current evidence is consistent with the view that judges are reflecting the difficulty of a common semantic chore which exploits both the syntax and the lexis of sentences: assigning sentence aspect. The data from our study do not support accounts of auxiliary selection as an operation involving two independent and sequential stages: the syntactic computation of unaccusativity/unergativity and the integration of aspectual and semantic information from the context. However, given the difficulty of interpreting the absence of first pass effects in eye movements, we cannot exclude an account that posits the parallel (late) processing of the syntax and the semantics of split intransitivity. We are unlikely to reach firmer conclusions until we examine the ASH effect in judgments under finer manipulations of parsing difficulty and of other cues to sentence aspect, and in a wider range of languages.

Appendix A. Target verbs

Target verbs, Experiments 2 and 3. (Starred items were used in Experiment 1)

Intransitive type	Auxiliary Selection Hierarchy Type					
	Core			Peripheral		
	Form		Freq	Form		Freq
	Infinitive	Participle		Infinitive	Participle	
Unaccusative	cadere *fall*	caduto*	124	bastare *suffice*	bastato*	226
	emergere *emerge*	emerso*	10	durare *last*	durato*	56
	entrare *enter*	entrato	284	esistere *exist*	esistito*	117
	fuggire *escape*	fuggito*	49	mancare *be missing*	mancato*	152
	giungere *arrive*	giunto*	114	parere *seem*	parso*	19
	nascere *be born*	nato*	185	prevalere *prevail*	prevalso*	20
	partire *leave*	partito*	170	restare *remain*	restato*	215

Appendix A   (*Continued*)

Intransitive type	Auxiliary Selection Hierarchy Type					
	Core			Peripheral		
	Form		Freq	Form		Freq
	Infinitive	Participle		Infinitive	Participle	
	scappare *run away*	scappato*	70	sopravvivere *survive*	sopravvissuto*	15
	uscire *go out*	uscito*	214	spettare *be up to*	spettato	17
Mean			135			93
Unergative	funzionare *function*	funzionato*	27	brillare *sparkle*	brillato*	20
	giocare *play*	giocato*	100	cedere *give up*	ceduto*	26
	lavorare *work*	lavorato*	208	correre *run*	corso*	192
	mentire *lie*	mentito*	35	fiorire *blossom*	fiorito	29
	piangere *cry*	pianto*	92	imperversare *rage*	imperversato*	1
	resistere *resist*	resistito	48	saltare *jump*	saltato*	93
	ridere *laugh*	riso*	28	tremare *tremble*	tremato*	32
	riflettere *reflect*	riflettuto*	113	vivere *live*	vissuto*	300
	telefonare *telephone*	telefonato*	118	volare *fly*	volato*	46
Mean			85			82

Appendix B. Materials for Experiment 1[†]

Intransitive Type	ASH Type*	Version	
		A	B
		Quartet 1	
Unaccusative	C	Il campione di tuffi … 'The diving champion …' … {è/*ha} <u>emerso</u> dall'acqua in cinque secondi.	Il sommozzatore … 'The scuba diver …' … {è/*ha} <u>emerso</u> dal lago a mani vuote.

Appendix B   (*Continued*)

Intransitive Type	ASH Type*	Version	
		A	B
Unaccusative	P	'... emerged from the water in five seconds.' ... {è/*ha} <u>restato</u> in apnea per quasi un minuto. '... remained without breathing for nearly a minute.'	'... emerged from the lake with empty hands.' ... {è/*ha} <u>restato</u> in acqua per quasi mezz'ora. '... remained in the water for more than half an hour.'
Unergative	C	... {ha/*è} <u>pianto</u> di gioia alla premiazione. '... wept with joy during the prize ceremony.'	... {ha/*è} <u>pianto</u> di commozione al recupero del cadavere. '... wept with emotion at the retrieval of the body.'
Unergative	P	... {ha/*è} <u>tremato</u> dal freddo tutto il giorno. '... trembled from the cold all day.'	... {ha/*è} <u>tremato</u> al pensiero di non poter risalire. '... trembled at the thought of being unable to rise again.'
		Quartet 2	
		Come si prevedeva mio fratello Piero ... 'As predicted my brother Piero ...'	Come al solito il piccolo Marco ... 'As usual little Marco ...'
Unaccusative	C	... {è/*ha} <u>fuggito</u> nel giardino. '... ran away in the garden.'	... {è/*ha} <u>fuggito</u> davanti agli estranei. '... ran away in front of strangers.'
Unaccusative	P	... {è/*ha} <u>mancato</u> alla riunione. '... was missing at the reunion.'	... {è/*ha} <u>mancato</u> all'appello. '... was missing when his name was called.'
Unergative	C	... ha <u>giocato</u> al casinò. '... played in the casino.'	... {ha/*è} <u>giocato</u> con gli altri bambini. '... played with the other children.'
Unergative	P	... {ha/*è} <u>saltato</u> piu' in alto di tutti. '... jumped higher than everyone else.'	... {ha/*è} <u>saltato</u> sul letto per ore. '... jumped on the bed for hours.'

Appendix B   (*Continued*)

Intransitive Type	ASH Type*	Version	
		A	B
		Quartet 3	
		Secondo Repubblica il Presidente . . . 'According to Repubblica the president . . .'	Secondo Panorama il ministro . . . 'According to Panorama the minister . . .'
Unaccusative	C	. . . {è/*ha} <u>caduto</u> mentre giocava a tennis. '. . . fell while he was playing tennis.'	. . . {è/*ha} <u>caduto</u> mentre sciava a Cortina. '. . . fell while he was skiing at Cortina.'
Unaccusative	P	. . . {è/*ha} <u>durato</u> in carica per troppo tempo. '. . . lasted in his role too long.'	. . . {è/*ha} <u>durato</u> in carica più del previsto. '. . . lasted in his role more than was predicted.'
Unergative	C	. . . {ha/*è} <u>riflettuto</u> a lungo sul da farsi. '. . . thought about what to do.'	. . . {ha/*è} <u>riflettuto</u> sulle sue responsabilità. '. . . reflected on his responsibilities.'
Unergative	P	. . . {ha/*è} <u>ceduto</u> alle richieste dell'ONU. '. . . gave in to the UN requests.'	. . . {ha/*è} <u>ceduto</u> alle pressioni del suo partito '. . . gave in to the pressure from his party.'
		Quartet 4	
		Il presidente della banca elvetica . . . 'The president of the Swiss bank . . .'	Il segretario del Partito Socialista . . . 'The secretary of the Socialist Party . . .'
Unaccusative	C	. . . {è/*ha} <u>giunto</u> a bordo della sua limousine. '. . . arrived in his limousine.'	. . . {è/*ha} <u>giunto</u> in visita ufficiale al Quirinale. '. . . arrived at the Quirinale on an official visit.'
Unaccusative	P	. . . {è/*ha} <u>sopravvissuto</u> alla crisi finanziaria. '. . . survived the financial crisis.'	. . . {è/*ha} <u>sopravvissuto</u> all'attentato. '. . . survived the attack.'
Unergative	C	. . . {ha/*è} <u>riso</u> in faccia ai suoi detrattori. '. . . laughed in the face of his critics.'	. . . {ha/*è} <u>riso</u> di fronte alle accuse. '. . . laughed when faced with the accusations.'
Unergative	P	. . . ha <u>volato</u> sempre con il suo aereo privato. '. . . always flew on his private jet.'	. . . {ha/*è} <u>volato</u> sempre con l'Alitalia. '. . . always flew with Alitalia.'

Appendix B (*Continued*)

Intransitive Type	ASH Type*	Version	
		A	B
		Quartet 5	
		Nonostante il pericolo, Gianni . . . 'Despite the danger Gianni . . .'	Vista la situazione Franco . . . 'Given the situation Franco . . .'
Unaccusative	C	. . . {è/*ha} scappato senza aspettarmi. '. . . ran away without waiting for me.'	. . . {è/*ha} scappato dalla porta di servizio. '. . . escaped from the back door.'
Unaccusative	P	. . . {è/*ha} parso molto controllato. '. . . seemed in control.'	. . . {è/*ha} parso molto agitato. '. . . seemed very agitated.'
Unergative	C	. . . {ha/*è} telefonato alla sua fidanzata. '. . . telephoned his fiancee.'	. . . {ha/*è} telefonato subito al suo avvocato. '. . . immediately telephoned his lawyer.'
Unergative	P	. . . {ha/*è} corso molto velocemente. '. . . ran very fast.'	. . . {ha/*è} corso come un forsennato. '. . . ran like a madman.'
		Quartet 6	
		Il gruppo di medici volontari . . . 'The group of volunteer doctors . . .'	Il contingente militare dell'ONU . . . 'The UN military contingent . . .'
Unaccusative	C	. . . {è/*ha} partito per le zone terremotate. '. . . left for the earthquake zone.'	. . . {è/*ha} partito alla volta del Kosovo. '. . . left for Kosovo.'
Unaccusative	P	. . . {è/*ha} bastato per prestare le prime cure '. . . was sufficient to help.'	. . . {è/*ha} bastato per garantire la tregua '. . . was sufficient to guarantee the truce.'
Unergative	C	. . . {ha/*è} lavorato giorno e notte. '. . . worked day and night.'	. . . {ha/*è} lavorato con molto impegno. '. . . worked with dedication.'
Unergative	P	. . . {ha/*è} brillato per la sua generosità '. . . shone for their generosity.'	. . . {ha/*è} brillato per la sua efficienza '. . . shone for its efficiency.'

Appendix B   (*Continued*)

Intransitive Type	ASH Type*	Version	
		A	B
		Quartet 7	
		Il governo democristiano ... 'The Christian Democrat government ...'	Il regime dittatoriale ... 'The dictatorship ...'
Unaccusative	C	... {è/*ha} <u>nato</u> dal sistema delle clientele. '... was born out of a system of bribes.'	... {è/*ha} <u>nato</u> dalla debolezza del governo. '... was born from the government's weakness.'
Unaccusative	P	... {è/*ha} <u>prevalso</u> sull'opposizione. '... prevailed over the opposition.'	... {è/*ha} <u>prevalso</u> sulla monarchia costituzionale. '... prevailed over the monarchy.'
Unergative	C	... {ha/*è} <u>mentito</u> ai suoi elettori. '... lied to its electorate.'	... {ha/*è} <u>mentito</u> al Paese per troppo tempo. '... lied to the country for too long.'
Unergative	P	... {ha/*è} <u>imperversato</u> per quarant'anni. '... raged for 40 years.'	... {ha/*è} <u>imperversato</u> per due generazioni '... raged for two generations.'
		Quartet 8	
		Sono sicuro che il fantasma in soffitta ... I'm sure that the ghost in the attic ...'	A quanto pare il mostro di Lochness ... It seems that the Lochness monster ...
Unaccusative	C	... {è/*ha} <u>uscito</u> dal comignolo. '... got out through the chimney.'	... {è/*ha} <u>uscito</u> dal suo nascondiglio. '... got out of his hiding place.'
Unaccusative	P	... {è/*ha} <u>esistito</u> davvero. '... really existed.'	... {è/*ha} <u>esistito</u> veramente. '... really existed
Unergative	C	... {ha/*è} <u>funzionato</u> da deterrente. '... functioned as a deterrent.'	... {ha/*è} <u>funzionato</u> come attrattiva turistica. '... functioned as a tourist attraction.'
Unergative	P	... {ha/*è} <u>vissuto</u> indisturbato. '... lived undisturbed.'	... {ha/*è} <u>vissuto</u> nascosto in profondità. '... lived hidden in deep water.'

[†] (Participants did not see the underlining which indicates critical participles here.)

* C = Core; P = Peripheral

Notes

*   This work was supported by joint ESRC (UK), CNRS (France) funding for collaboration between social science research centers, a Faculty Research Grant in the Faculty of Arts, University of Edinburgh; and Poste Rouge support from the CNRS (Laboratoire Parole et Langage) for the first author. The authors are grateful to M. Louise Kelly and to Peter Hipwell for assistance with preparation of materials and running of experiments. Antonella Sorace is now at the Universities of Edinburgh and Tromsø. Correspondence address: E. G. Bard, Linguistics and English Language, School of Philosophy, Psychology, and Language Sciences, University of Edinburgh, Edinburgh EH8 9AD, U.K. E-mail: ellen@ling.ed.ac.uk.

1. Ne-cliticization is a less reliable diagnostic of split intransitivity than auxiliary selection since it is sensitive to a number of discourse and aspectual factors that cut across the unaccusative-unergative distinction (Bentley 2004; Levin and Rappaport Hovav 1995; Lonzi 1986). This point is not crucial to the topic of the present paper, because split intransitivity can be established on other grounds.

2. The set of verbs found in the English resultative construction overlaps only partially with the set of verbs requiring *essere* in Italian. Causes of crosslinguistic mismatches include: (a) different conceptualizations of verbs across languages; (b) different syntax-semantics mappings; (c) interactions with language-particular syntactic or semantic constraints. In the case of the resultative construction in English, event complexity as defined in Levin and Rappaport Hovav (2005) seems to constrain the set of verbs that can enter the construction.

3. It can be argued (as a reviewer does) that this restriction is a potential weakness of the approach because it excludes unaccusative change of state verbs with transitive alternants ("anticausative" verbs). There are two arguments for excluding dyadic intransitives, one empirical and one theoretical. First, these verbs, which have been found to elicit weak preferences for *essere* in experiments on Italian (Bard et al. 1996; Sorace 1993a, 2000), have more frequent transitive alternants that regularly select *avere*. Because speakers may simply encounter such verbs at least as often with *avere* as with *essere*, the effects of aspectual semantics could be difficult to distinguish from effects of mere familiarity. Second, several authors have actually questioned the syntactic status of dyadic verbs in different languages, arguing that they should be regarded as unergative and not unaccusative (Haegeman 1994; Jones 1993; Labelle 1992).

4. Gradience is even more evident in German, where indefinite change and telic change are distinguished by prefixes: verbs such as *rosten* 'rust' tend to be accepted with both *sein* 'be' and *haben* 'have', whereas *verrosten* 'rust (up)' elicit a clear and strong preference for *sein* (Keller and Sorace 2003).

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