The Online Processing of Progressive Aspect Morphology in L2 English

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1. Introduction

This study examines parser computations in the identification of possible aspectual values for the aspectual morpheme *-ing* by learners of English as a second language (L2). Specifically, the study focuses on processing load asymmetries in the composition of *-ing* with activity and accomplishment predicates, resulting from distinct identifications of imperfective semantics at different stages of L2 development. The motivation for this study comes both from the empirical research on the second language acquisition (SLA) of tense-aspect (Bardovi-Harlig, 2000; Li & Shirai, 2000), and from linguistic approaches to the formal semantics on the progressive aspect operator (i.e., PROG) (de Swart, 1998; Moens & Steedman, 1988).

Within L2 tense-aspect research, there is robust empirical evidence supporting the Aspect Hypothesis (Andersen & Shirai, 1994), according to which the distribution of perfective/imperfective past morphology depends on the aspectual semantics of the verb phrase (VP). The Aspect Hypothesis makes four predictions, which can be summarized as follows: In the earliest stage, learners will use perfective or past morphology with telic VPs (achievements and accomplishments), imperfective with states, progressive with activities, and no overextension of progressive marking to states (Andersen & Shirai, 1994; Bardovi-Harlig, 2000). A body of L2 research based on production data from various L1-L2 combinations largely agrees that in the initial stages of acquisition, the distribution of tense-aspect morphology is strongly associated with aspectual classes with congruent semantics (e.g., Bardovi-Harlig & Reynolds, 1995; Hasbún, 1995; Kim, 2012; Shirai, 1995).

Crucially, recent research on the acquisition of aspectual systems in an L2 highlights the multiple layers implicated in the acquisition of aspectual knowledge (e.g., Gabriele, 2010; Montrul & Slabakova, 2003; Slabakova, 2008; Slabakova & Montrul, 2002). Aspectual knowledge involves the lexical semantics of verbs, the semantics of direct object determiner phrases (DPs), and the semantics of aspectual morphology. Specifically, acquiring the semantics of an aspectual morpheme requires at least two steps: identifying the range of possible aspectual values for the morpheme, which varies cross-linguistically within a certain range, and eventually selecting the semantic value that fits best with the available evidence according to the current state of grammar (Slabakova, 2008). A body of recent L2 generative research investigates the Universal Grammar (UG)-governed acquisition of semantics of aspectual morphemes in various L2s (Gabriele, 2005; Montrul & Slabakova, 2002; Slabakova & Montrul, 2002), as well as the compositional semantics of VPs (Gabriele, 2008, 2010; Slabakova, 2001).

This study is focused on the past progressive form in English (i.e., the realization of the imperfective in English) in response to the call for more research in L2 acquisition of imperfective from additional theoretical frameworks (Bardovi-Harlig, 2005, 2012). Reviewing L2 tense and aspect research, Bardovi-Harlig (2005) argues that, compared to studies of the perfective past, those of the imperfective past have been less robust, resulting in a limited availability of data and findings. In relation to the previous findings on early stages of second language acquisition, of particular interest for the current study is the observation that aspectual morphology is in complementary distribution with semantically compatible predicates (Bardovi-Harlig, 2005): In L2 English, *-ing* predominantly

[*] I would like to thank my audience at SLRF 2012 for their comments. I am grateful to Laurent Dekydtspotter and two anonymous reviewers for their valuable comments and feedback. All remaining errors are my own.

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appears with dynamic and atelic predicates, whereas *-ed* predominantly appears with telic predicates. Provided that these are the most basic pairings of verbal and morphological features, these strong association patterns may be robustly retained in learners who have passed the initial stage of development (e.g., Robison, 1995). Taking this background into consideration, I hypothesized that the bias for using *-ing* with activity predicates in production might be detectable as learners' processing systems compute meaning in the course of sentence processing.

2. The semantics of the progressive in English

In the formal analysis of progressive semantics, functional morphemes such as progressive *-ing* are viewed as *aspect modifiers* or *aspectual operators* that induce certain aspectual operations/coercion on the VP denotations (de Swart, 1998; Verkuyl, 1993). Specifically, the English progressive is generally considered an aspectual operator, namely, PROG, which transforms an *event* into more like a *state*; PROG produces a *progressive state* which describes the *process* as ongoing or as being extended through time without any implication of completion (de Swart, 1998; Kamp & Reyle, 1993; Moens, 1987; Moens & Steedman, 1988; Vlach, 1981). Within this theoretical framework, the progressive *-ing* maps dynamic eventuality descriptions onto their corresponding *states* (de Swart, 1998). More specifically, Vlach (1981) and Moens (1987) claim that the progressive marker in English only combines with *process* sentences and the resulting sentence is stative. When a non-*process* sentence is combined with the progressive marker, the sentence should be first turned into a *process.*

Consider the categorization of eventuality types (Figure 1). The eventuality types can be divided into two large dimensions: stative versus dynamic. In addition, eventualities are ontologically divided into either homogeneous or quantized.

<table>
<tr><td>STATIVE [–dynamic]</td><td colspan="3">DYNAMIC</td></tr>
<tr><td rowspan="2">(states)</td><td rowspan="2">(processes/activities)</td><td colspan="2">Events</td></tr>
<tr><td>(culminated processes/ accomplishments)</td><td>(achievements)</td></tr>
<tr><td colspan="2">HOMOGENEOUS</td><td colspan="2">QUANTIZED</td></tr>
</table>

Figure 1. The categorization of eventuality types (de Swart, 1998).

Both *processes* (activities) and *culminated processes* (accomplishments) enter into the super-category of [+dynamic] eventualities. They only differ in a [±homogeneous] dimension; *processes* have homogeneous reference, whereas *culminated processes* have non-homogeneous reference. So, what happens in the domain of eventualities when a progressive combines with *culminated process*, like *run a mile*? First, the eventuality must be mapped to a *process*. PROG is required here, so that the culmination point is stripped off from the referent of the expression (Moens, 1987). Then, a *process* of *running* is left and PROG transition operates again by mapping this *process* part onto the *progressive state* (*progstate*). These aspectual transitions can be considered 'aspectual type shifts.' Aspectual transitions in the event schema are illustrated in detail in Moens and Steedman (1988, p. 18). The computations of two aspectual transitions interpreted from the semantics of PROG can be simplified as follows:

(1) *culminated process* (accomplishment) → *processes* (activity) → *progressive states*
| |
PROG transition PROG transition

Mapping *culminated processes* to *processes* involves a transition across the [±homogeneous] distinction, while mapping *processes* to *states* involves a transition across the larger [±dynamic] distinction. In other words, for *culminated processes* such as *run a mile*, two-step aspectual transitions are involved: across the [±homogeneous] dimension and across the [±dynamic] dimension. For *processes* such as *run*, only a one-step transition across the [±dynamic] dimension is involved.

3. The Study

3.1. Research question and hypotheses

This study addresses L2 English learners' real-time processing of progressive morphology, in relation to its semantics and computations detailed in the previous section. The research question the study seeks to answer is:

(2) How is a semantic value for the aspectual morpheme *-ing* identified and computed in L2 sentence processing?

The working assumption is that processing loads reflect processing costs. Processing load will reflect the cost of aspectual computations. Fewer aspectual transitions are expected to take less time to process (i.e., be less costly) than more transitions. Additionally, the parser will be guided to avoid costly operations (i.e., economy in processing). Thus, with *progressive states* as the endpoint, the parser's cost-avoidance strategy will favor the processing of progressive *-ing* with *processes* rather than with *culminated processes* because a single-step transition should be less costly than a two-step transition.

Two hypotheses are considered about how learners identify the semantics of the *-ing* morphology in the course of processing, with a function of cost-avoidance assumed. Hypothesis 1 (Aspectual Coercion Hypothesis) predicts that learners' identification of the aspectual morpheme *-ing* will be first guided by imperfective semantics [+homogeneous, +dynamic] in view of the strong association of the (imperfective) *-ing* morphology with [−telic, +durative] predicates in the input. In Hypothesis 1, the parser identifies *-ing* as a viewpoint presenting eventualities as [+homogeneous, +dynamic] (3a, b), given that this kind of identification affords the least cost in aspectual transition for dynamic eventualities. Learners will be further directed by the avoidance of processing costs: in the event ontology, the *only* way for *-ing* to satisfy these criteria is for it to characterize homogenous events, i.e., *processes.*

(3) a. Mary was writing.
[$_{\text{Aspect}}$ [+homogeneous, +dynamic] [Ø [$_{\text{VP}}$ Activity]]]

b. Mary was writing a letter.
[$_{\text{Aspect}}$ [+homogeneous, +dynamic] [PROC [$_{\text{VP}}$ Accomplishments]]]

Mismatching VP-semantics (3b) are repaired by UG-sanctioned operators {PROG, PROC}. In (3a), since activity predicates already denote *processes* with the features [+homogeneous, +dynamic], no further operation (aspectual transition) is needed. In (3b), the [+homogeneous, +dynamic] specification of *-ing* requires that *culminated processes* (accomplishment predicates) be mapped onto their *process* parts by stripping off the culmination. According to Hypothesis 1, therefore, learners will favor *-ing* with *processes* which incurs no cost, rather than with *culminated processes*, which incurs the cost of a single transition across domain distinction [+culmination] into [−culmination]. The least operation for achieving an imperfective semantics is with the PROC operator, which maps *event* onto *process* descriptions (de Swart, 1998).

Hypothesis 2 (Aspectual Operator Identification Hypothesis) predicts that learners' identification of *-ing* during the parsing will be guided by the *range* of aspectual transitions for the imperfective viewpoint. This hypothesis involves mapping dynamic VPs to *progressive state* semantics. The parser identifies operator values for *-ing* within {PROG, PROC} (de Swart, 1998). Transitions for PROC are a subset, with the transition across the [±dynamic] dimension missing. Thus, when the PROG operation is selected, the cost of PROG depends on the transitions inherent in its application. Aspectual transitions for PROG are detailed in (4a, b):

(4) a. Mary was writing.
[$_{Aspect}$ PROG [$_{VP}$ Activity]]

PROG maps *processes* to their *progressive states*; thus, a single aspectual transition is required as shown in the following diagram:

(*process*: Mary write)
↓
(Transition $_{[progstate]}$ (*process*: Mary write)).

b. Mary was writing a letter.
[$_{Aspect}$ PROG [$_{VP}$ Accomplishment]]

PROG maps *culminated processes* to their *progressive states* in two aspectual transitions represented by the following diagram:

(*culminated process*: *Mary write a letter*))
↓
(Transition $_{[-culmination]}$ (*culminated process*: *Mary write a letter*))
↓
(Transition $_{[progstate]}$ (Transition $_{[-culmination]}$ (*culminated process*: *Mary write a letter*)))

Hence, if PROG is assumed, learners will prefer progressive *-ing* with [−telic] VPs rather than with *culminated processes.* With PROG selected, relative costs for (3a, b) and (4a, b) align. Selecting PROC, rather than PROG, avoids a transition cost in (4b). However, under this selection, *-ing* will be *temporarily incompatible* with *processes*, forcing a switch to PROG given positive evidence. As discussed earlier, a one-step transition from *processes* to the *progressive state* (4a) should be less costly and more preferable than a two-step transition from *culminated process* to their *process* parts, and then to the *progressive state* (4b). Unless a *progstate* is required, the parser will compute PROC. The identification of such a processing moment would identify the parsing procedures necessary for Hypothesis 2, and rule out Hypothesis 1.

3.2. Rationale of the processing task

The question is *how* we can observe learners' computation of such aspect transitions in the processing of *-ing.* Reading times (RTs) collected from a moving window procedure reflect the nature of the computations involved in L2 processing (e.g., Juffs, 2001); thus, the main task employed for this study is a word-by-word self-paced reading task in the noncumulative moving-window presentation (Just, Carpenter, & Woolley, 1982). For on-line observation of how L2 learners identify the semantics of aspect morphology *-ing*, compared to the default past morphology *-ed*, garden-path sentences such as in (5) were designed.

(5) a. ¿ When he *baked/was baking* the cake smelled so sweet.

b. [$_{CP}$ [$_{CP}$ When he [$_{VP}$ *baked/was baking* [$_{DP}$ *the cake*]]] …

c. [$_{CP}$ [$_{CP}$ When he [$_{VP}$ *baked/was baking* __]] [$_{S}$ [$_{DP}$ the cake] [$_{VP}$ smelled so sweet]]].

In the garden-path (GP) processing model, the post-verbal DP *the cake* in (5b) is initially attached under VP as a result of the Late Closure strategy (Frazier, 1987) presumed to follow from Structure Minimization (Fodor & Inoue, 1998), according to which closing the subordinate clause late at the direct object *the cake* is preferred by attaching an incoming component to the phrase currently being processed, if grammatically permissible. Juffs and Harrington (1996) observed that sentences with an optionally transitive verb (e.g., *After Bill drank the water proved to be poisoned*) usually elicit measurable GP effects in native speakers and L2 learners of English.

Importantly, this study investigates an additional factor such as the semantics of *baked/baking* which can yield different levels of commitments to this analysis as a result of the [+homogeneous] semantics of progressive sentences, which favors [−telic] predicates with *-ing*. In monolingual research using an eye-tracking technique, Frazier, Carminati, Cook, Majewski, and Rayer (2006) found that for native speakers of English, the processing costs associated with recovery from a subordinate clause in the simple past were higher than those in the past progressive. For L2 learners, different processing costs due to aspectual transitions will depend on their identification procedures.

In (5), *baked* or *baking* is followed by a temporarily ambiguous DP that could be interpreted as the direct object of the preceding verb or the subject of a main clause; also the bounded direct object *the cake* can potentially provide an endpoint. Importantly, the experimental sentences include "incremental theme verbs" (Dowty, 1991) which can derive either telic (the accomplishment class) or atelic predicates (activity classes) with the presence or absence of an endpoint (i.e., bounded direct object). This ambiguous DP is not supposed to be disambiguated until the parser encounters the following verb *smell*; we can observe the reanalysis difficulty by measuring RTs on this segment (V2).

In short, parsing procedures for the identification of aspectual morpheme *-ing* will be investigated by observing L2 learners' syntactic processing, which requires the alignment of default syntactic structure (Late Closure/Minimize Structure) and argument structure computations, but is mitigated by aspectual specifications through telicity. Along with Chan's (2012) cross-linguistic study, which tested the prototype account (Shirai & Andersen, 1995) in L2 sentence processing, the current investigation of garden-path sentence processing will serve as one of the first L2 studies examining interaction between Aktionsarten and grammatical aspect in processing.

4. Method

4.1. Participants

Thirty-two learners of L2 English from a Chinese or Korean L1 background at intermediate-advanced and low-advanced levels of L2 English participated. They were grouped into two proficiency groups of 16 learners each, based on the results of a cloze test (Brown, 1980). A control group of 24 native English speakers also participated in the study.

4.2. Materials and procedure

Participants performed a word-by-word self-paced reading task, accompanied by a Verb Cloze-Passage Task and Imperfectivity Judgment Task. The main defining goal of the three different tasks was to determine L2 learners' identification of *-ing* by investigating their use and interpretation of *-ing* versus *-ed* in combination with [±telic] VPs. I will present the description of the materials separately.

4.2.1. Verb Cloze-Passage Task

A Verb Cloze-Passage was implemented to ensure the presence of an aspectual *-ing* in learners' interlanguage. A controlled task like this could provide the opportunity to modify a story text, so that various predicates from different aspect categories could be balanced across the foreground and background of the story. This task manipulated narrative structure (foreground and background) with Aktionsarten, such as activities and accomplishments. It was expected that learners would use *was/were -ing* when an imperfective viewpoint was called for in the background (the Discourse Hypothesis; Bardovi-Harlig, 1998), and it was also expected that this would be affected by Aktionsarten (the Aspect Hypothesis). Participants were provided base forms of the verb predicates and were instructed to supply the missing inflections for the appropriate context, as in the excerpts (6) below.

(6) Excerpts from the passage:

…First, Rob started to walk home. Then, he _____ (run). As he _____ (run to his village), he _____ (realize) he didn't have any shoes on…While he _____ (eat his meal), he _____ (tell the story) about what _____ (happen) to him 20 years ago. His daughter _____ (cry) after hearing the story…

The written answers provided by the participants were coded for morphology (e.g., simple past, past progressive, pluperfect, present, base, etc.). The distribution of tense-aspect morphology was analyzed, maintaining the distinction between foreground and background.

4.2.2. Imperfectivity Judgment Task

The goal of the Imperfectivity Judgment Task was to test knowledge of the imperfective-perfective distinction in terms of the interpretation of completion and its consequent state. This task consisted of 20 basic sentences containing accomplishment predicates, such as *When they built the Golden Gate Bridge, they used the best materials*, modeled from Moens and Steedman (1998). A 2 (Perfective, Imperfective) x 2 (Process, Consequence) design was used. The quadruple design was implemented and participants read only one form of each quadruple. The four experimental conditions are presented with examples in (7):

(7) a. When they built the Golden Gate Bridge, they used the best materials. [PERF-Process]
b. When they built the Golden Gate Bridge, they finally solved most of their traffic problems. [PERF-Consequence]
c. When they were building the Golden Gate Bridge, they used the best materials. [IMPF-Process]
d. When they were building the Golden Gate Bridge, they finally solved most of their traffic problems. [IMPF-Consequence]

The participants were instructed to read each sentence on a computer screen. Upon reading each sentence, they were asked to judge if the sentence made good sense, in terms of meaning continuation. They provided their answers (Yes or No) on paper. It was expected that learners would be sensitive to (im)perfectivity, by preferring continuations that fit in the default event schema (7c, IMPF-Process) rather than (7d, IMPF-Consequence), everything else being equal.

4.2.3. Self-Paced Reading Task

The rationale of this main task is highlighted in detail in Section 3. The processing experiment used garden-path sentences such as (8a) and (8b) in a 2 (grammatical aspect: *-ing* vs. *-ed*) × 2 (sentence structure: garden-path vs. non garden-path) design. Twenty experimental sentences were embedded in 30 fillers. The experimental sentences were counterbalanced so that each participant saw five items from each of the four conditions. Each sentence began with an initial clause composed of a subject and verb; the verb was either in the simple past (8a, c) or the past progressive form (8b, d). Next followed a DP *the cake* that could either be interpreted as the direct object of the preceding verb (8a, b) or the subject of a new clause (8c, d). The on-line experiment was controlled and recorded by the software package LINGER (Rohde, 2001). Reading times (RTs) for each segment were recorded and analyzed in milliseconds (ms).

(8) a. When / he / baked / the / cake / smelled / so / very / good. [PERF-GP condition]
b. When / he / was / baking / the / cake / smelled / so / very / good. [IMPF-GP condition]
c. When / he / baked / the / cake / it / smelled / so / very / good. [PERF-non GP condition]
d. When / he / was / baking / the / cake / it / smelled / so / very / good. [IMPF-non GP condition]

The participants were instructed to read each sentence as quickly, yet as carefully, as possible on a computer screen. A grammaticality judgment question followed each sentence, in order to ensure that participants read the sentences attentively.

For native-like systems, the prediction was that the processing costs associated with garden-path recovery from a subordinate clause in the progressive (8b) with the value PROG should be less than those in (8a); thus (8b) should be easier to process than (8a). Since *he was baking the cake* involves aspect shift, which is more costly to process than *he was baking*, the parser would not strongly commit to the direct object analysis.

5. Results

The results of each task are reported in this section. Since the learners performed alike regardless of L1 background across all three tasks, the results are reported only by proficiency level (i.e., lower-proficiency group and higher-proficiency group).

5.1. Verb Cloze-Passage Task

The central finding of this task was that the rates of the *-ing* inflection for activities and accomplishments in backgrounded clauses showed a very different distribution across the learner groups; as demonstrated in Figure 2, the higher-proficiency group associated *-ing* more frequently with activity predicates than with accomplishment predicates in the background (58% and 67%, respectively). In contrast, the lower-proficiency group produced more *-ing* with backgrounded accomplishments (55%) than with backgrounded activities (25%); they thus selected more *-ed* markings with backgrounded activities. In backgrounded activities, increased rates of *-ing* use was observed from lower-level learners to higher-level learners. In the native speaker group, the rate of use of simple past *-ed* was higher overall for accomplishments than for activities (regardless of the grounding), and the rate of use of progressive was higher for activities than accomplishments in the background. In foregrounded clauses, each proficiency group showed a very similar distribution of *-ed* for both activities and accomplishments.

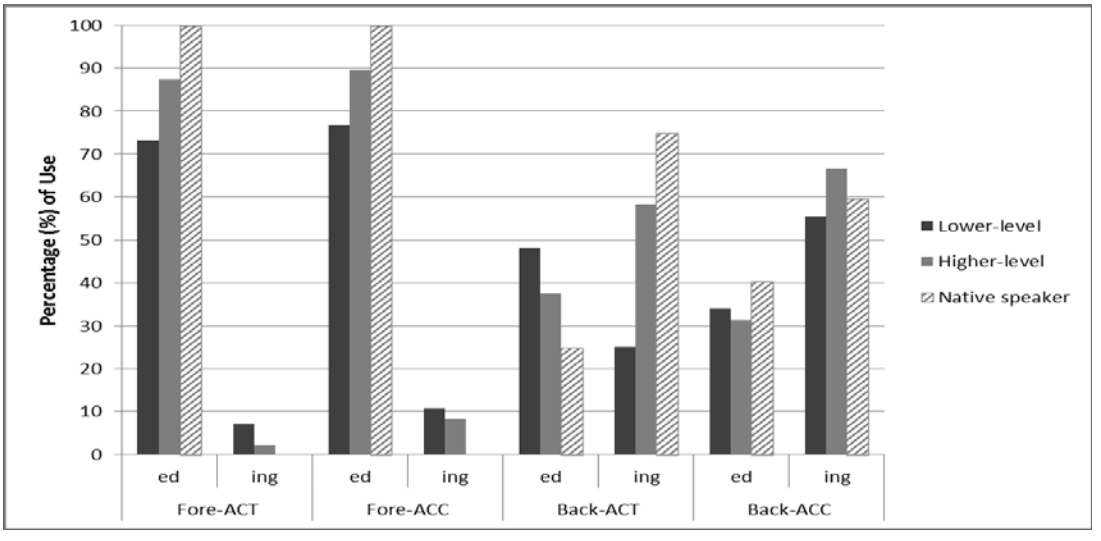

Figure 2. The distribution of *-ed* and *-ing* in foreground and background.
(*Note.* ACT= Activities, ACC= Accomplishments, Fore= Foreground, Back= Background)

5.2. Imperfectivity Judgment Task

A repeated measures analysis (ANOVA) was performed on the percentages of yes-answers by each condition and revealed that there was no difference among the three groups' judgments. A paired samples *t*-test was conducted and found that all three groups significantly disfavored the IMPF-Consequence condition (7d), compared to the IMPF-Process (7c); $t(26) = 2.5$, $p = .019$.[1]

This result indicates that that the three groups of participants differentiated process and consequence sentences when they were combined with *-ing*. Thus, all three groups judged the imperfective-consequence sentences as anomalous more often than the imperfective-process sentences. It appears that the learner groups have an imperfective-perfective distinction, showing sensitivity to the homogeneous/quantized contrast.

[1] The Bonferroni correction for multiple comparisons has been applied.

5.3. Self-Paced Reading Task

Since recovery of a GP effect can be observed on RTs for the verb in the main clause (V2), the RTs for the V2 segment (e.g., *smelled* in (8)) and the subsequent regions were analyzed and compared across the conditions. A two-way repeated-measures ANOVA was carried out on the mean RTs for the V2 segment with aspect (simple past *-ed* vs. progressive *-ing*) and GP (garden path condition vs. non-garden path condition) as within-subject factors and proficiency (lower-proficiency group vs. higher-proficiency group vs. native speaker group) as a between-subjects factor. The ANOVA revealed that the interaction among aspect, proficiency, and GP was significant ($F(1, 604) = 16.165$, $p < .001$), indicating that the participant groups' recovery from the original misanalysis was affected differently by aspect manipulation in *when*-clauses.

First, the native speaker group did not show any reading time differences in processing the aspectual contrast (PERF-GP: 478 ms vs. IMPF-GP: 448 ms), although they exhibited the shortest RTs among the three groups. Importantly, both of the learner groups showed measurable evidence of evaluating the ambiguous post-verbal DP as a direct object of the preceding verb, showing spikes at the V2 segment. Regarding the higher-level learners' reading profiles for GP conditions, the mean RT on V2 (*smelled* in Figure 3) was significantly shorter when the verb appeared in the progressive (IMPF-GP: 678 ms) than in the simple past (PERF-GP: 824 ms) (Figure 3). Post-hoc *t*-test comparisons showed that the mean difference (146 ms) was statistically significant, $t(21) = 11.105$, $p = .001$. This suggests that higher-level learners' identification for the semantics of *-ing* favors [−telic] predicates.

In stark contrast to the higher-level group, the mean RT on V2 for the lower-level group was significantly shorter when the verb appeared in the simple past (PERF-GP: 779 ms) than in the progressive form (IMPF-GP: 979 ms) (Figure 4). Post-hoc analysis showed that the mean difference (200 ms) was statistically significant, $t(21) = 21.35$, $p < .001$. This suggests that their identification for the semantics of *-ing* favors [+telic] predicates.

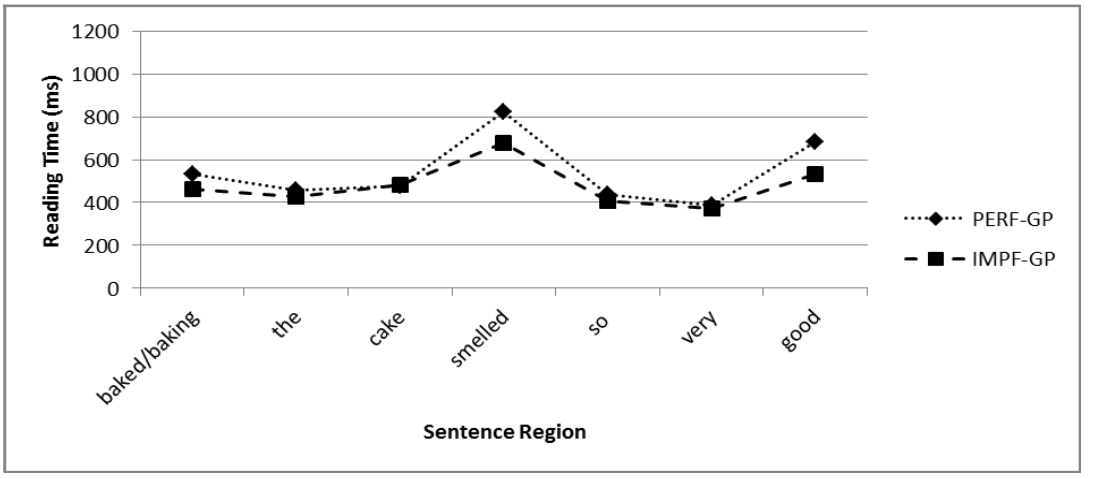

Figure 3. Word-by-word reading times for garden path sentences (Higher-level group).

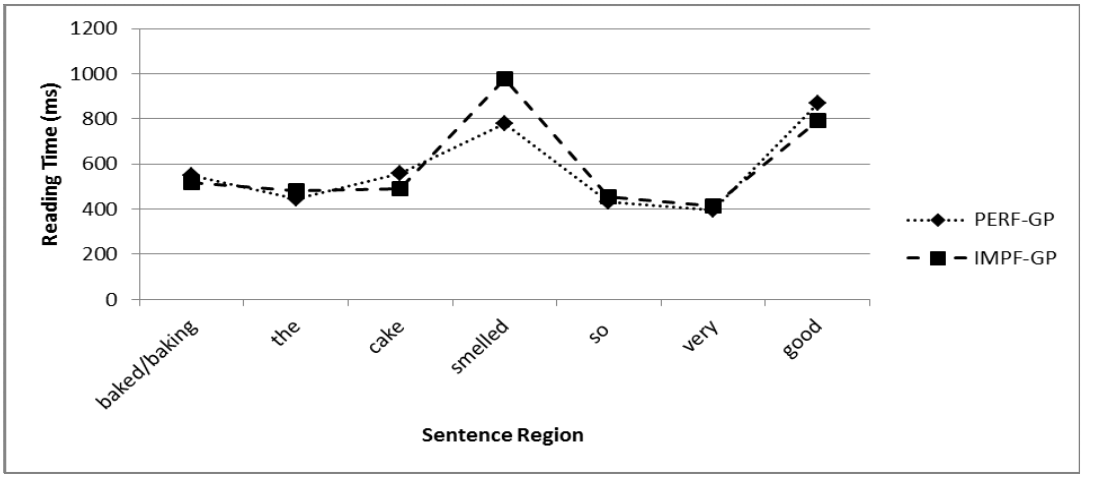

Figure 4. Word-by-word reading times for garden path sentences (Lower-level group).

6. Discussion

The three different tasks yielded results that can inform our understanding of how semantic values for the aspectual morpheme *-ing* are identified. The results from a Verb Cloze-Passage Task suggest that L2 learners in this study had knowledge of *-ing* as aspectual morphology by supplying it when the imperfective viewpoint was needed; the results from the Imperfectivity Judgment Task suggest that both learner groups had an imperfective-perfective distinction, showing sensitivity to the homogeneous/quantized contrast. However, judging only by these results, we do not yet know what kind of imperfective semantics was identified by the learners. Beyond this, the processing data seems to speak to the processes of identification of the semantics of *-ing*.

Learners' processing profiles were found to be modulated by grammatical aspect and proficiency. In the Self-Paced Reading Task, it was expected, on the processing procedures inherent in Hypothesis 1, that the parser encountering the *-ing* marking would be led to anticipate [−telic] VP-semantics without a culmination, and it was detected in the higher proficiency group, showing that imperfectivity reduced the garden-path effect. The parsing procedures compatible with Hypothesis 2, however, predicted that learners might quickly entertain PROC (rather than PROG) as a value because of the costs of the complex transitions inherent in PROG. This would clearly identify a stage where the value of *-ing* might fluctuate between PROG, if a *progstate* target is identified, and a less costly PROC, if a *progstate* target is not identified. Indeed, the lower-level group did not conform to the predictions of Hypothesis 1 or to those of a target-like PROG semantics. Rather, this group demonstrated the opposite behavior: *-ing* morphology guided the lower-proficiency group to anticipate [+telic] VP-semantics with a culmination, suggesting that these learners interpreted the post-verbal DP as the endpoint or culmination of the whole VP by identifying *-ing* as having the function of removing the culmination, exclusively.

Such results are unexpected unless sub-semantic aspectual transitions are considered. The operator PROG maps dynamic events to *progressive states*, which involves two transitions from *culminated processes* to *processes* and from *processes* to *progressive states*. Lower-level learners' results from both processing and controlled production tasks are compatible with the first transition from *culminated processes* to *processes* within the event domain only. The transition from *processes* to *progressive states* across events and states is probably an unnecessary operation to achieve an imperfective point of view and thus was not observed. In contrast, higher-level learners' processing profile (which seemingly aligns with the native speakers; Frazier et al., 2006) was compatible with the computation of the second aspectual transition from *processes* to *progressive states*, as well as a transition from *culminated processes* to *processes.*

The results across multiple tasks for each learner group were consistent. Crucially, the lower proficiency group's behavior can be understood only when the subatomic aspectual transitions involved in the imperfective aspect are considered. In processing, learners seem first limited to the

transitions in the domains of [+dynamic] events before they can compute the transition across the largest [±dynamic] boundary, as demonstrated in the lower-level learners. Presumably, it is because transitions across domain distinctions [±culmination], which are still within the [+dynamic] event domain, might be less costly than the transition across larger distinctions such as [±dynamic]. These processing patterns, therefore, bear on the issue of the identification of the precise semantics for *-ing*. If the results from the lower-level learners were unexpected from the view of Hypothesis 1, it can be argued that distinct semantic values presumably computed on the fly for interlanguage *-ing* at different stages of acquisition favor Hypothesis 2, in which semantic values for *-ing* may fluctuate between PROC and PROG.

7. Conclusion

Two possible hypotheses for learners' identification of *-ing* semantics were introduced in Section 3. Hypothesis 1 predicted that learners would identify *-ing* as characterizing a homogenous event guided by the [–telic, +durative] features of the predicates with which it is preferentially associated in the input. This should yield less cost with activity predicates that denote matching [+homogeneous, +dynamic] specification for *-ing*, than with accomplishment predicates that require an aspectual shift. Hypothesis 2 predicted that learners' identification of *-ing* in processing would be guided by aspectual transitions involved in the aspectual operators. Values may fluctuate between PROG and PROC as a function of the costs inherent in deriving a *progstate*. When *progstate* is the semantic target, both hypotheses predict that learners will favor *-ing* with *processes* rather than *culminated processes* in the course of processing because the former combination (*-ing* with *processes*) incurs no cost, or less costs than the latter combination (*-ing* with *culminated processes*). The two hypotheses can be distinguished in terms of the parsing behavior that they allow. Consider the lower-level learner group. The results of this group which preferred *-ing* with *culminated processes* to *processes* cannot be explained by matching semantics shared by *-ing* and activity predicates; thus Hypothesis 1 was challenged. However, Hypothesis 2 allows for this possibility: this is due to learners' (in)ability to compute all the aspectual transitions for *-ing* at different stages of acquisition. Lower proficiency learners may imperfectly compute the semantics of *-ing* not as PROG but as PROC (de Swart, 1998). The sequence of processing behavior is an *a priori* reflex of identification processes for the semantic values for *-ing* in lower versus higher proficiency learners.

L2 learners' real-time processing of garden-path sentences suggests distinct semantic computations for interlanguage *-ing* at different stages of acquisition. The Aspectual Operator Identification Hypothesis (Hypothesis 2) as a point of departure can provide new insights not only into L2 aspect processing mechanisms, but also into L2 tense-aspect marking mechanisms at different stages in development. This could potentially serve as a bridge between different research frameworks in explaining the acquisition of the L2 tense and aspect system, by retaining the strengths of each approach.

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