

## Processing (the) events: lexical and structural ingredients of inner aspect\*

Linnaea Stockall · E. Matthew Husband

What is the aspectual representation of verbs and how is that representation used to construct the aspectual interpretation of a sentence during online sentence processing? In this paper we use psycholinguistic techniques to address both these questions. In the first experiment, a processing correlate of telicity is identified by manipulating verbal telicity (inherently telic vs. unspecified verbs) and direct object quantization, finding a principled delay in the use of these verbs' aspectual representation in which both the verb and its internal argument are required before the comprehension system can commit to a telic or atelic interpretation. In the second experiment, this processing correlate reveals no differences in processing between inherently atelic and unspecified verbs, delayed or otherwise. We argue that together these experiments support theories that distinguish between two verb classifications, a class of inherently telic verbs and a class of unspecified verbs, but not those that include a class of inherently atelic verbs.

*Keywords* aspectual interpretation, semantic commitments, telicity, lexical semantics of verbs, sentence processing

### Introduction

It is well known that the telicity of an eventive predicate is determined by properties of both the predicate's verb and its internal argument (Verkuyl 1972). For instance, if we use the availability of a terminative interpretation to diagnose the presence of a telic predicate, the telicity of a predicate containing the verb *solve* alternates depending on properties of its internal argument. A terminative interpretation is available when the internal argument is quantized, as in (1a), but not when the internal argument is homogeneous, as in (1b). This

---

\*We are grateful to Sarah VanWagenen for her thoughtful and penetrating comments on an earlier draft of this paper. As described by Matt in the introduction to this volume, she helped us to appreciate that far from adjudicating between competing theories about incrementality and depth in parsing, our results (especially experiment 1) are unexpected, and thus puzzling, for any fully implemented parser. Her perspective will continue to have an impact as we pursue an answer to this puzzle. We would also like to thank David Adger, Daniel Harbour and colleagues and audiences too numerous to mention for feedback at various stages of the development of this work, and Alan Beretta for bringing us together on this project in the first place.

diagnostic shows us that (1a) is a telic predicate and (1b) is an atelic predicate.<sup>2</sup>

- (1) a. Sarah solved/read the problem (in six minutes).
- b. Sarah solved/read problems \*(in six minutes).

This stands in contrast to predicates containing verbs like *find* in (2) or *push* in (3) where the quantization of the internal argument does not affect the availability of a terminative interpretation. A terminative interpretation appears to always be available for predicates with the verb *find*, but never with the verb *push*, suggesting that in these cases the verb itself is the primary determinant of the predicate's telicity.

- (2) a. Sarah found/noticed the book in two hours.
- b. Sarah found/noticed books in two hours.
- (3) a. Sarah pushed/pulled the cart \*(in five seconds).
- b. Sarah pushed/pulled carts \*(in five seconds).

The different roles that verbs play in determining the telicity of their predicates have posed a long standing question concerning the nature of the lexical representation of verbs. Focusing on the relationship between a verb and its internal argument, the picture above appears to support a three-way classification of verbs into those which form inherently telic and atelic predicates, and those which do not specify the telicity of their predicates, corresponding roughly to Vendler's (1957) achievement, activity, and accomplishment classes respectively. The inherent specification for telicity, then, forms part of the lexical representation of these verbs, say, by bearing a feature which either triggers or blocks the formation of a telic predicate.

However, the question of whether any verbs are, in fact, inherently specified for telicity is debated. While general consensus has supported the existence of a class of inherently telic verbs (Rappaport Hovav 2008; Mittwoch 1991; Rothstein 2004), the status and behavior of putatively inherently atelic verbs like those in (3) have been more contentious, with work both supporting an inherently atelic class of verbs (Dowty 1991; Kennedy and Levin 2008; Krifka 1989, 1992; Tenny 1994; Verkuyl 1993) and arguing against an inherently atelic class of verbs (Borer 2005; Schein 2002). Arguments concerning inherently atelic verbs have hinged primarily on issues concerning how world knowledge may influence the availability of terminative interpretations. Borer (2005), for instance, observes that although *push* and *pull* are paragon cases for inherently atelic verbs, when their internal argument is *lever* as in (4), *push* and *pull* behave like (1), with a terminative interpretation available when the internal argument is quantized, as in (4a), and absent when the internal argument is homogeneous, as in (4b).

- (4) a. Sarah pushed/pulled the lever (in five seconds).
- b. Sarah pushed/pulled levers \*(in five seconds).

---

<sup>2</sup>We focus here on the availability of terminative interpretations as diagnosed with *in x time* which are argued to be acceptable only with telic predicates (Piñón 2008). Other event interpretations and aspectual tests, including durative interpretations of atelic predicates and interruptive and iterative interpretations of telic predicates will be set aside.

Given that a terminative interpretation is possible for *push* and *pull*, one might suggest that inherently atelic verbs with quantized internal arguments always form telic predicates, even in the case of (3a), but world knowledge blocks the terminative interpretation. To address this possibility, a different method is needed.

In this short report, we describe two experiments using online sentence processing to investigate lexical aspect by uncovering the time course in which the features of verbs are accessed and used to construct a predicate's telicity. This technique helps to side step certain issues of world knowledge by probing for certain predicted interactions between the formal features of verbs and the features of the internal argument. To preview our results, our first experiment supports theories with a class of inherently telic verbs, while our second experiment fails to support theories with a class of inherently atelic verbs even in those cases where a terminative interpretation is unavailable.

In Section 1, we lay out our assumptions about the representation of telicity and discuss the relationship between grammatical structure and online sentence processing in section 2. Section 3 reports two self-paced reading experiments. Experiment 1 in Section 3.1 finds a processing correlate of telicity using inherently telic verbs, while Experiment 2 in Section 3.2 uses this processing correlate to examine the representation of inherently atelic verbs. The final section summarizes the results and implications of these two studies and concludes.

## 1 Aspectual features of verb

Although one of the earliest and most influential proposals concerning the aspectual representation of verbs comes from Vendler (1957), Verkuyl (1972) represents perhaps the first systematic study of aspectual composition and the division of labor between the verb and other linguistic units. In his theory, verbs carry either a +ADDTO feature, indicating a dynamic lexical aspect, or a -ADDTO feature, indicating a nondynamic lexical aspect. The telicity of a predicate is determined by both the value of the ADDTO feature of its verb along with the quantity of its argument (represented as  $\pm$ SQA). Verkuyl's (1993) amendment of this theory with the *plus principle* proposes that a telic interpretation of a predicate emerges only if both the ADDTO and SQA features were positive, as shown in (5).

- (5) a. Sarah solved<sub>+ADDTO</sub> the problem<sub>+SQA</sub> (in an hour).  
 b. Sarah solved<sub>+ADDTO</sub> problems<sub>-SQA</sub> \*(in an hour).  
 c. Sarah pushed<sub>-ADDTO</sub> the cart<sub>+SQA</sub> \*(in an hour).  
 d. Sarah pushed<sub>-ADDTO</sub> carts<sub>-SQA</sub> \*(in an hour).

Following Verkuyl, Krifka (1989, 1992, 1998) proposed a mereological theory of aspectual composition which, following insights from Bach (1986), linked the notion of telicity to the notion of quantity. In his approach, a telic interpretation arises from a quantized event. An event could become quantized compositionally by mapping the quantization of an internal argument to the event via an incremental theme. For Krifka, verbs whose process applies incrementally to their internal argument assign an incremental theme role, allowing the internal argument to 'measure out' the event (in Tenny's (1994) terms).

Interestingly, both Verkuyl and Krifka's accounts share a core assumption that there are verbs that are inherently atelic. Under Verkuyl's theory, inherently atelic verbs are those

verbs which are -ADDT0 and thus cannot map the quantization of their internal argument to the event. Under Krifka's theory, inherently atelic verbs are those verbs that do not assign an incremental theme and therefore also cannot map the quantization of their internal argument to the event. Neither Verkuyl or Krifka's theory, however, argues for a class of inherently telic verbs, and indeed, Verkuyl (1989) argues against inherently telic verbs as a separate class. He argues that 'inherently telic' verbs are unspecified verbs that world knowledge specifies as having punctual durations, thus leading them to appear to always be telic. Based on this latter account, verbs that seem to be inherently telic are actually unspecified, with later world knowledge coming into play in determining the ultimate interpretation.

A different approach to the aspectual specification of verbs comes from an investigation of events of scalar change (Beavers 2007; Filip 1999; Hay et al. 1999; Kennedy and Levin 2008; Piñón 2008). In these accounts, verbs are associated with scales of change and differences in scale structure result in the different aspectual behaviors by mapping the scale structure to the event. Possible scale structures include two-point and multi-point scales which are either open or closed, and a predicate's telicity is determined in part by whether a scale is open or closed. Two-point scales, such as (6a), describe a transition from not having a property to having a property and are inherently closed. Multi-point scales describe an incremental change which could be either closed, as in (6b), or open, as in (6c).

- (6) a. Sarah awoke (in five seconds).
- b. Sarah emptied the sink (in a few minutes).
- c. Sarah widened the gap \*(in one hour).

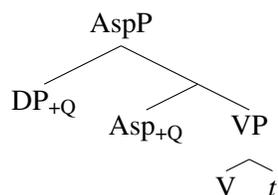
Like Verkuyl and Krifka's theories, the scalar approach admits a class of inherently atelic verbs, namely, verbs that are associated with (multi-point) open scales. Because these scales lack a maximum point, they describe unbounded change and thus have no terminus. The scalar approach differs, however, from Verkuyl and Krifka's approach in also admitting a class of inherently telic verbs, namely, those verbs associated with two-point (closed) scales. Two-point scales are inherently closed and therefore verbs associated with two-point scales are inherently telic (Rappaport Hovav 2008).

A final view comes from Borer (2005), who maintains an essentially mereological view of telicity, but proposes that it is mediated through the syntax. Under her approach, a telic predicate has a specific syntactic structure, e.g. one containing the functional head Asp, which requires a certain syntactic configuration to be licensed to project. One way the syntax can license the projection of AspP is by having an internal argument that is quantized, represented as +Q in her theory. A second way AspP can be licensed to project is by having a verb that is quantized.<sup>3</sup> The configurations for these cases are given in (7). Borer further argues that atelic predicates have no dedicated syntactic configuration. Instead, atelicity emerges whenever Asp does not project. This can occur when the syntax fails to license Asp (for instance, because the verb is not inherently telic and the internal argument is not +Q), but also more generally when the syntax does not require the projection of Asp. Indeed, Borer argues that Asp is only required to project when the verb is inherently telic, since inherently telic verbs carry Asp in their representation.

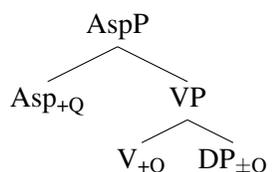
---

<sup>3</sup>Borer (2005) treats these cases as idioms, in that they exist as a verb with Asp.

(7) a.



b.



As such, Borer's account parts ways with the assumptions in both Verkuyl/Krifka's approach and scalar approaches that verbs can be inherently atelic. Instead, putatively atelic verbs should behave like unspecified verbs, with world knowledge coming into play in determining the ultimate availability of a terminative interpretation.

To summarize, each of these approaches assumes a different typology of aspectual verb features. The Verkuyl/Krifka approach proposes a two-way distinction between inherently atelic verbs and unspecified verbs. The scalar approach proposes a three-way distinction between inherently atelic verbs, inherently telic verbs, and unspecified verbs. Borer's approach proposes a two-way distinction between inherently telic verbs and unspecified verbs. Abstracting away from the particulars of each of these proposals, we adopt the following language for the purposes of this paper.  $V_{-Q}$  stands for a verb bearing a -ADDTO/non-incremental theme role or an association with a multi-point open scale.  $V_{+Q}$  stands for a verb associated with a two-point closed scale or one which bundles an Asp head as part of its representation.

## 2 Using aspectual features in online sentence processing

Research attempting to establish which of the possible typologies of aspectual features of verbs have thus far made use only of traditional linguistic methods. While these have been useful in delimiting the possibilities, it is well-known that linguistic judgments can be influenced by a variety of factors, including world knowledge. Indeed, it has been on these grounds that different researchers have arrived at difference conclusions concerning the inventory of lexical aspectual features, as discussed above.

A different way to detect the presence of a lexical difference between potential aspectual classes of verbs is to investigate when the comprehension system makes use of lexical information. During processing, the comprehension system recovers the lexical content of words, including formal lexical features. This content can then be used to project structure and make interpretative commitments.

In previous research, attempts to detect the comprehension system's commitment to an aspectual interpretation have relied on observing a processing cost due to the coercion of a durative temporal modifier (e.g. *for years*) to an iterative or incomplete interpretation when combined with a telic predicate (Todorova et al. 2000; Piñango et al. 1999, 2006; Townsend and Seegmiller 2004; Pickering et al. 2006; Brennan and Pyllkkänen 2008; Townsend 2012). By measuring the reading times of of a word or phrase in a self-paced reading task, Todorova

et al. (2000) found that a durative modifier like *for years* was read for a longer time after reading a telic predicate like *send a check* compared to an atelic predicate like *send checks*. This research, and much after it, confirmed that the telicity of a predicate is determined rapidly; that is, by the time the comprehension system is interpreting a durative temporal modifier, the system has already committed to a telic or atelic interpretation of the predicate. Brennan and Pykkänen (2008) reverse the order of the temporal modifier and the predicate, and use the very high temporal resolution of MEG to show that determination of telicity is very rapid indeed. Evoked neural responses to verbs like *sneeze* reflected significantly greater processing costs, in brain areas associated with other forms of coercion, when they occurred in sentences that began with durative adverbials like *for hours*. However, Brennan and Pykkänen (2008) only used intransitive verbs, so their study did not provide the opportunity to distinguish between lexical and compositional sources of aspectual interpretations.

However, Gennari and Poeppel (2003), using self-paced reading, found that stative transitive verbs were read more slowly than eventive transitive verbs<sup>4</sup>, suggesting that aspectually relevant features of verbs themselves, if present, can affect processing responses. As such, we should expect the comprehension system to make use of aspectually relevant features when projecting structure and making interpretative commitments.

This approach predicts important interactions between possible aspectual features of verbs and their internal arguments. Restricting ourselves to transitive cases to enable clear predications, if a verb is aspectually unspecified, then the comprehension system must recover the quantization of the internal argument and use that to construct a telic or atelic predicate. Given that these two predicates differ, we expect their processing profiles to also be different. The case for verbs with inherent telicity, however, is different. If a verb is inherently telic or inherently atelic, the comprehension system must recover this information from the verb itself and use that to construct a telic or atelic predicate respectively, regardless of the quantization of the internal argument. We would thus expect a similar processing profile for all predicates containing, say, *find*, regardless of the Q value of the internal argument. Finally, we expect similar processing profiles for all telic predicates and similar processing profiles for all atelic predicates.

Taken together, a three-way distinction, as made by the scalar approach, predicts two interactions. Pairing inherently telic verbs with unspecified verbs, as in (8a), it predicts three telic predicates and one atelic predicate. Pairing inherently atelic verbs with unspecified verbs, as in (8b), it predicts three atelic predicates and one telic predicate. Two-way approaches to aspect predict only one interaction. The Verkuyl/Krifka approach predicts only the interaction in (8b), and the Borer approach predicts only the interaction in (8a).

(8)	a.	<table style="border-collapse: collapse; margin-left: 20px;"> <tr> <td style="padding-right: 10px;"></td> <td style="text-align: center; border-bottom: 1px solid black;"><math>V_{\text{unspec}}</math></td> <td style="text-align: center; border-bottom: 1px solid black;"><math>V_{+Q}</math></td> </tr> <tr> <td style="padding-right: 10px;">DP<sub>+Q</sub></td> <td style="text-align: center;">telic</td> <td style="text-align: center;">telic</td> </tr> <tr> <td style="padding-right: 10px;">DP<sub>-Q</sub></td> <td style="text-align: center;">atelic</td> <td style="text-align: center;">telic</td> </tr> </table>		$V_{\text{unspec}}$	$V_{+Q}$	DP <sub>+Q</sub>	telic	telic	DP <sub>-Q</sub>	atelic	telic
	$V_{\text{unspec}}$	$V_{+Q}$									
DP <sub>+Q</sub>	telic	telic									
DP <sub>-Q</sub>	atelic	telic									
	b.	<table style="border-collapse: collapse; margin-left: 20px;"> <tr> <td style="padding-right: 10px;"></td> <td style="text-align: center; border-bottom: 1px solid black;"><math>V_{\text{unspec}}</math></td> <td style="text-align: center; border-bottom: 1px solid black;"><math>V_{-Q}</math></td> </tr> <tr> <td style="padding-right: 10px;">DP<sub>+Q</sub></td> <td style="text-align: center;">telic</td> <td style="text-align: center;">atelic</td> </tr> <tr> <td style="padding-right: 10px;">DP<sub>-Q</sub></td> <td style="text-align: center;">atelic</td> <td style="text-align: center;">atelic</td> </tr> </table>		$V_{\text{unspec}}$	$V_{-Q}$	DP <sub>+Q</sub>	telic	atelic	DP <sub>-Q</sub>	atelic	atelic
	$V_{\text{unspec}}$	$V_{-Q}$									
DP <sub>+Q</sub>	telic	atelic									
DP <sub>-Q</sub>	atelic	atelic									

<sup>4</sup>The reading time slowdown emerged very rapidly, during the processing of the lexical verbs themselves, and did not persist into the post-verbal arguments region

Experiment 1 investigates the incremental processing predictions in (8a) of aspectual interpretations using inherently telic verbs which appear to be well supported in the literature. Experiment 2 goes on to then use the processing correlate found in Experiment 1 to examine the processing predictions in (8b) using inherently atelic verbs.

### 3 Experiments

Below we report two self-paced reading experiments investigating the online interpretation of telicity. Statistical significance was evaluated using linear mixed effects models with subjects and items as random factors unless otherwise indicated, using the R statistical package (<http://www.R-project.org>). Markov Chain Monte Carlo sampling was used to estimate  $p$  values for all linear mixed effects models (see Baayen et al. (2008) for justification and explanation of this technique).

#### 3.1 Experiment 1

Experiment 1 was designed to investigate how verbal sources of aspectual information are interpreted in real time. We manipulated verbal telicity (inherently telic vs. unspecified) and the internal argument determiner (definite vs. null). In English, noun phrases with null determiners are homogenous ( $Q_-$ ), while noun phrases with definite determiners are quantized ( $Q_+$ ). Materials consisted of 48 sets of 4 sentences, as in (9). This design predicts an interaction due to the combination of verb and internal argument type: only an unspecified verb with a null determiner internal argument, seen in (9c), gives rise to an atelic interpretation. All other combinations trigger a telic interpretation.

- (9)
- a. INHERENTLY TELIC, NULL (TELIC)  
The expert physicist lost files on the formation of black holes.
  - b. INHERENTLY TELIC, DEFINITE (TELIC)  
The expert physicist lost the files on the formation of black holes.
  - c. UNSPECIFIED, NULL (ATELIC)  
The expert physicist read files on the formation of black holes.
  - d. UNSPECIFIED, DEFINITE (TELIC)  
The expert physicist read the files on the formation of black holes.

Verbs were classified as telic or unspecified using Dowty (1979)'s *Subj VP-ed for X time* and *Subj spent X time VP-ing* tests, which are incompatible with telic events. Both the null and definite determiner version of each sentence was tested. Verbs that were always judged as unacceptable with both definite and null determiner objects were classified as inherently telic, as in (9a) and (9b), and verbs which were judged acceptable with null determiners, but unacceptable with the definite determiners, were classified as unspecified, as in (9c) and (9d). The inflected verb forms in the telic and unspecified verb conditions were matched for length and lexical frequency and were also normed for transitivity to ensure the conditions did not differ in how likely verbs were to be followed by an object DP. Twenty-five Michigan State University undergraduates completed sentence fragments consisting of the stimulus items up to the critical verb (*The expert physicist lost .../The expert physicist read ...*). Inherently

telic verb fragments were continued with object DPs 88% of the time, and unspecified verbs, 87% of the time ( $t(47) = .511, p = .612$ ), thus transitivity did not vary between verb conditions. Finally, object nouns in these conditions were always plural.

Sixty native English-speaking students from Michigan State University participated in Experiment 1. Participants performed a self-paced word-by-word moving window reading task. Each participant saw 48 experimental stimuli (12 in each condition) and 122 filler sentences (including garden-path, complement coercion, and ungrammatical sentences). Items were assigned to participants using a Latin squares design. After each sentence, participants were asked to rate the acceptability of sentences on a 1 to 5 scale. The rating task was designed to ensure participants were required to comprehend the sentences they were reading, and to provide a measure of sentence acceptability.

The mean and standard error for acceptability judgments are given in Table 1. A main effect of verb type was found on acceptability scores ( $t = 3.53, p^{MCMC} < 0.001$ ), such that sentences containing unspecified verbs were judged as less acceptable than sentences containing inherently telic verbs. There was no effect of the determiner type and, crucially, no interaction, suggesting that acceptability did not drive any interaction in the self-paced reading data. There is no evidence that participants had any preference for a specific verb type + DP type combination in the experiment.

Table 1: Mean and standard error acceptability ratings for Experiment 1 (1 = “unacceptable”, 5 = “fully acceptable”)

Verb Type	Determiner Type	<i>M</i>	<i>SE</i>
Unspecified	Null	3.76	0.089
	Definite	3.67	0.087
Inherently Telic	Null	4.03	0.083
	Definite	4.01	0.072

A graph of the reading time data is given in Figure 1. Each point on the graph represents the average reading time for that word.<sup>5</sup> Prior to statistical analysis, raw reading times were log transformed to correct for skew (Baayen et al. 2008). Log reading times greater than 7.5 were excluded from analysis, resulting in the loss of 1.8% of the data. We compared reading times on the verb, the direct object noun, and first and second spillover regions (noun+1 and noun+2, respectively) with verb type, determiner type, and their interaction as predictors in the initial model, using the inherently telic + definite condition as a baseline to detect the predicted interaction. If the interaction was not significant in the initial model, it was removed before fitting the final model.

We found no significant effects on the reading times on the verb, determiner, or noun+2 regions. On the noun region, we found a simple effect of determiner type on the reading times. Nouns with a null determiner were read significantly more slowly than nouns preceded by a definite determiner. This effect of determiner type on our noun reading time is known to arise independently in both subject and object position (Gordon et al. 2004). There was

<sup>5</sup>Note that since sentences with null determiners have no overt morphology, no determiner reading times can be given. This results in a gap in the line plot, though no gap or delay was present in the sentences read by our participants.

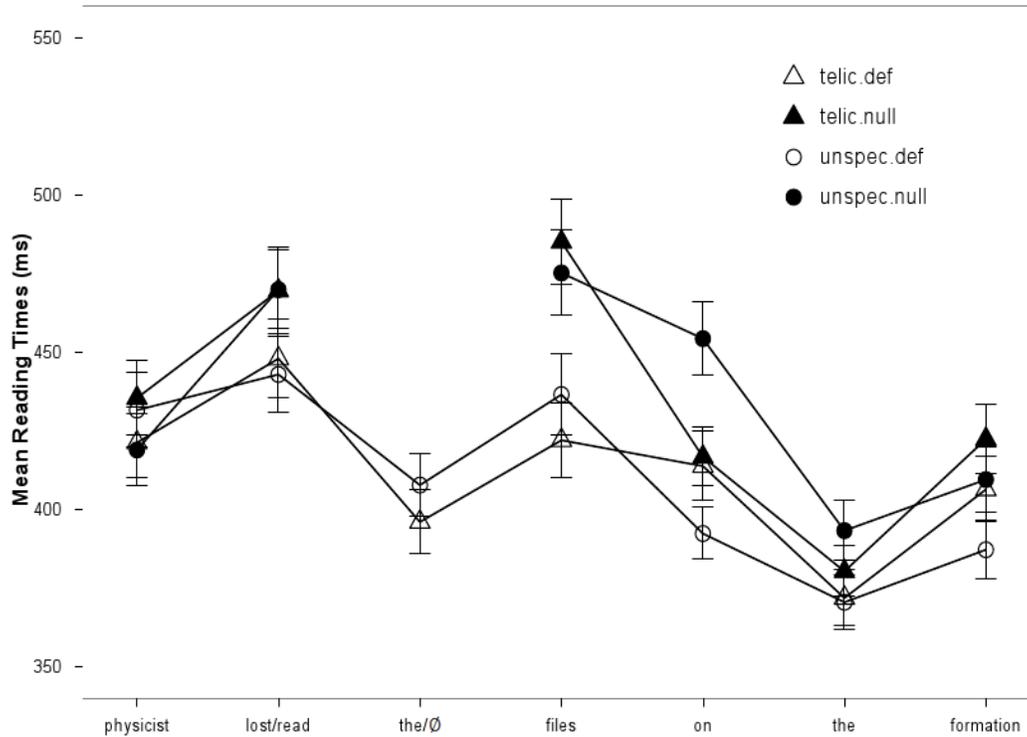


Figure 1: Word by word reading times by condition for Experiment 1. Error bars indicate standard error of the mean.

Table 2: Estimates, standard errors,  $z$  values, and  $p$  values of the final linear-mixed effects model for Experiment 1.

		Estimate	$SE$	$z$ value	$p^{MCMC}$
Noun	Intercept (telic, def)	5.998	.035	171.29	<.0001
	verb (unspec)	-.002	.020	-.08	.9234
	determiner (null)	.071	.014	4.97	.0001
Noun+1	Intercept (telic, def)	5.947	.028	213.71	<.0001
	verb (unspec)	.016	.017	.91	.3804
	determiner (null)	.014	.017	.81	.4212
	verb x det. (unspec, null)	.078	.025	3.15	.0020

no significant interaction on the noun region. On the noun+1 region, we found a significant interaction of verb type and determiner type. This spillover region was read significantly more slowly in the unspecified verb + null determiner (atelic) condition compared to the other three (telic) conditions. A summary of the linear mixed effects models for the noun and noun+1 region are given in Table 2.

The slowdown in the atelic condition relative to the three types of telic conditions suggests that properties of both the object DP and the verb are used rapidly online to construct an aspectual interpretation. However, the lack of any effect of verb type on the verb or the noun reading times is surprising. Most current parsing models assume highly incremental, predictive parsing (as discussed in several of the papers in this volume), in which an aspectual interpretation could be generated as soon as the  $Q_+$  feature on an inherently telic verb is parsed. Instead we find no effect of the lexical telicity of the verb until the internal argument has been parsed, and, presumably, the minimal VP assembled. The immediate slow down in reading times on the noun triggered by the null determiner makes it clear that if a  $Q_+$  feature on a verb was parsed and interpreted immediately, we should expect to see immediate effects<sup>6</sup>. Although inherently telic verbs contribute to aspectual interpretation, their contribution appears to only take effect once their  $Q_+$  feature is in the appropriate syntactic structure for interpretation<sup>7</sup>.

Regardless of this surprising delay, the interaction found in Experiment 1 provides a firm processing correlate of aspectual interpretation: atelic and telic predicates are associated with distinct responses. Experiment 2 turns to the question of whether there are really inherently atelic verbs, i.e. verbs specified as  $Q_-$ . Under the three verb class analysis given in (8), both inherently telic and inherently atelic verbs bear a specified Q feature.

In addition to the interaction found above, evidence for the  $Q_+$  feature for certain verbs traditionally comes from predicates where a telic interpretation is available even though their internal argument is homogeneous (Mittwoch 1991; Borer 2005). For instance, although the internal arguments *oil* and *bedrock* in (10) are homogeneous, a repeated event interpretation is available with *for hours*, indicating a telic interpretation for the predicate is possible. Since this telic interpretation is not licensed by the internal argument, it has been argued that it must emerge from some inherent feature carried by the verb.

- (10) a. The drill struck oil for hours. (repeated event interpretation)  
 b. The drill struck bedrock for hours. (repeated event interpretation)

The basic observation motivating a  $Q_-$  feature for certain verbs comes from similar cases, namely, the behavior of predicates which have an atelic interpretation even though their internal argument is quantized. Even though *the cart* is quantized in (11a), a telic interpretation of *push the cart* seems unavailable; only a single event interpretation is available with *for hours*. However, unlike the verb *strike* in (10), the verb *push* is not invariably associated with an atelic interpretation. For instance, a repeated event interpretation becomes available when the object is *the button*, as in (11b) (Borer 2005).

<sup>6</sup>See also Gennari and Poeppel (2003) who find immediate differences in self paced reading times for stative vs. eventive verbs as discussed above.

<sup>7</sup>We have in mind here the large family of approaches to lexical/internal aspect which assume an Asp or AgrO phrase, projected above the VP, is the domain of aspectual interpretation, as in Borer (2005)'s approach discussed above. See also Rosen (1999); MacDonald (2008); Travis (2010) *inter alia*.

- (11) a. Sarah pushed the cart for hours. (single event interpretation)  
 b. Sarah pushed the button for hours. (repeated event interpretation)

Borer argues that the difference between (11a) and (11b) arises because of our world knowledge, i.e. there are clear real world telic events of pushing buttons, but not of pushing carts. Without real world concepts supporting a telic interpretation of *push the cart*, only an atelic interpretation can emerge. As such, ‘inherently’ atelic verbs like *push* may not differ grammatically from unspecified verbs: both lack a Q feature, telic interpretation in both (11a) and (11b) is determined by the quantized internal argument. However, while a quantized internal argument is a necessary condition for a telic interpretation in these cases, it is not a sufficient one. World knowledge is also required. This analysis proposes that there are only two classes of verbs, those which bear a Q<sub>+</sub> feature and those which have no Q feature at all.

This predicts that in online processing ‘inherently’ atelic verbs and unspecified verbs should show the same behavior since they both lack a Q feature. An analysis which maintains the existence of inherently atelic verbs, however, predicts a pattern similar to that found in Experiment 1, in which a Q<sub>-</sub> on the verb produces an interaction once the minimal VP has been constructed.

### 3.2 Experiment 2

Experiment 2 was designed to investigate the processing of predicates such as *push the cart* which involve a quantized internal argument usually associated with telic interpretations, but which are judged to be atelic.

Experiment 2 investigates whether inherently atelic verbs behave like inherently telic verbs or like unspecified verbs by directly comparing the clearly unspecified verbs from Experiment 1 with verbs like *push* which often lead to an atelic interpretation of their predicate regardless of their internal argument and, thus, are argued to bear a Q<sub>-</sub> feature. Although certain predicates, such as (11b), appear to license a telic interpretation, we used only those cases where the classic tests for telicity fail to detect the availability of a telic interpretation. As in Experiment 1, the verb-type factor was crossed with the determiner-type factor. Materials consisted of 40 sets of 4 sentences, as in Experiment 1, and 164 fillers. This design, again, predicts an interaction due to the combination of verb and internal argument type: only an unspecified verb with a definite determiner internal argument, given in (12c), is interpreted as telic. All other combinations are interpreted as atelic.

- (12) a. INHERENTLY ATELIC, NULL (ATELIC)  
 The local horticulturist roamed gardens in the neighborhood.  
 b. INHERENTLY ATELIC, DEFINITE (ATELIC)  
 The local horticulturist roamed the gardens in the neighborhood.  
 c. UNSPECIFIED, NULL (ATELIC)  
 The local horticulturist inspected gardens in the neighborhood.  
 d. UNSPECIFIED, DEFINITE (TELIC)  
 The local horticulturist inspected the gardens in the neighborhood.

Verbs were classified as inherently atelic or unspecified using the same methodology as in Experiment 1. Verbs that were judged as acceptable in the *Subj VP-ed for X time* and *Subj spent X time VP-ing* frames with both definite and null determiner objects were classified as inherently atelic, as in (12a) and (12b), and verbs which were judged acceptable with a null determiner object, but unacceptable with the definite determiner object were classified as unspecified verbs, as in (9c) and (9d). The inflected verb forms were matched for length, and lexical frequency.

Sixty Michigan State University undergraduates participated in Experiment 2. The same self-paced reading paradigm as Experiment 1 was used.

The mean and standard error for acceptability judgments are given in Table 3. As in Experiment 1, we found a main effect of verb type on acceptability scores ( $t = 2.46$ ,  $p^{MCMC} = 0.014$ ). In this case, sentences containing inherently atelic verbs were judged as less acceptable than sentences containing unspecified verbs. There was no effect of the determiner manipulation and no interaction, suggesting that participants did not have any preference for a specific verb type + DP type combination in the experiment.

Table 3: Mean and standard error acceptability ratings for Experiment 2 (1 = “unacceptable”, 5 = “fully acceptable”)

Verb Type	Determiner Type	<i>M</i>	<i>SE</i>
Unspecified	Null	3.92	0.049
	Definite	3.97	0.047
Inherently Atelic	Null	3.86	0.048
	Definite	3.82	0.048

A graph of the reading time data is given in Figure 2. Raw reading times were log transformed to correct for skew prior to analysis. Log reading times greater than 7.5 were excluded from analysis, resulting in the loss of 3.47% of the data. The same regions as in Experiment 1 were analyzed, with verb type, determiner type, and their interaction as predictors in the initial model using the inherently atelic + null condition as a baseline to detect the predicted interaction. If the interaction was not significant in the initial model, it

Table 4: Estimates, standard errors, *z* values, and *p* values of the final linear-mixed effects model for Experiment 2.

		Estimate	<i>SE</i>	<i>z</i> value	$p^{MCMC}$
Noun	Intercept (atelic, bare)	6.171	.033	187.76	<.0001
	verb (unspec)	-.008	.014	-.59	.5608
	det (def)	-.065	.014	-4.66	.0001
Noun+1	Intercept (atelic, bare)	6.083	.026	236.12	<.0001
	verb (unspec)	-.005	.011	-.40	.6820
	det (def)	-.020	.011	-1.75	.0826

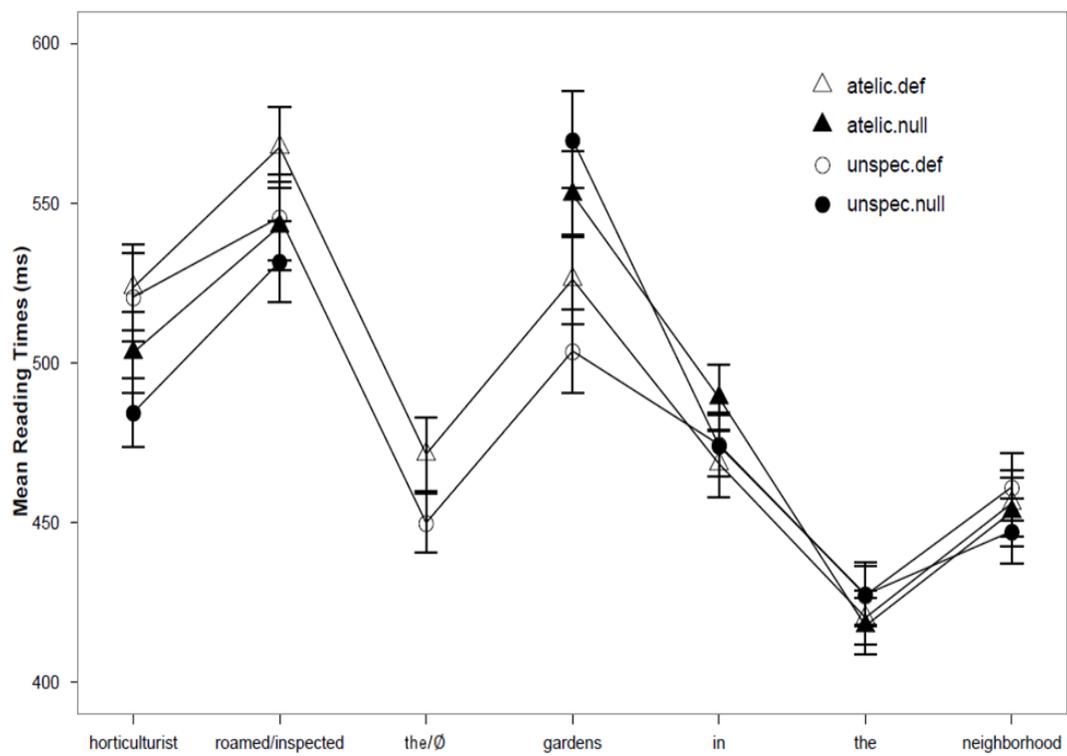


Figure 2: Word by word reading times by condition for Experiment 2. Error bars indicate standard error of the mean.

was removed before fitting the final model.

We found no significant effects on reading times at the verb, determiner, or noun+2 regions. On the noun region, we found a simple effect of determiner type on the reading times. As in Experiment 1, nouns with null determiners were read more slowly than nouns preceded by definite determiners. There was no significant interaction on the noun region. On the noun+1 region, we found a continuing trend for the null condition to be read more slowly than the definite condition, although no effects reached significance. Additionally, there was no significant interaction. A summary of the linear mixed effects models for the noun and noun+1 region are given in Table 4.

Unlike Experiment 1, where there was clear evidence that the result of combining a verb with a definite plural vs. bare plural was systematically different as a function of verb category, there was no evidence for such a difference in Experiment 2. Thus Experiment 1 provides evidence that supports a class of verbs that are inherently telic, and argues that this class contrasts with the unspecified verbs that have no lexical specification for telicity. Experiment 2 provides no such evidence for a lexical distinction between unspecified verbs such as *solve* or *drink* and verbs like *push* or *roam*. In both cases, the comprehension system appears to be guided by the quantization of the internal argument only. Although we find no interaction in online processing, we suspect that after this initial processing phase, other sources of information, such as world knowledge about real world telic and atelic events, play a role in determining the final aspectual interpretation reflected in traditional linguistic judgments.

## Conclusion

Accumulated over many decades now, a wide range of research has argued for an articulated syntactic structure underlying telicity in which lexical and structural factors conspire to generate subtle differences in interpretation. Experiment 1 provides clear evidence that inherently telic verbs are associated with a different processing profile from unspecified verbs. In Experiment 2, we found that so called ‘inherently’ atelic verbs do not pattern like their inherently telic counterparts. Instead, they follow the processing profile of unspecified verbs, with differences only emerging in the whole sentence acceptability judgment task.<sup>8</sup> Adding to the observations coming from traditional linguistic methods which argue that inherently atelic verbs can behave like unspecified verbs more generally (Borer 2005; Schein 2002), we argue that the same processing profile of inherently atelic and unspecified verbs is further evidence that there is no  $Q_-$  feature for verbal roots, suggesting that the lexical  $Q$  feature may be privative.

Although the underlying structure of ‘inherently’ atelic and unspecified verbs does not differ, verbs traditionally thought of as inherently atelic are those with particular fine grained meanings, such as applied motion. It appears that while the comprehension system recovers information licensing a telic interpretation of these predicates, the fine-grained meanings that arise from these predicates sometimes fail to support a telic interpretation. Thus Experiment

---

<sup>8</sup>At present, we have no explanation for the particular pattern of judgment task preferences, with sentences containing inherently telic verbs preferred over sentences containing unspecified verbs (Experiment 1) and sentences containing unspecified verbs preferred over sentences containing ‘inherently’ atelic verbs (Experiment 2).

2 points to the difference between a structurally licensed interpretation and an interpretation which is supported by wider world knowledge.

The evidence presented here also demonstrates that, while perhaps highly abstract, syntactic structure appears to place conditions on the online computation of aspectual interpretations. It seems that even if the lexical verb has the right features or specifications to license a telic interpretation for a predicate, this interpretation is not actually generated until at least the minimal VP structure is complete. This finding is not expected given assumptions about incremental processing dating back at least to Just and Carpenter (1980) and Marslen-Wilson and Tyler (1980), nor is it predicted given computational models of parsing, and seems to suggest that there may be limits on incrementality tied to interpretability conditions of abstract syntactic features and structures.

Whatever the precise explanation for the time course of aspectual interpretation, these studies support those theories in which the representation of verbs is divided into a class which is inherently telic and a class which is aspectually unspecified, by providing an online measure of aspectual interpretation.

## References

- Baayen, R.H., D.J. Davidson, and D.M. Bates. 2008. Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language* 59:390–412.
- Bach, Emmon. 1986. The algebra of events. *Linguistics and Philosophy* 9:5–16.
- Beavers, J. 2007. Scalar complexity and the structure of events. *Event Structures in Linguistic Form and Interpretation*.
- Borer, Hagit. 2005. *The normal course of events*. Oxford: Oxford University Press.
- Brennan, J., and L. Pykkänen. 2008. Processing events: Behavioral and neuromagnetic correlates of aspectual coercion. *Brain and Language* 106:132–143.
- Dowty, David. 1979. *Word meaning and Montague grammar: The semantics of verbs and times in generative semantics and in Montague's PTQ*. Springer.
- Dowty, David. 1991. Thematic proto-roles and argument selection. *Language* 67:547–619.
- Filip, Hana. 1999. *Aspect, eventuality types, and nominal reference*. Garland, New York.
- Gennari, S., and D. Poeppel. 2003. Processing correlates of lexical semantic complexity. *Cognition* 89:27–41.
- Gordon, P.C., R. Hendrick, and M. Johnson. 2004. Effects of noun phrase type on sentence complexity. *Journal of Memory and Language* 51:97–114.
- Hay, Jennifer, Chris Kennedy, and Beth Levin. 1999. Scalar structure underlies telicity in “degree achievements”. In *Proceedings of Semantics and Linguistic Theory IX*, ed. T. Mathews and D. Strolovitch, 127–144.
- Just, M.A., and P.A. Carpenter. 1980. A theory of reading: From eye fixations to comprehension. *Psychological Review* 87:329–354.

- Kennedy, Chris, and Beth Levin. 2008. Measure of change: The adjectival core of degree achievements. In *Adjectives and adverbs: Syntax, semantics and discourse*, 156–182. Oxford University Press.
- Krifka, Manfred. 1989. Nominal reference, temporal constitution and quantification in event semantics. In *Semantics and contextual expression*, ed. R. Bartsch, J. van Benthem, and P. van Emde Boas, 75–115. Foris: Dordrecht.
- Krifka, Manfred. 1992. Thematic relations as links between nominal reference and temporal constitution. In *Lexical matters*, ed. I.A. Sag and A. Szabolcsi, 29–53. Cambridge University Press.
- Krifka, Manfred. 1998. The origins of telicity. In *Events and grammar*, ed. S. Rothstein, 197–235. Kluwer Academic Publishers.
- MacDonald, Jonathan E. 2008. Domain of aspectual interpretation. *Linguistic Inquiry* 39:128–147.
- Marslen-Wilson, W., and L.K. Tyler. 1980. The temporal structure of spoken language understanding. *Cognition* 8:1–71.
- Mittwoch, Anita. 1991. In defense of Vendler's achievements. *Belgian Journal of Linguistics* 6:71–84.
- Pickering, M.J., B. McElree, S. Frisson, L. Chen, and M.J. Traxler. 2006. Underspecification and aspectual coercion. *Discourse Processes* 42:131–155.
- Piñango, M.M., A. Winnick, R. Ullah, and E. Zurif. 2006. Time-course of semantic composition: The case of aspectual coercion. *Journal of Psycholinguistic Research* 35:233–244.
- Piñango, M.M., E. Zurif, and R. Jackendoff. 1999. Real-time processing implications of enriched composition at the syntax–semantics interface. *Journal of Psycholinguistic Research* 28:395–414.
- Piñón, Christopher. 2008. Aspectual composition with degrees. In *Adjectives and Adverbs: Syntax, Semantics, and Discourse*, ed. Louise McNally and Christopher Kennedy, 183–219.
- Rappaport Hovav, Malka. 2008. Lexicalized meaning and the internal temporal structure of events. In *Theoretical and crosslinguistic approaches to the semantics of aspect*, ed. S. Rothstein. John Benjamins.
- Rosen, Sara T. 1999. The syntactic representation of linguistic events. *Glott International* 4:3–11.
- Rothstein, Susan D. 2004. *Structuring events: A study in the semantics of lexical aspect*. Blackwell Publishing.

- Schein, Barry. 2002. Events and the semantic content of thematic relations. In *Logical form, language and semantic content: On contemporary developments in the philosophy of language & linguistics*, ed. G. Preyer and G. Peter, 263–344. Oxford University Press.
- Tenny, Carol L. 1994. *Aspectual roles and the syntax-semantics interface*. Springer.
- Todorova, M., K. Straub, W. Badecker, and R. Frank. 2000. Aspectual coercion and the online computation of sentential aspect. *Proceedings of the 22nd Annual Conference of the Cognitive Science Society* 3–8.
- Townsend, D.J. 2012. Aspectual coercion in eye movements. *Journal of Psycholinguistic Research* 42:281–306.
- Townsend, D.J.T., and M.S.S. Seegmiller. 2004. The linguistic representation and processing of event structure. *Journal of Cognitive Science* 5:157–244.
- Travis, Lisa. 2010. *Inner aspect: the articulation of VP*. Dordrecht: Springer.
- Vendler, Zeno. 1957. Verbs and times. *Philosophical Review* 66:143–160.
- Verkuyl, Henk J. 1972. *The compositional nature of the aspects*, volume 15 of *Foundations of Language Supplementary Series*. Dordrecht: Reidel.
- Verkuyl, Henk J. 1989. Aspectual classes and aspectual composition. *Linguistics and Philosophy* 12:39–94.
- Verkuyl, Henk J. 1993. *A theory of aspectuality: The interaction between temporal and atemporal structure*. Cambridge University Press.

### Affiliations

Linnaea Stockall	E. Matthew Husband
Department of Linguistics	St. Hugh's College
Queen Mary University of London	University of Oxford
<a href="mailto:l.stockall@qmul.ac.uk">l.stockall@qmul.ac.uk</a>	<a href="mailto:matthew.husband@ling-phil.ox.ac.uk">matthew.husband@ling-phil.ox.ac.uk</a>