

RUNNING HEAD: VP-INTERNAL EVENT COMPOSITION

VP-Internal Event Composition:

Processing Evidence for Phrase-Level Event Interpretation

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Abstract

Language conveys information about events through subtle variations in lexical and functional structure. This paper adds to a growing literature concerned with the processing of event interpretations. In particular, we focus on how the verbal and nominal constituents of verb phrases determine whether an event is aspectually interpreted as telic (temporally bounded) or atelic (temporally unbounded). We report two studies addressing both the lexical and compositional factors involved in interpreting telicity. Using a lexical decision task, we find that inherently telic verbs do not differ from verb unspecified for telicity even though inherently telic verbs are thought to have a more complex lexical semantic representation. However, the results of a self-paced reading study find processing differences between aspectual interpretations. Atelic interpretations result in longer processing times than telic interpretations. These aspectual interpretation effects appeared only upon completion of the initial VP (the verb and its direct object), which supports a phrase level, rather than lexical level, theory of aspect.

Keywords: aspectual interpretation; semantic commitments; semantic composition; telicity; verb semantics

Introduction

The classification of linguistic events in terms of whether they last for any length of time and whether they have an inherent end point has a long history (going back at least to Aristotle, as noted in Folli and Harley (2006)) and continues to excite considerable interest today in both linguistic (Borer, 2005; MacDonald, 2008; Ramchand, 2008; Rothstein, 2004; Thompson, 2006) and psycholinguistic (O’Byryan, 2003; Pickering, McElree, Frisson, Chen, & Traxler, 2006; Piñango, Zurif, & Jackendoff, 1999; Piñango, Winnick, Ullah, & Zurif, 2006; Todorova, Straub, Badecker, & Frank, 2000; Townsend & Seegmiller, 2004) research. The most widely adopted event classification system, in which events are specified as either telic (having an end point) or atelic, and durative (lasting for some amount of time) or non-durative, comes from proposals made by Vendler (1957). The names Vendler gave to his four aspectual classes, and an example of each, is given in Table 1.

Table 1: Vendler's (1957) aspectual classes and their feature decomposition

	Telic	Atelic
Durative	ACCOMPLISHMENT <i>Harry ate the pizza.</i>	ACTIVITY <i>John pushed the cart.</i>
Non-Durative	ACHIEVEMENT <i>Sarah solved the puzzle.</i>	STATE <i>Lisa knew the answer.</i>

Dowty (1979) provided a number of linguistic tests for Vendler’s aspectual classes. The telicity of an event, for instance, can be diagnosed by adverbial modification tests. Telic events can be modified with an *in X time* adverbial such as *in an hour*, with the interpretation that the event took an hour to finish, while atelic events can not as in (1).¹

¹ Sentence judgments are as follows: a * indicates ungrammaticality, while a # indicates

- (1) a. Harry ate the pizza in an hour. [TELIC]
 b. John pushed the cart #in an hour. [ATELIC]

While sentence (1b) does allow the interpretation that John began to push the cart after one hour had elapsed, it does not permit the interpretation in which John finished pushing the cart in one hour.

Lexical vs. Compositional Components of Event Interpretations

The telicity of some events appears to be entirely determined by the lexical semantics of the verb itself. *Explode* and *find*, for example, are inherently telic verbs and always allow end point modification (2), whereas *sleep* and *fly* are inherently atelic verbs, and always block end point modification (3).

- (2) Inherently telic verbs
- a. The bomb exploded in ten minutes. [TELIC]
 b. John found beer in ten minutes. [TELIC]
 c. John found the beer in ten minutes. [TELIC]
- (3) Inherently atelic verbs
- a. John slept #in eight hours. [ATELIC]
 b. John flew planes #in eight hours. [ATELIC]

an unavailable interpretation. Often in this paper, # will indicate that *in X time* cannot modify an event's end point.

c. John flew the plane #in eight hours. [ATELIC]

For these verbs, other elements of the sentence, including changes in the properties of the direct object, do not affect the overall event interpretation of the sentence. However, Verkuyl (1972) demonstrated that for many verbs, telicity often *does* depend on properties of the direct object as in (4).

(4) Unspecified Verbs

a. John drank beer #in ten minutes. [ATELIC]

b. John drank the beer in ten minutes. [TELIC]

c. John built toy planes #in eight hours. [ATELIC]

d. John built the toy plane in eight hours. [TELIC]

For verbs like *drink* and *build*, the event interpretation depends on properties of the direct object; bounded direct objects give rise to telic interpretations while unbounded (mass and bare plural) direct objects give rise to atelic interpretations.² We will refer to these verbs as unspecified verbs as they do not seem to specify the telicity of the event they denote. The existence of unspecified verbs, and the sensitivity of aspectual interpretations to direct objects,

² Both mass nouns like *beer* and bare plurals like *planes* are known for allowing atelic interpretations. Mass nouns and bare plurals are argued to allow “aspectual leaks” because of the cumulativity of their denotation (Verkuyl, 1989). A syntactic hallmark of these two phrases, and of unbounded interpretation in general, is their lack of determiner in English.

led Verkuyl (1972) to argue that ‘lexical aspect’ is actually a property of VPs.

Much work since has proposed compositional ways to build event VPs from their component parts (Krifka, 1992, 1998; Verkuyl, 1993; Schmitt, 1996; Borer, 2005; Ramchand, 1997, 2008), resulting in a calculus of events that depends on both verb semantics and the bounded/unbounded status of direct objects, as in Table 2. VPs that include either a telic verb or a bounded object lead to telic interpretations. The absence of both of these elements leads to atelic interpretations.

Table 2- Calculus of Events

VERB TYPE	OBJECT TYPE	TELICITY	VP
Unspecified	Unbounded	Atelic	drink beer
Unspecified	Bounded	Telic	drink the beer
Telic	Unbounded	Telic	find beer
Telic	Bounded	Telic	find the beer

We report two experiments exploring the processing of both lexical and compositional sources of telicity. Following observations made in the literature that the lexical semantic complexity of verbs triggers processing distinctions, we first examine the lexical semantic complexity of inherently telic and unspecified verbs. We report a lexical decision study which does not find processing distinctions between these two verb classes. We then turn to the compositional factors which are argued to play a role in determining telicity. We report a self-paced reading study that manipulates these factors and finds a processing correlate of event interpretation that distinguishes between telic and atelic events.

The Lexical Semantics of Telicity

The fundamental distinction between inherently telic verbs, and verbs which are unspecified for telicity, is that inherently telic verbs entail that the events they denote have a

determinate end point, while unspecified verbs do not. We can represent this schematically as a difference in the aspectual features as in (5). Inherently telic verbs have additional representational content that unspecified verbs simply lack. Various theories instantiate this kind of proposal in different ways, but they all share the property of attributing additional semantic complexity to inherently telic verbs as compared to unspecified verbs (Borer, 2005; Dowty, 1979; Pustejovsky, 1991; Rothstein, 2004).

- (5) a. Unspecified Verbs (*drink, build*): [Ø, ...]
 b. Inherently Telic Verbs (*explode, find*): [+TELIC, ...]

Processing Telicity – Lexical Sources

A number of experiments have found evidence that differences in the complexity of lexical semantic representations of verbs and nouns have consequences for processing. Table 3 summarizes the results of four such studies.

Table 3 - Summary of Research on Lexical Semantic Complexity

EXPERIMENT	LEXICAL SEMANTIC CONTRAST	HYPOTHESIZED REPRESENTATIONAL DIFFERENCE	EXPERIMENTAL METHODS USED	RESULTS
Gillon, Kehayia and Taler (1999)	Mass vs. count nouns	Mass nouns have M feature, count nouns do not (<i>Gillon, 1992</i>)	Visual lexical decision	Mass nouns evoke slower LDTs than count nouns
McKoon and Macfarland (2002)	Internally vs. externally caused verbs	Externally caused verbs: CAUSE (x (BECOME IN STATE)) Internally caused verbs: x (BECOME IN STATE) (<i>McKoon & Macfarland, 2000</i>)	Whole sentence reading, visual lexical decision	Externally caused verbs associated with slower reading times and LDTs
Gennari and Poeppel (2003)	Stative vs. causative eventive verbs	Events: break → CAUSE(BECOME (y be-broken)) States: deserve → x deserve y (<i>Dowty, 1979</i>)	Self-paced reading, visual lexical decision	Events associated with slower reading times and LDTs
Brennan and Pylkkänen (in press)	Subject Experiencer vs. Object Experiencer Psych verbs	Object Experiencer Psych verbs entail a causation of the mental state by the subject, Subject Experiencer Psych verbs have no such entailment (<i>Pylkkänen, 2000</i>)	Self-paced reading, MEG	ObjExp Psych verbs associated with slower reading times than SubjExp

Gillon et al. (1999) find a processing difference for mass vs. count nouns, attributable to the monovalent feature M, that is argued to be part of the lexical representation of mass nouns, but not count nouns (Gillon, 1992). Gennari and Poeppel (2003), McKoon and Macfarland (2002) and Brennan and Pylkkänen (in press) all find that verbs which are argued to have more complex lexical representations evoke slower processing responses than verbs with less complex representations in a variety of measures. Gennari and Poeppel (2003), for example, demonstrated that eventive verbs, which are claimed to have extra content in their lexical semantic representations (Dowty, 1979) elicit slower response times than stative verbs. These

results all show that lexical semantic factors affecting event interpretations have rapid and important effects on processing.

Additional evidence that the lexical semantics of a verb's event structure are interpreted online comes from experiments investigating cases where inherently telic verbs are combined with durative adverbials, such as *until* and *for an hour*, that are not compatible with telic events. When these adverbials modify a telic event, a shift in interpretation is required that either iterates or stretches the event to accommodate the adverbial's durative requirement. This shift in interpretation is called aspectual coercion (Pustejovsky, 1995; Jackendoff, 1997) and has been found to elicit increased processing costs (Brennan & Pyllkkänen, 2008; Piñango, Zurif, & Jackendoff, 1999; Piñango, Winnick, Ullah, & Zurif, 2006). Brennan and Pyllkkänen (2008), for instance, found that the event structure of a verb affects processing when preceded by a durative modifier. They examined the processing of punctual verbs (a subclass of inherently telic verbs) like *sneeze*, which receive an iterative interpretation when combined with a durative modifier. In a self-paced reading task, they found that punctual verbs in sentences like (6a) were read more slowly than those in (6b).

- (6) a. *Coercion*: Throughout the day the student sneezed in the back of the classroom.
 b. *Control*: After twenty minutes the student sneezed in the back of the classroom.

A magnetoencephalography experiment found that the cost associated with aspectual coercion in sentences like (6a) evoked significantly greater neural responses in several brain regions, including a peak of increased neuromagnetic activity at ~450ms after verb onset in the anterior midline area, a region previously associated with complement coercion (Pyllkkänen &

McElree, 2007). Together with other findings, these studies demonstrate the online processing effects associated with the event structure of verbs and show that event interpretations are rapidly generated.

Experiment 1: Visual Lexical Decision

Since the lexical representation of unspecified verbs is argued to be less complex than inherently telic verbs, we would expect unspecified verbs to be processed faster than inherently telic verbs. Experiment 1 tested this prediction in a lexical decision task which has been shown to be sensitive to lexical semantic complexity (Gennari & Poeppel, 2003; McKoon & Macfarland, 2002).

Materials

Materials consisted of 48 inherently telic verbs and 48 unspecified verbs in their stem (present tense) form, and 96 length-matched pronounceable nonwords from the ARC Nonword Database (Rastle, Harrington, & Coltheart 2002). The verbs were matched for length, lexical frequency, orthographic and phonological neighborhood density, mean bigram frequency and number of syllables (see Table 4 for stimulus properties). Fillers consisted of 218 words and 218 nonwords from a separate study

Table 4 - Stimulus Characteristics

CONDITION	LENGTH	HAL FREQ	ORTHO #N	PHONO #N	BIGRAM <i>M</i>	SYLL #
unspecified	5.83	63470.98	4.27	11.31	3955.66	1.73
inherently telic	5.58	39522.31	4.48	10.27	3755.61	1.69
pairwise comparison	p>0.24	p>0.85	p>0.85	p>0.72	p>0.51	p>0.77

All stimulus characteristics taken from the English Lexicon Project Database (Balota, D.A., Yap, M.J., Cortese, M.J., Hutchison, K.A., Kessler, B., Loftis, B., Neely, J.H., Nelson, D.L., Simpson, G.B., & Treiman, R. (2007))

Design and Procedure

Sixty native English-speaking students from Michigan State University participated. Each participant saw all stimuli. Following Gennari and Poeppel (2003), words were presented with varying inter-trial times (500-1500ms) at the center of the screen. Before each stimulus item, a fixation cross was presented for 500ms. Participants indicated their response via keyboard button press.

Results

The mean proportion of errors was 3% for inherently telic verbs and 5% for unspecified verbs. This difference was not significant ($t(47)=-.999$; $p=.323$).

For further analyses, inaccurate responses and reaction times falling outside 2.5 standard deviations from the mean reaction time of the verbs were excluded, resulting in a 2.8% loss of data. A paired samples t -test found that inherently telic verbs did not significantly differ from unspecified verbs by either participants or items ($t1(59)=1.323$, $p=.191$; $t2(47)=.477$, $p=.635$) (Table 5). This result suggests that the lexical processing of inherently telic verbs and unspecified verbs does not differ.

Table 5. *Reaction times for Experiment 1*

VERB TYPE	<i>M</i>	<i>SE</i>
Unspecified	610	9.0
Telic	614	9.0

Discussion

The failure to find a significant difference between the lexical decision times for inherently telic verbs and unspecified verbs suggests that telicity may not actually be a property of verbs and thus not a part of a verb's lexical semantic representation, even though inherently telic verbs are thought to have a more complex lexical semantic representation compared to

unspecified verbs. This result is in contrast to the state/event distinction and the internal/external causation distinction of verbs which do affect single word lexical processing, and are also argued to be encoded in the lexical semantics of individual verbs. One possible explanation for the failure to find a difference in this experiment is that telicity may not actually be a property of verbs and thus not a part of a verb's lexical semantic representation.

Alternatively, it may also be the case that inherently telic verbs do differ in their lexical semantic representation from unspecified verbs, but that aspectual features of verbs, like +TELIC are not activated until they are combined with other linguistic elements to build an interpretable event. Since the telicity of a linguistic event is thought to be a property of VPs and not verbs themselves, we might not expect there to be any processing difference between these two types of verbs alone. Instead, we would expect to find the costs of telicity only as a result of processing VPs.

In the following section, we review the syntax and semantics of telicity which takes into account the direct object alongside the verb when interpreting telicity.

The Syntax and Semantics of Telicity

As discussed above, telicity is only partly determined by the lexical semantics of individual verbs – properties of the direct object also play an important role. Theories in both syntax and semantics have been addressing what these properties are and how they are structured.

Theories of the syntax underlying aspectual interpretations have argued that telic events have more complex syntactic representations than atelic events. This more complex structure comes from evidence for an aspectual phrase (AspP) which must be present for a VP to receive a telic interpretation (Borer, 1994, 1998, 2005; van Hout, 1996, 2000; Ramchand, 1997, 2008;

Ritter & Rosen, 1998, 2000; Schmitt, 1996; Tenny, 1987, 1994). AspP can be licensed either by an aspectual feature of a verb (Figure 1,; Ba) or by a bounded direct object (Figure 1,; Bb).

Bounded direct objects are singled out in these cases because they are said to “measure out” or delimit events (Tenny, 1994). When an inherently telic verb or a bounded direct object is not present, AspP fails to project and the VP receives an atelic interpretation (Figure 1,; A).

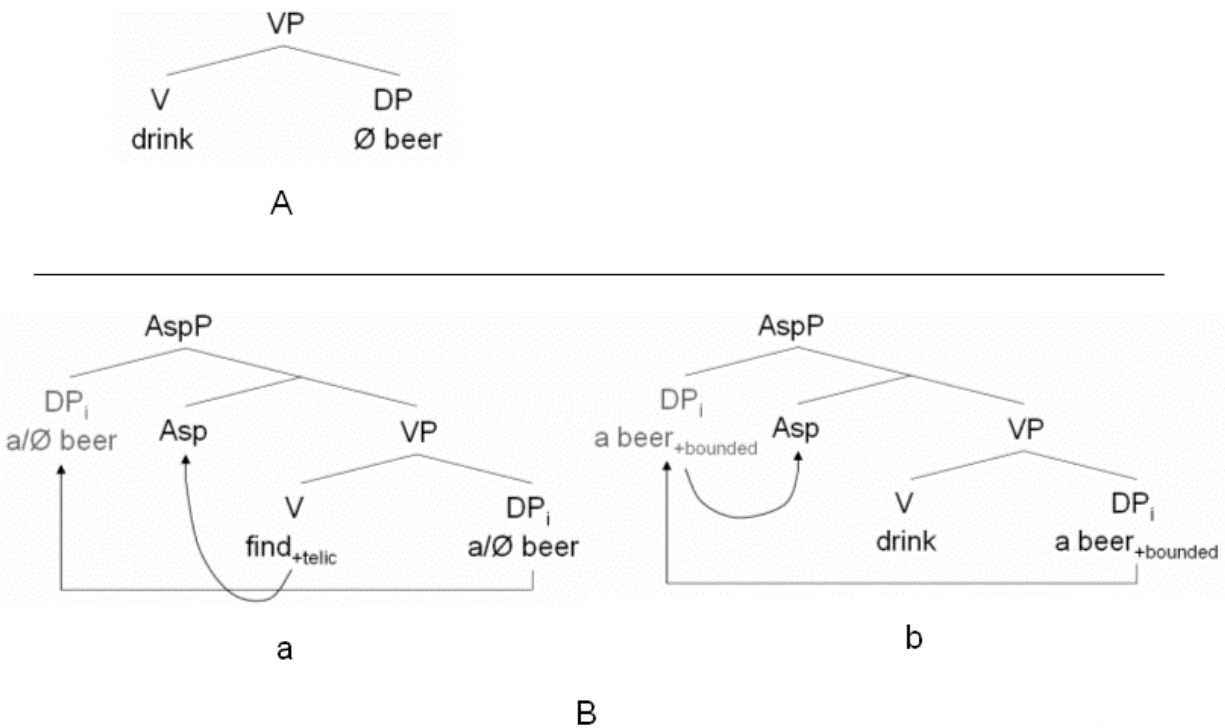


Figure 1 – Syntactic Structures for Atelic and Telic VPs:

(A) Atelic VPs do not project an AspP as neither the verb nor the direct object license its projection. (B) Telic VPs license projection of an AspP either by the aspectual feature of the verb (a) or by the direct object’s boundedness (b).

Semantic theories make different claims about the complexity of telicity, arguing that atelic events are necessarily more complex than telic events. This is because the denotations of

atelic events are cumulative, as defined in (7) (Bach, 1986; Borer, 2005; Kiparsky, 1998; Krifka, 1992; 1998; Rothstein, 2004; Link, 1998). Whether a denotation is cumulative or not depends on whether any two events of a given type can be summed together to create another event of the same type. Atelic events like *drink beer* are cumulative; the sum of two events which are both referred to as *drink beer* is an event which can also be referred to as *drink beer*. Telic events, however, are not cumulative; the sum of two events which are both referred to as *drink a beer* does not result in an event which can also be referred to as *drink a beer*. Instead, the event is one which would be referred to as *drink two beers*, thus there is clear upper bound on every non-cumulative (telic) event. However, there is no such upper bound on a cumulative (atelic) event. Representing a cumulative event requires a more complex model-theoretic representation than a noncumulative object or event (Figure 2). In processing terms, interpreting events which have no clear upper-bound should be more difficult than processing clearly bounded events.

(7) **Cumulative:** $\exists x,y [P(x) \wedge P(y) \wedge \neg x = y] \wedge \forall x,y [P(x) \wedge P(y) \rightarrow P(x \oplus y)]$

P is cumulative iff there is an x and y (x distinct from y) with property P such that the sum of x and y also have property P. (Krifka, 1998)

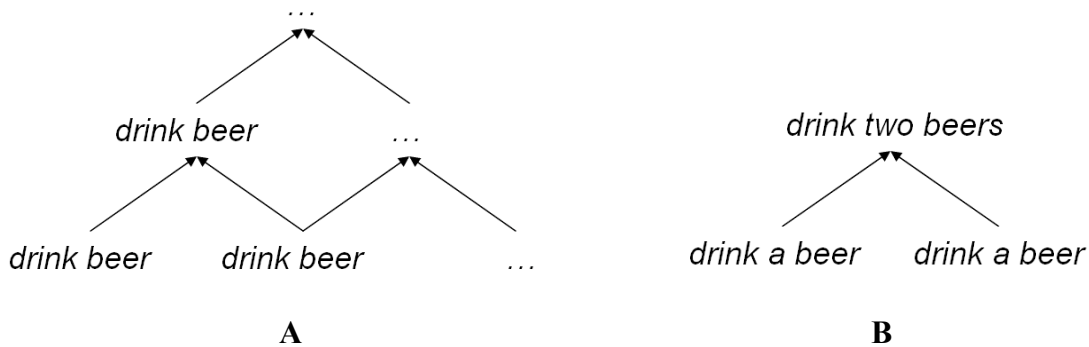


Figure 2 – Models for Atelic and Telic Interpretation:

(A) Atelic models are cumulative and can be summed to create an unbounded event of the same type. (B) Telic models are not cumulative and do not sum to create an unbounded event of the same type.

Processing Aspectual Interpretations

Few studies concerned with the processing of telicity have focused on the compositional factors involved. However, an early study on aspectual coercion by Todorova, Straub, Badecker, and Frank (2000) manipulated the bounded/unbounded status of the direct object to affect the telicity of the event. They compared telic and atelic events, combined with durative or neutral adverbials as in (8), using a self-paced stop-making-sense reading paradigm in which participants evaluated the sensicality of the sentences they were reading, region by region.

- (8) a. Even though Howard sent a check to his daughter for many years... [BOUNDED, DURATIVE]
 b. Even though Howard sent checks to his daughter for many years... [UNBOUNDED, DURATIVE]
 c. Even though Howard sent a check to his daughter last year... [BOUNDED, NEUTRAL]
 d. Even though Howard sent checks to his daughter last year... [UNBOUNDED, NEUTRAL]

They found significantly greater reading times and greater rejection rates on the adverbial region in the mismatch condition (bounded, durative) as compared to the other three conditions,

thus confirming that event interpretations resulting from a direct object's bounded/unbounded status are computed quickly, and are already established by the time adverbial modification occurs.

However, evidence for incremental aspectual interpretations is not uncontroversial. Proctor, Dicky, and Rips (2004) manipulated verb type, DP type, and temporal modifier type to test for aspectual coercion. Using both self-paced reading and comprehension questions concerning the telicity of sentences, they found that while aspectual interpretations affected comprehension robustly, there was only weak evidence for aspectual interpretation effects on reading times themselves. However, these weak effects may be attributable to the fact that some of the object DPs in their unbounded condition contained possessive determiners (*Polar Purity's ice water/cube*). Possessive determiner DPs are a type of bounded DP and trigger telic interpretations.

More worryingly, Pickering, McElree, Frisson, Chen and Traxler (2006) found no effect of aspectual coercion in either self-paced reading or eyetracking experiments, using materials very similar to those of Todorova, et al. (2000). However, they used frequentive adverbials like *every year* instead of durative adverbials like *for years*. Frequentive adverbs are quantificational and, unlike durative adverbials, may not need to coerce event interpretations (Rothstein, 1995; Husband & Stockall, 2008). Since frequentive adverbials do not mismatch with the event interpretation and thus do not trigger aspectual coercion, they may not cause any processing delays.

In any case, results from aspectual coercion experiments only provide us with an upper limit on the incrementality of event interpretation. These studies show that commitments to telicity are made before a modifying adverbial is processed. However, these results remain

neutral concerning the initial processing required to form the VP event interpretation. No study has reported a processing correlate associated with the initial construction of telicity by the VP itself. The existing research on aspectual coercion (Brennan & Pyllkkänen, 2008; Piñango, et al., 1999, 2006; Todorova, et al., 2000) does not allow us to address this issue either because the adverbial phrases that actually probe aspectual interpretations occur after the verb phrase is complete, or because the verb phrases are intransitive, and therefore there is no direct object present to contribute to aspectual interpretation.

Assuming that event interpretation is highly incremental, there still remains the question: what is the smallest linguistic unit that the parser can assign an aspectual interpretation to? One possibility is of course the verb itself – perhaps an inherently telic verb immediately triggers a telic interpretation. A highly incremental parser which commits to interpretations as soon as a word licenses that interpretation should make immediate and full use of an inherently telic verb to commit to a telic interpretation (Just & Carpenter, 1980). However, linguistic accounts of telicity argue that aspectual interpretations require a minimal VP (the verb and its direct object; Verkuyl, 1972), and thus we could see small delays in committing to aspectual interpretations. This would be consistent with Frazier’s (1999) proposal of immediate partial interpretation in that the parser has an unambiguous cue for telic interpretation as soon as the verb is processed, but is required to delay interpreting this cue until enough grammatical structure is available to license aspectual interpretation, namely the minimal VP.

Experiment 2

In Experiment 2, we investigate the timing of the initial commitment to event interpretation by embedding the verbs from experiment 1 in sentential contexts. If the parser immediately commits to an event interpretation using only the lexical semantics of the verb, we

expect reading times to differ at the verb itself (Gennari & Poeppel, 2003; McKoon & Macfarland, 2002). The parser may then be required to revise its event interpretation after processing the direct object, generating additional processing costs in the case of an aspectual mismatch. However, if event interpretations require both the verb and its direct object, the parser may delay commitment to an event interpretation until it has processed the initial VP, predicting no difference between reading times until completion of the initial VP.

Experiment 2 also provides a test of the representational claims concerning events. If processing costs are driven by syntactic representations, telic events should be more costly than atelic events since they require a more complex syntactic structure. However, if processing costs are driven by semantic interpretation, atelic events should be more costly than telic events since they require a more complex model interpretation.

Materials

From Experiment 1, each inherently telic verb was paired with an unspecified verb, and a transitive declarative sentence context as in (9).

(9) The expert physicist **lost/read** the files on the formation of black holes.

In order to investigate how aspectual interpretations are generated, **verb type** (inherently telic or unspecified) was crossed with DP boundedness (unbounded [null determiner] or bounded [definite determiner]), resulting in 4 versions of each sentence as in (9'). Object nouns in these conditions were always plural. Appendix A gives the set of sentences used in this experiment.

(9') The expert physicist **lost/read** Ø/the files on the formation of black holes.

The inflected verb forms were matched for length (mean inherently telic: 6.9, mean unspecified: 7.0; $F(2,47)=0.045, p=.832$) and HAL lexical frequency (English Lexicon Project, Balota, et al., 2007) (mean inherently telic: 25074.13, mean unspecified: 55631.35; $F(2,47)=1.678, p=0.198$). The semantic congruence of all subject-verb and verb-object pairs used in the experiment was evaluated by Latent Semantic Analysis, and neither subject-verb congruence or verb-object congruence varied significantly as a function of verb type (mean LSA scores for subject-verb: inherently telic 0.17, unspecified 0.16, ($F(2,47) = 0.082, p=0.776$) and verb-object: inherently telic: 0.14 unspecified: 0.15 ($F(2,47)= 0.138, p=0.711$)).

Sentences containing unspecified verbs and unbounded DP direct objects, which have atelic interpretations, are predicted to be associated with different processing times than any of the other three sentence types, which have telic interpretations as predicted by the Calculus of Events (Table 2).

We also created an additional 4 versions of each sentence with singular noun direct objects, in order to manipulate DP definiteness as in (9"), resulting in 8 conditions in total.

(9") The expert physicist **lost/read** the/a file on the formation of black holes.

This manipulation was designed to control for the possibility that any differences we observed in the verb type x DP boundedness manipulation might be due to the fact that bare plural DPs, as indefinites, can receive a range of interpretations.

Norming Studies

Three norming studies were carried out in order to ensure our materials varied along the

intended dimensions, and not any others.

First, in order to ensure our verbs were appropriately classified, four trained linguists, naïve to the purposes of the experiment, tested the null and definite determiner versions of each sentence with Dowty's (1979) *Subj VP-ed for X time* and *Subj spent X time VP-ing* tests, which are incompatible with telic events. Sentences containing inherently telic verbs were judged to be less acceptable than sentences containing unspecified verbs on these tests ($F(1,3)=13.678$, $p=.034$; $F(1,47)=35.620$, $p<.001$), see Table 6.

Table 6. *Event Boundedness Judgments*

VERB TYPE	DP TYPE	<i>M</i>	<i>SE</i>
Unspecified	Unbounded	0.85	0.052
	Bounded	0.83	0.064
Inherently Telic	Unbounded	0.45	0.101
	Bounded	0.05	0.115

Second, verbs were rated for imageability by 21 MSU undergraduates using the technique described in Chiarello et al. (1999), and were found to not differ (mean inherently telic=3.68, mean unspecified=3.70; $t(47)=.136$, $p=.893$).

Finally, verbs were normed for transitivity to ensure the conditions did not differ in how likely verbs were to be followed by an object DP. Twenty-five MSU undergraduates completed sentence fragments consisting of the stimulus items up to the critical verb as in (10).

(10) The expert physicist **lost/read** _____.

Inherently telic verbs were followed by 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.

Design and Procedure

Sixty native English-speaking students from Michigan State University participated in this study. 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 (1=bad; 5=good). The rating task was designed to ensure participants were required to comprehend the sentences they were reading, and to provide additional norming data.

Results

Acceptability Rating

A repeated measures ANOVA revealed a significant main effect of verb type by both participants ($F1$) and items ($F2$) on acceptability scores ($F1(1,59)=20.858, p<.001$; $F2(1,47)=14.590, p<.001$). Sentences with telic verbs were rated higher overall than sentences with unspecified verbs. All other effects were non-significant. The mean and standard error for acceptability judgments are given in Table 7. A post-hoc review of the items suggested that the unspecified-unbounded condition of several items was judged worst overall, but removal of the lowest rated items (8 items which had acceptability scores below 2.7 in at least one condition) showed a similar main effect of verb type ($F1(1,59)=5.980, p<.017$; $F2(1,39)=7.780, p<.008$) with all other effects being non-significant. Critically, no analysis of the acceptability data revealed an interaction, suggesting that acceptability of event type did not drive any interaction in the self-paced reading data. These results address possible concerns about whether

participants have any preference for a specific verb type + DP type combination, as we find no evidence of such a preference in the acceptability ratings.

Table 7. *Acceptability Judgments for Experiment 2*

Verb Type	Object Type	<i>M</i>	<i>SE</i>
Unspecified	Unbounded	3.76	0.089
	Bounded	3.67	0.087
Telic	Unbounded	4.03	0.083
	Bounded	4.01	0.072

Reading Times

Outliers deviating by more than 2 standard deviations from the mean reading time of all words were excluded from further analysis, resulting in the loss of 4.2% of the data. Reading times are shown in Figure 3.

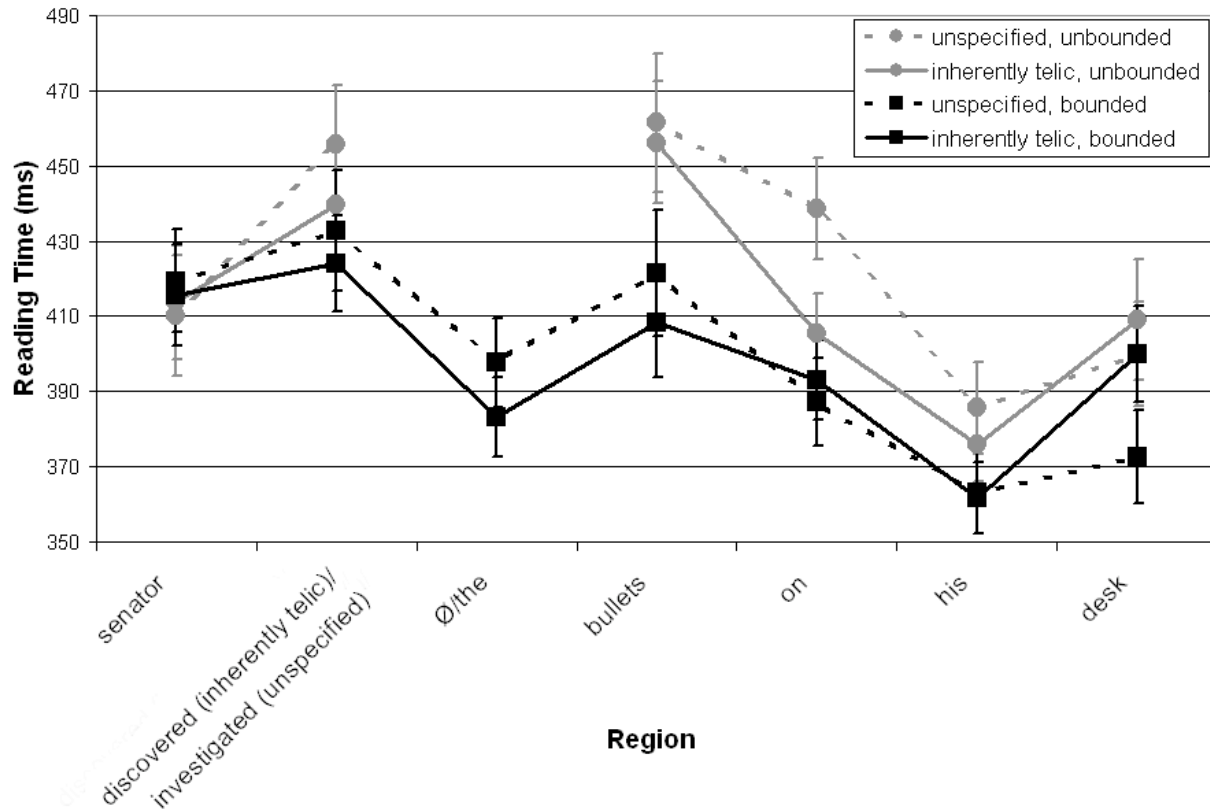


Figure 3 - Word by Word Reading Times: Verb Type and DP Type. Error bars indicate standard error of the mean.

In our first analysis, we compared reading times on the noun and n+1 position with a 2 (verb type) x 2 (determiner boundedness) repeated measures ANOVA for the sentences with plural direct objects. We found a main effect of DP type on the noun position ($F(1,59)=19.167$, $p<.001$; $F(1,47)=13.051$, $p=.001$) and the noun+1 position ($F(1,59)=10.262$, $p=.002$; $F(1,47)=16.648$, $p<.001$). A significant interaction between verb type and DP type was also found at the noun+1 position ($F(1,59)=4.579$, $p=.037$; $F(1,47)=3.876$, $p=.055$). Planned comparisons between means on the noun+1 position revealed significant differences between inherently telic and unspecified unbounded-DP conditions ($t(59)=2.250$, $p=.028$; $t(47)=2.030$,

$p=.048$) and unspecified unbounded- and bounded-DP conditions ($t1(59)=3.749, p<.001$; $t2(47)=3.961, p<.001$).

The main effect of determiner type on DP reading time is not unprecedented as Gordon, Hendrick and Johnson (2004) also find that bare plural arguments evoke slower reading times than definite plural DPs, in both subject and object position. Crucially, while the main effect of unbounded DP difficulty continues into the next region, we also observe an interaction, such that the unspecified verb + unbounded DP condition evokes significantly slower reading times than any other conditions. This sustained slowdown in the atelic event condition relative to the three types of telic event conditions suggests that properties of both the object DP and the verb are used immediately in aspectual interpretation. Finally, consistent with the results of Experiment 1, no significant main effects of verb type were revealed during online sentence processing.

In a second analysis, we compared reading times on the determiner, noun and n+1 position with a 2 (verb type) x 2 (determiner definiteness) repeated measures ANOVA for the sentences with singular direct objects. We found a main effect of verb type on determiner reading times ($F1(1,59)=4.600, p=.033, F2(1,47)= 5.4112, p=.021$) and on noun reading times in the analysis by subjects but not by items ($F1(1,59)=5.144, p=.025, F2(1,47)= 3.1462, p=0.078$). We found no effect on n+1 reading times, and no main effect of determiner definiteness on any region (all $ps>.09$). Planned comparisons reveal that the main effect of verb type was largely driven by increased reading times in the unspecified verb + definite DP condition. On the determiner itself, the unspecified + definite condition was read 12.58ms longer than the inherently telic + definite condition ($t1(59)= 2.1694, p<0.04$), but no other pairwise comparisons were significant (all $ps>.1$). On the noun region, this condition was read 16.72ms longer ($t1(59)= 2.2248, p<0.03$), and again, no other comparisons were significant (all $ps>.1$). This finding

suggests that, if anything, indefiniteness should lead to faster reading times when preceded by unspecified verbs, contrary to our findings that bare plural DPs are read significantly slower when preceded by unspecified verbs. While it is not clear why definite determiners following unspecified verbs are associated with small reading time increases as compared to inherently telic verbs, what is crucial for the results of our manipulations for aspectual interpretation is that this effect can not explain the significant slow down associated with unbounded DPs following unspecified verbs since there is no significant difference between indefinite determiners as a function of verb type, or between definite and indefinite determiners following unspecified verbs.

General Discussion

In a self-paced reading experiment we find that the combination of an unspecified verb and an unbounded direct object is associated with a significantly different pattern of reading times than any other combination of verb and direct object. We find no main effect of verb type in either the self-paced reading experiment, or in a lexical decision experiment comparing the same verbs, in contrast to previous studies comparing verbs with different event semantics. These results suggest that aspectual differences between verbs do not have interpretational consequences for the verbs alone, but instead only become apparent when verbs are integrated in a verb phrase.

The self-paced reading results show that atelic events are more difficult to process than telic events, but that this effect is not due to differences in the lexical semantic complexity of the verbs alone. Instead, the effect arises from the composition of the verb and its direct object. Both telic interpretations derived from the bounded direct object of unspecified verbs and telic interpretations derived from inherently telic verbs evoke a similar processing profile at the initial

VP boundary, and telic interpretations triggered by inherently telic verbs with bounded direct objects are indistinguishable from those triggered by only the inherently telic verb or the bounded direct object alone. All three cases of telic interpretation are different from atelic interpretation. Atelic interpretation resulting from an unspecified verb with an unbounded direct object elicits a unique, slower processing profile at the initial VP boundary. Thus semantic composition within the VP itself plays a critical role in aspectual interpretation, as predicted by the Calculus of Events (Table 2).

Processing Hypotheses: Immediate vs. Delayed Interpretation

These findings suggest that the parser makes interpretative commitments to the telicity of a sentence online and that the point at which the parser must decide between a telic and atelic interpretation is at the boundary of the initial VP. This result is consistent with Verkuyl (1972) and other phrase level theories of aspect argued for in linguistic theory which propose that aspectual interpretation is linked to an aspectual projection, AspP, which is only licensed to project a) over VP (verb and direct object) configurations, and b) when an inherently telic verb or bounded direct object is present. Evidence of this sort provides an argument against the kind of highly incremental parser in sentence processing which is typically assumed to use information in the current linguistic expression to make immediate and full semantic interpretations (Just & Carpenter, 1980). This result is more compatible with a parser which is allowed to delay semantic interpretation in a principled fashion. Crucially, we observe the parser delaying initial commitment to an aspectual interpretation even when given an unambiguous cue, i.e. an inherently telic verb. Previous studies on the incrementality of sentence interpretation have observed delays to interpretation when the parser is confronted with ambiguous cues such as polysemous words, collective vs. distributive interpretation, and temporal interpretation

(Frazier & Rayner, 1990; Frazier, Pacht, & Rayner, 1999; Dickey, 2001). Our study expands on these results by demonstrating that the parser may delay interpretation even in the face of an unambiguous cue if that delay is required by the grammar. Frazier's (1999) principle of immediate partial interpretation given in (11) proposes that the grammar provides strong constraints on the decision points at which the parser makes commitments to interpretation.

(11) *Immediate Partial Interpretation*: Perceivers must choose between grammatically incompatible meanings of a word or constituent immediately, by the end of the word or constituent, unless this conflicts with the dictates of the grammar.

The parser not only must choose between grammatically incompatible meanings of the word or constituent it is currently processing, but is also required to delay committing to any interpretation which is not currently licensed by the grammar. In the case of aspectual interpretation, the grammatical requirements for projecting AspP must be satisfied before an aspectual interpretation is made, and those requirements are only met once the initial VP is processed.

A way to think about why the grammar requires a delay in the interpretation of a lexical feature is captured in recent theories of feature checking in minimalist syntax. For instance, a very clear prediction of feature checking theories is that there is the possibility of a delay between when a feature enters the derivation and when that feature becomes semantically interpretable (Chomsky, 1995; Pesetsky & Torrego, 2007). In these theories, functional heads provide values for lexical features which make those features semantically interpretable. However, there is a possibility that the functional head which is required to check a particular

lexical feature will not be present in the syntax when that lexical feature enters the derivation. For instance, a lexical feature like +TELIC enters the derivation attached to an inherently telic verb and requires the functional head AspP to provide it with a semantically interpretable value. Since AspP has a grammatical requirement that it can only project over VPs, there is a predicted delay between when the +TELIC feature enters the derivation (i.e. on the inherently telic verb) and when AspP will be able to project and provide it with a semantically interpretable value (i.e. after the minimal VP is projected). This system predicts that the semantic interpretation of aspect must await the initial VP even though inherently telic verbs are cues to telic interpretations because the feature +TELIC requires a value from AspP to be semantically interpreted. Given the findings of this study, other cases of the delay between when a lexical feature enters the derivation and when the grammatical requirements of the functional head that provides it a semantic value are met are worth pursuing.

Thus both theoretical linguistic and psycholinguistic evidence converges on the VP as the domain for aspectual interpretation. The parser makes interpretative commitments to telicity only at this point, consistent with the principle of immediate partial interpretation. This is not unlike other interpretative decisions in which the grammar constrains the timing and range of possible decisions the parser must make.

The results reported here have consequences for our interpretation of the previous literature on processing a verb's event structure. Recall that Gennari and Poeppel (2003) and McKoon and Macfarland (2002) both report differences in lexical decision times that are a function of lexical event structure differences between verb types. In order to reconcile these results with the model of aspectual interpretation we are proposing here, we suggest that both Gennari and Poeppel's and McKoon and McFarland's lexical decision results reflect the costs of

retrieving lexical semantic representations, and not the costs associated with aspectual interpretation. While we found no significant differences between inherently telic and unspecified verbs in lexical decision, these two verb classes do trigger sentential processing differences, as seen in the interaction of the lexical semantics of verbs with their direct objects. What information the parser draws upon to distinguish these two classes and why their effects only show up in sentential contexts, unlike Gennari and Poeppel (2003) and McKoon and Macfarland (2002), is a matter for future research.

The aspectual coercion results of Brennan and Pylkkänen (2008) are, however, consistent with our claim that the parser requires a VP to make an aspectual interpretation. The verbs used in Brennan and Pylkkänen's experiments were intransitive, and thus the verb itself also projects the initial VP, so no delay in parsing an aspectual interpretation is expected. It is also possible that preposed adverbial clauses which modify aspectual interpretations force early projection of the VP over the verb, thus also licensing projection of AspP at the verb. Further research will be required to decide between these proposals.

Representational Hypotheses: Structural vs. Model Accounts

Interestingly, we find that atelic interpretation incurs a higher processing cost than telic interpretation. This observation is predicted by semantic accounts which posit that atelic events have a more complex model interpretation compared to telic events (Bach, 1986; Borer, 2005; Kiparsky, 1998; Krifka, 1992; 1998; Rothstein, 2004; Link, 1998). The interpretation of an atelic event requires a representation which is cumulative and has no clear upper-bound; whereas, the interpretation of a telic event is satisfied by a bounded representation. Assuming that unbounded representations are more costly to retrieve or construct, the processing difficulty of atelic over telic interpretation is explained.

This is not to say that syntactic structure plays no role in online sentence interpretation. As argued above, syntactic structure has processing consequences, if only in defining the interpretative domains for the parser. However, the costs of model complexity for atelic interpretation appear to be over and above whatever costs are associated with the additional syntactic structure present for telic interpretation. Certainly, further work is needed to determine a more precise time course for the generation of syntactic structure and the mapping to semantic models.

The results of this study and others suggest a two stage model of aspectual processing in which the parser first projects syntactic structure, and then, if licensed by the grammar, commits to an interpretation of that structure by constructing a semantic model. In the first stage, the verb and its direct object cue the parser to construct a VP. At this point, the parser checks the verb's aspectual features and properties of the direct object. If the verb is inherently telic or the direct object is bounded, the parser projects an AspP. In the second stage, the parser commits to an aspectual interpretation based on the syntactic structure projected in the first stage and constructs a semantic model to interpret the VP. If AspP was projected because of an inherently telic verb or a bounded direct object, a non-cumulative semantic model is constructed. If AspP was not projected because the verb was unspecified and its direct object was unbounded, a cumulative semantic model is constructed.

In conclusion, this research provides evidence concerning the time course of aspectual processing specifically and has implications for the processing of compositional structures more generally. The present data establish the VP as the domain for aspectual interpretation. The composition of a verb's lexical semantics with its direct object properties is used rapidly by the parser to commit to an aspectual interpretation. Although rapid, aspectual interpretation still

takes time to construct, with atelic interpretation incurring the higher cost.

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Appendix A. Sentence Materials from Experiment 2

(telic/unspecified non-count/count)

1. The amateur skater achieved/tried Ø/the techniques in her practice but she fell in the contest.
2. The biotech lab took/used Ø/the donations from big tobacco but it is now finding new funds.
3. The cancer researcher measured/combined Ø/the cells and a virus and took careful notes.
4. The clever student attained/researched Ø/the awards from the dean before she applied for a scholarship.
5. The corporate executive denied/studied Ø/the rumors of serious misconduct and fired his law firm.
6. The county judge imposed/praised Ø/the penalties on the factory but the spills did not stop.
7. The elderly cat trapped/chased Ø/the rats in the basement so we called the exterminators.
8. The girl scout stole/saved Ø/the toys for her friend and hid some dolls for herself.
9. The high schooler threw/carried Ø/the javelins across the field but his aim did not improve.
10. The lonely teenager spied/ogled Ø/the babes in his class but he did not ask anyone out.
11. The marathon runner earned/sought Ø/the trophies in amateur racing but he was outrun on the pro track.
12. The new employee invented/believed Ø/the anecdotes about his boss and he was fired.
13. The old collector accepted/reviewed Ø/the specimens from his assistant and paid him generously.
14. The paranoid senator discovered/investigated Ø/the bullets on his desk before calling security.
15. The protective uncle delivered/criticized Ø/the gifts to his niece and his family disliked him.
16. The research geologist struck/examined Ø/the veins in the cave but he found no gold.

17. The retired teacher selected/reserved Ø/the samples of local wine though he enjoyed French wine more.
18. The scary dragon devoured/terrified Ø/the goats from the village and the people were afraid.
19. The soccer player scored/watched Ø/the goals in the practice then shot wide in the game.
20. The timid dog bit/inspected Ø/the trainers from the school until he got used to the lessons
21. The tv producer cancelled/hosted Ø/the programs about former celebrities and her reputation was ruined.
22. The young scholar received/read Ø/the atlases on his birthday and he was happy.
23. The weary traveler found/kept Ø/the coins in the nightstand to buy lunch with.
24. The proud grandmother offered/served Ø/the cookies to her grandson after they ate dinner.
25. The inexperienced gardener bought/grew Ø/the flowers for his garden in the springtime.
26. The aged guitarist noted/played Ø/the songs coming from the jukebox as the drummer set up.
27. The frightened clerk refused/invested Ø/the bribes from the lawyer and sent a memo to the judge.
28. The former editor spotted/wrote Ø/the letters on his desktop and delivered it the next day.
29. The grizzly woodsman trapped/fed Ø/the squirrels in the woods after a long morning of hunting.
30. The district attorney dismissed/assessed Ø/the charges in the civil case and wrote his briefing that afternoon.
31. The store owner hired/discussed Ø/the assistants from the temp agency after his afternoon meeting.
32. The volunteer worker rescued/groomed Ø/the puppies in the animal shelter and made an appointment with the vet.

33. The restaurant manager fired/scolded Ø/the waitresses for giving bad service to the foreign customers.
34. The police precinct arrested/jailed Ø/the dealers for drug trafficking after an anonymous tip.
35. The state court convicted/tried Ø/the assailants on criminal charges for domestic abuse.
36. The medical practitioner cured/diagnosed Ø/the diseases found primarily in Northern Africa.
37. The naval officer executed/designed Ø/the orders to attack the bay after sunset.
38. The public historian invited/considered Ø/the speakers for a roundtable discussion on southern plantations.
39. The shaken statesman recognized/questioned Ø/the suspects in the lineup and pointed out the attacker.
40. The grey fox startled/ate Ø/the rabbits hiding under a bush beside the canyon.
41. The university program rejected/taught Ø/the graduates for research purposes in the current study.
42. The teaching assistant accepted/graded Ø/the papers that the students turned in late.
43. The committee staff informed/interviewed Ø/the lobbyists about changes in the environmental bill.
44. The senior writer shocked/commended Ø/the reporters with stories about current global poverty.
45. The recording studio convinced/persuaded Ø/the artists to sign a contraction on their label.
46. The sleepy sophomore forgot/sharpened Ø/the pencils for the test on Thursday morning.
47. The army mechanic heard/repaired Ø/the missiles on the day of the attack.
48. The expert physicist lost/read Ø/the files on the formation of black holes.