Using eye-tracking to study the on-line processing of case-marking information among intermediate L2 learners of German

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Abstract

This study uses eye-tracking to examine the processing of case-marking information in ambiguous subject- and object-first wh*-questions in German. The position of the lexical verb was also manipulated via verb tense to investigate whether verb location influences how intermediate L2 learners process L2 sentences. Results show that intermediate L2 German learners were sensitive to case-marking information, exhibiting longer processing times on subject-first than object-first sentences, regardless of verb location. German native speakers exhibited the opposite word order preference, with longer processing times on object-first than subject-first sentences, replicating previous findings. These results are discussed in light of current L2 processing research, highlighting how methodological constraints influence researchers' abilities to measure the on-line processing of morphosyntactic information among intermediate L2 learners.*

1. Introduction

A central question addressed by a variety of research traditions in the field of second language acquisition is the relationship between lexical-semantic and morphosyntactic knowledge among second language (L2) learners. In the area of foreign language learning, questions surrounding this relationship often revolve around what types of information learners attend to when comprehending L2 input, and how their ability or inability to develop connections between grammatical forms and semantic meaning contributes to L2 learners' developing linguistic system (e.g., Doughty and Williams 1998; VanPatten 2004; VanPatten et al. 2004). In the area of L2 psycholinguistic research, a growing number of studies have also focused on how L2 learners process lexical-semantic and morphosyntactic information in real time. Several of these studies have found evidence to suggest that even highly proficient L2 speakers may not use

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syntactic-based parsing principles to the same extent as native speakers, relying more on lexical-semantic and pragmatic information during on-line processing (see Clahsen and Felser 2006 for a recent review; but see Dekydtspotter et al. 2006 for counterarguments).

To explore the relationship between morphosyntactic and lexical-semantic processing among L2 learners further, the present study employed eye-tracking methodology in an attempt to replicate and expand upon earlier findings reported by Jackson (2008), with regard to how intermediate L2 learners of German (English L1) use case-marking information to assign grammatical roles when reading temporarily ambiguous subject- and object-first *wh*-questions in German.[1] A robust case-marking system is a core grammatical feature of German, and a wide body of L1 German research suggests that German native speakers rapidly use case-marking information to predict upcoming arguments in a sentence (e.g., Bader and Meng 1999; Friederici and Frisch 2000; Schlesewsky et al. 2000). On the other hand, the German case-marking system is often difficult for L2 learners of German to master (e.g., Henry et al. 2009; Jackson 2007) and L2 learners may have difficulty integrating case-marking information rapidly during on-line processing, regardless of whether this grammatical feature exists in their first language (L1) (e.g., Hopp 2006a, 2006b).

The present study also examines whether encountering the lexical semantics of the main verb early on in a sentence impacts L2 German learners' ability to assign grammatical roles incrementally. To this end, we contrast the processing of structures in which the lexical verb appears in the final position of a clause in complex verb tenses, as in the present-perfect tense, with structures in which the lexical verb appears in the second position of a clause in simple verb tenses, such as the simple-past tense. By focusing on intermediate-level L2 learners who are in the process of learning a second language primarily through classroom-based instruction, as opposed to highly proficient L2 speakers, the present study also seeks to investigate how less proficient L2 learners process lexical and grammatical information in real time. As such, the present study addresses theoretical and methodological issues of interest to psycholinguists, while simultaneously contributing to larger questions regarding the mechanisms that underlie the reading and comprehension of L2 input.

1. We recognize that German native speakers use case-marking information, along with word order, to assign both grammatical functions and thematic roles in a sentence (e.g., Bornkessel and Schlesewsky 2006). However, in the experiment reported here there was a one-to-one mapping of the grammatical roles of *subject* and *direct object* with the thematic roles of *agent* and *patient*. There was no experimental condition in which the grammatical subject of the target sentence was not simultaneously the agent of the target sentence. Therefore, we will refer to the assignment of grammatical roles, as opposed to thematic roles, throughout this paper.

1.1. *Importance of the lexical verb*

One area of interest in several L2 processing studies is L2 speakers' ability to use verb subcategorization information when processing L2 sentences (Blattner 2007; Dussias and Cramer 2008; Frenck-Mestre and Pynte 1997). The results of such studies have shown that highly proficient L2 speakers use verb-subcategorization information to predict upcoming sentential arguments in the L2, even when this information differs from that of their L1. In an eye-tracking experiment, Frenck-Mestre and Pynte (1997) found that when reading sentences containing an optionally-transitive verb (e.g., *obeyed*) in the adjunct clause, L2 English speakers (French L1) exhibited longer total reading times and more regressions at the disambiguating region (underlined below) relative to intransitive control sentences, such as (2), upon discovering that the previous noun phrase was the subject of the matrix clause and not the direct object of the adjunct clause.

(1) *Every time the dog obeyed the pretty girl showed her approval.*
(optionally transitive)

(2) *Every time the dog barked the pretty girl showed her approval.* (intransitive)
(Frenck-Mestre and Pynte 1997: 134)

Importantly, all of the optionally-transitive verbs in the English target sentences were used intransitively in French, indicating that the L2 English speakers did not simply transfer verb subcategorization properties from their L1 to the L2.

Unlike findings examining L1 and L2 verb subcategorization preferences (e.g., Blattner 2007; Dussias and Cramer 2008; Frenck-Mestre and Pynte 1997), research that has examined L2 processing of verb-final languages, such as German and Dutch, have shown that L2 speakers' ability to predict argument structure is more limited when they encounter the lexical verb late in a sentence. For instance, Havik et al. (2009) found that when reading temporarily ambiguous subject and object relative clauses, such as *Dat is de vrouw die de meisjes heeft/hebben gezien* 'that is the woman who has seen the girls/who the girls have seen', only L2 Dutch speakers (German L1) with higher L1 and L2 working memory capacity exhibited an on-line preference for subject-first sentences – with longer reading times on the word immediately following the disambiguating auxiliary verb. L2 speakers with lower working memory capacity exhibited no on-line reading differences according to word order. Importantly, this lack of significant reading time effects appeared even though the speakers' L1 was German – a language which also contains verb-final constructions, and exhibits a subject-first preference for relative clauses and other sentence types

(e.g., Bader and Meng 1999; Schlesewsky et al. 2000; Schriefers et al. 1995). Further, this lack of significant reading time effects occurred even though the accompanying comprehension verification statements explicitly tested the assignment of grammatical roles.

In a second experiment in which accompanying verification statements did not highlight the assignment of grammatical roles in the target sentences, even the high working memory L2 speakers exhibited no reading time differences across conditions. This contrasts with results from Dutch native speakers, who showed the predicted on-line preference for subject-first sentences regardless of working memory and regardless of the content of the accompanying verification statements. Based on these findings, Havik et al. (2009) concluded that in the absence of biasing lexical or pragmatic information, L2 speakers are less likely to use morphosyntactic information while processing the L2 incrementally.

In another self-paced reading study that examined how L2 speakers process verb-final subject-object ambiguities in German (English or Dutch L1), Hopp (2006b) found that L2 proficiency was also a crucial factor in determining whether L2 speakers exhibited a subject-first preference during on-line processing. Whereas both German native speakers and L2 German speakers, regardless of proficiency level, demonstrated higher comprehension accuracy on subject-first sentences, such as (3), compared to object-first sentences, such as (4), only the German native speakers and the most proficient near-native L2 German speakers exhibited a parallel difference in reading times at the first noun phrase (underlined below), which was presented as a single segment, with longer reading times on object-first sentences than subject-first sentences.

(3) *Er denkt, dass <u>der Physiker</u> am Freitag* (subject-first)
he thinks that the$_{NOM}$ physicist on Friday
den Chemiker gegrüsst hat.
the$_{ACC}$ chemist greeted has
'He thinks that the physicist greeted the chemist on Friday.'

(4) *Er denkt, dass <u>den Physiker</u> am Freitag* (object-first)
he thinks that the$_{ACC}$ physicist on Friday
der Chemiker gegrüsst hat.
the$_{NOM}$ chemist greeted has
'He thinks that the chemist greeted the physicist on Friday.'
(Hopp 2006b: 378)

Reading times among advanced, but not near-native, L2 speakers did not differ according to word order until the final word in the sentence, suggesting that

although they differentiated subject- and object-first sentences, they were unable to process disambiguating case-marking information immediately at the disambiguating region.[2]

While the sentences used by Hopp (2006b) contained only unambiguous nouns, so that participants could identify object-first sentences as such immediately at the first noun phrase, Jackson (2008) used temporarily ambiguous *wh*-questions, such as (5)–(8) below, in a self-paced reading task to test directly whether early access to the lexical verb has an impact on on-line processing among both native speakers and intermediate and advanced L2 learners of German (English L1). Like Hopp (2006b), the disambiguating noun phrase was presented as a single segment. German native speakers exhibited a subject-first preference, with longer reading times on the disambiguating noun phrase (underlined below), regardless of verb tense. These results were in line with previous L1 German studies, which have found that German native speakers can process sentences incrementally and assign grammatical roles regardless of verb placement (e.g., Friederici and Frisch 2000).

(5) *Welche* *Ingenieurin* *traf* (sub-first; simple past)
which$_{NOM/ACC}$ engineer$_{FEM}$ met
<u>den Chemiker</u> *gestern* *Nachmittag* *im* *Café?*
the$_{ACC}$ chemist$_{MASC}$ yesterday afternoon in-the cafe?
'Which engineer met the chemist yesterday afternoon in the cafe?'

(6) *Welche* *Ingenieurin* *traf* (obj-first; simple past)
which$_{NOM/ACC}$ engineer$_{FEM}$ met
<u>der Chemiker</u> *gestern* *Nachmittag* *im* *Café?*
the$_{NOM}$ chemist$_{MASC}$ yesterday afternoon in-the cafe?
'Which engineer did the chemist meet yesterday afternoon in the cafe?'

(7) *Welche* *Ingenieurin* *hat* (sub-first; pres. perfect)
which $_{NOM/ACC}$ engineer$_{FEM}$ has
<u>den Chemiker</u> *gestern* *Nachmittag* *getroffen?*
the$_{ACC}$ chemist$_{MASC}$ yesterday afternoon met?
'Which engineer met the chemist yesterday afternoon?'

(8) *Welche* *Ingenieurin* *hat* (obj-first; pres. perfect)
which$_{NOM/ACC}$ engineer$_{FEM}$ has
<u>der Chemiker</u> *gestern* *Nachmittag* *getroffen?*
the$_{NOM}$ chemist$_{MASC}$ yesterday afternoon met?
'Which engineer did the chemist meet yesterday afternoon?'
(Jackson 2008: 887)

2. But see Hopp (2009) for evidence that even advanced L2 German speakers are sensitive to the interaction between case-marking information, word order, and information structure when scrambled object-first sentences are presented in a larger discourse context.

Similar to the German native speakers, the advanced L2 learners of German also exhibited a subject-first preference at the disambiguating region. However, this preference only appeared in simple-past tense sentences, in which participants encountered the lexical verb prior to the disambiguating region. The advanced L2 learners of German showed no differences in reading times according to word order in present-perfect tense sentences. These findings raise the possibility that although more proficient L2 learners can and will use L2 morphosyntactic information in real time, the extent to which they use such information to interpret L2 sentences in an incremental fashion may be more dependent on the presence of crucial lexical-semantic information early on in the sentence. Further, their reading times on the final segment of the sentence were longer on present-perfect tense sentences than simple-past tense sentences, even though the sentence-final phrase (e.g., *im Café* 'in the cafe') was longer in simple-past tense sentences than the past participle (e.g. *getroffen* 'met') in present-perfect tense sentences. These results suggested that the advanced L2 learners of German also had difficulty integrating the lexical verb with earlier sentential arguments, although this finding remained speculative given that the past participle coincided with the end of the sentence and involved comparing different word classes across conditions.

In contrast, the only significant reading time effects among the intermediate L2 learners of German in Jackson (2008) appeared on the last phrase of the sentence, with longer reading times on object-first sentences than subject-first sentences regardless of verb tense. Similar to the L2 speakers in Hopp (2006b), this indicated that the intermediate L2 learners recognized the importance of case-marking information for assigning grammatical roles in German. Had they completely overlooked this information there should have been no reading time differences according to word order anywhere in the target sentences. However, they did not appear to process this information immediately at the disambiguating region. One interpretation of these findings is that even though the intermediate L2 learners assigned grammatical roles in an incremental fashion, the processing of morphosyntactic case-marking information is more effortful at lower proficiency levels, leading to a delay in when such effects appeared. Alternatively, the intermediate L2 learners could have waited until they had read the entire sentence to piece together its meaning, leading to longer reading times on dispreferred object-first sentences at the final phrase. The results reported by Jackson provided no means for teasing apart the validity of these two explanations. Furthermore, the possibility that the intermediate L2 learners employed a wait-and-see approach to processing the German sentences might have been exacerbated by the self-paced-reading paradigm, in which readers are presented with one word or segment of a sentence at a time.

1.2. *The importance of research methodology*

While there is some debate as to whether the self-paced reading paradigm is sensitive enough to truly observe incremental parsing decisions among monolingual speakers of a language (e.g., Rayner et al. 1989), research has shown that results from self-paced reading tasks often parallel those from methodologies that allow for more fine-grained measures of on-line processing, such as eye-tracking (e.g., Mak et al. 2006; Mitchell 2004; Wilson and Garnsey 2009). Among monolinguals, any differences between self-paced reading and eye-tracking lie more in the level of analysis available than the actual processing mechanisms these different methodologies purport to measure. Similarly, the few studies that have made direct comparisons between self-paced reading and eye-tracking among L2 populations have also reported parallel results across methodologies (e.g., Cramer and Dussias 2007; see Frenck-Mestre 2005 for a recent review). However, these studies have focused on highly proficient L2 speakers. Given the differences in presentation mode across these two methodologies – namely the word-by-word presentation mode of self-paced reading as compared to the presentation of entire sentences at once in eye-tracking studies – it remains to be seen whether using more fine-grained behavioral research methods with less proficient L2 populations will also lead to parallel results across methodologies.

Eye-tracking methodology was used in earlier research by Bernhardt (1984, 1991) to explore how native German readers, advanced L2 German readers and intermediate L2 German readers (English L1) process semantic and syntactic information when reading German texts. Bernhardt found that, regardless of proficiency, participants used cues in the texts to anticipate upcoming words and events, in that they spent more time on subsequent words or phrases and were more likely to regress back to earlier portions of a text when later information did not match initial expectations. At the same time, intermediate L2 readers were more likely to focus on content words while reading, and skipped over many function words, including determiners carrying case-marking information. This contrasted with the native German participants, who spent more time reading function words, especially in the initial phases of reading a target text. Results from the advanced L2 readers lay between those of the intermediate L2 readers and the German native speakers, in that they focused on certain function words but they did not focus on as many different function words as the native speakers.

While Bernhardt (1984, 1991) examined native and L2 processing at the paragraph level, other eye-tracking studies that have focused on sentence-level processing have reported comparable differences in eye-tracking patterns as a function of L2 proficiency. For example, Keating (2009) investigated how Spanish native speakers and L2 learners of Spanish (English L1) at various

proficiency levels processed grammatical gender agreement in Spanish, relying on a variety of eye-tracking measures, including measures that reflect the initial phase of processing a word, such as first-pass reading times (or gaze duration), and measures that reflect later stages of processing and reanalysis, such as total reading times or the proportion of regressions back to a critical region (see also Boland 2004). Keating found that Spanish native speakers were sensitive to violations in Spanish grammatical gender agreement regardless of the distance between a noun and its modifying adjective, exhibiting longer total reading times and more regressions when the ending on postnominal adjectives did not match the gender of the preceding noun. However, total reading times and the proportion of regressions among the advanced L2 learners of Spanish only increased when the mismatched adjective was directly adjacent to the noun in question. In contrast, beginning and intermediate L2 learners of Spanish exhibited no on-line sensitivity to such violations, regardless of the distance between the noun and the adjective. As with Bernhardt, Keating's findings suggest that with increased proficiency, L2 learners become sensitive to and can rapidly process L2 morphosyntactic information in real time, but that differences between L2 learners and native speakers may persist.

More recent work comparing off-line grammaticality judgments with on-line event-related potentials (ERPs) has found a disassociation between on-line and off-line behavior among beginning and intermediate L2 learners (Osterhout et al. 2006; Tokowicz and MacWhinney 2005). Osterhout et al. (2006) found ERP evidence to suggest that L2 learners of French, with as little as one month of L2 exposure in a foreign language classroom, were sensitive to syntactic violations in French, even though their performance on a corresponding off-line grammaticality judgment task was at chance. Tokowicz and MacWhinney (2005) reported a similar dichotomy between ERP and off-line findings from L2 learners of Spanish who had had one to four semesters of classroom exposure prior to the study. These studies suggest that even when L2 learners do not demonstrate explicit knowledge of particular L2 grammatical structures, as measured by off-line grammaticality judgment tasks, they may still possess implicit knowledge of such structures, as measured by more sensitive ERP data.

These findings highlight the importance of gathering data from L2 learners via a variety of research methodologies. Further, the on-line evidence suggesting that even beginning-level L2 learners possess implicit knowledge of L2 grammatical structures has been found via more sensitive testing measures, like ERP experiments. This has lead several researchers to suggest that even among methodologies that measure real-time language processing, those methodologies that allow for more fine-grained analyses, such as eye-tracking, relative to potentially less-sensitive measures, such as self-paced reading, may be especially important in L2 research (Frenck-Mestre 2005; Keating 2009). In short, without evidence from converging sources, including evidence from multiple

sources aimed to measure real-time language processing, L2 researchers run the risk of mischaracterizing learners' knowledge of L2 grammatical structures and their ability to use such knowledge in real time.

1.3. *Present study*

The present experiment uses eye-tracking methodology in conjunction with the target stimuli from Jackson (2008) in an attempt to replicate the self-paced reading results from the intermediate-level L2 learners of German and the German native speakers reported by Jackson, using a more fine-grained and naturalistic measure of on-line processing. Whereas self-paced reading methodology allows participants to see only one word or phrase at a time, without the possibility of re-reading earlier segments of a sentence, eye-tracking provides participants the opportunity to read sentences in a manner that more closely resembles a natural reading task. The text is not fragmented into single words or phrases but rather is presented all at once, allowing participants to freely move their eyes across a printed line of text. In addition, readers can re-read critical words and regress to earlier regions in the target sentences as often as needed. This latter feature of eye-tracking methodology allows researchers to tease apart early stages of on-line processing from later stages of processing and reanalysis. In addition, while many researchers combine words into larger critical regions to strengthen statistical analyses (e.g., Frenck-Mestre and Pynte 1997; Wilson and Garnsey 2009) one also has the ability with eye-tracking data to fractionate reading times into distinct components (Carreiras and Clifton 2004) and to analyze shorter function words, like determiners and pronouns, independently from content words (e.g., Sanford and Filik 2007). In the present study, analyzing the disambiguating determiner separately from the noun may prove crucial in revealing whether English-speaking learners of German are sensitive to case-marking information encoded on German determiners.

Thus, by using eye-tracking methodology, the present study not only addresses an important methodological issue in L2 sentence processing research, but also speaks to an open question regarding how L2 learners, and intermediate L2 learners in particular, process L2 input in real time. If intermediate L2 learners of German (English L1) continue to show no immediate word order effects at the point they encounter disambiguating case-marking information, even when the data collection technique provides high temporal resolution, this would support the hypothesis that especially less proficient L2 learners may not immediately integrate grammatical information when reading and comprehending ambiguous L2 sentences (e.g., Havik et al. 2009; Keating 2009). If, however, intermediate L2 learners of German exhibit immediate effects for word order at either the disambiguating determiner or the second

noun, this would support the claim that even less proficient L2 learners can and do process L2 morphological information in real time, and that the ability to uncover a sensitivity to such structures may depend on the measurement used (e.g., Frenck-Mestre 2005; Osterhout et al. 2005; Tokowicz and MacWhinney 2005). Furthermore, if intermediate L2 learners of German immediately process case-marking information, then one might predict that such word order effects would appear in early processing, measured by reading times the first time they encounter the determiner or second noun (i.e., gaze duration). However, if case-marking information is not available to intermediate L2 learners until later processing stages, then any word order effects should be evident only in later processing measures, like second-pass or total reading times.

In addition to examining both subject- and object-first sentences, by manipulating the location of the lexical verb, the present study investigates whether encountering the lexical verb prior to the disambiguating region influences L2 on-line processing. Specifically, if L2 learners make a stronger commitment to assigning grammatical roles when they have access to the lexical semantics of the main verb (i.e., the "what" of "who does what to whom") prior to reading the disambiguating noun phrase, then one would expect to see stronger word order effects at the disambiguating determiner and possibly the second noun in simple-past tense sentences relative to present-perfect tense sentences. However, if L2 learners assign grammatical roles independently from knowing the lexical-semantic properties of the main verb – or, alternatively, if they don't make structural commitments at all, regardless of lexical semantics – then one would predict there would be no interaction between word order and verb tense on any of the eye-tracking measures under investigation.

2. Method

2.1. *Participants*

Twenty-five L2 learners of German (English L1) were recruited from upper-level undergraduate German courses. All received payment for their participation. Data from one participant were excluded due to a high percentage of track loss during the eye-tracking experiment. Thus, all results reported here are based on data from 24 L2 participants. The L2 participants began learning German at age 10 or later and all but one had begun learning German in high school. Including the years of high school study, the participants had been learning German, on average, for 6.2 years at the time of the study. Based on the self-proficiency ratings detailed in Table 1, the participants considered English their dominant language and would best be described as intermediate-level L2 learners, based on their self-ratings of L1 English and L2 German

Table 1. *Biographical information*

	English L2 learners of German		German native speakers	
	English (L1) *M (SD)*	German (L2) *M (SD)*	German (L1) *M (SD)*	English (L2) *M (SD)*
Self-ratings of proficiency[a]				
Reading	9.8 (0.4)	6.3 (1.0)	9.8 (0.8)	8.0 (1.1)
Writing	9.8 (0.4)	6.2 (1.1)	9.7 (0.7)	6.9 (1.5)
Listening	9.9 (0.3)	6.8 (1.3)	9.9 (0.3)	8.3 (0.9)
Speaking	9.9 (0.3)	5.8 (1.6)	9.9 (0.3)	7.1 (1.1)
Total years learning German	N/A	6.2 (1.4)	N/A	N/A
German proficiency task score[b]	N/A	16.5 (2.5)	N/A	N/A
German vocabulary task score[c]	N/A	94.7 (2.0)	N/A	N/A

a. Self-proficiency ratings are on a scale of 1 to 10, 1=least native-like; 10=most native-like.
b. Proficiency task score is out of 30 possible points.
c. Vocabulary task score is out of 100 %.

proficiency. Not surprisingly, paired *t*-tests comparing participants' self-ratings in English and German revealed significant differences for all four skills, with the participants rating their L1 English skills as significantly higher than their L2 German skills (all p-values $< .001$). All participants scored between 11 and 20 points ($M = 16.5$) on the 30-point proficiency task used in Jackson (2008) to measure participants' German grammar and vocabulary knowledge (Goethe Institut 2004). This task assessed a variety of grammatical structures in German, including case-marking and word order rules. Although not a standardized test, the Goethe Institut provides approximate ratings for this German proficiency task using the six levels outlined in the Common European Framework. Participants' scores corresponded to the third (B1) and fourth (B2) levels of the Common European Framework, thereby supporting the characterization of these participants as intermediate-level L2 learners.

The L2 participants also completed a vocabulary task in which they matched German words with their English translations. This task was designed to measure their knowledge of the German words included in the eye-tracking experiment described below. All participants scored at least 90.1 % on this task ($M = 94.7\,\%$). Both the vocabulary task and the German proficiency task were administered after the eye-tracking task so as not to influence the results on the primary portion of the experiment.

Fifteen German native speakers were recruited from the same university community as the L2 participants to provide a baseline for comparison. All of the German participants had been living in the United States for less than two years at the time of the experiment ($M = 9.6$ months). Data from one German participant were excluded due to a high percentage of track loss during the eye-tracking experiment. Therefore, all results reported here are from the remaining 14 participants. As detailed in Table 1, these German native speakers rated themselves as fluent L2 English speakers. However, paired *t*-tests comparing their self-ratings in German to their self-ratings in English indicated that they considered themselves to be significantly more proficient in German than in English (all $ps < .01$). Furthermore, they all reported that they continued to use German on a regular basis even though they were living in an English-speaking environment at the time of the study.

2.2. *Materials and design*

All target sentences consisted of a *wh*-question based on those used in Jackson (2008), provided previously as examples (5)–(8). The vocabulary used in all experimental items was drawn from a variety of first year German textbooks, to ensure that the participants would be familiar with the words in the target sentences. The first variable manipulated in the target sentences was word order (subject-first vs. object-first). The initial *wh*-element in each sentence always contained a feminine or neuter noun, such that it was ambiguous whether this initial *wh*-phrase was the subject or direct object of the target sentence. Disambiguating case-marking information appeared on the determiner of the second noun phrase. This second noun was always masculine, as only masculine nouns are unambiguously marked for nominative or accusative case in German. Furthermore, all nouns included in the target sentences were singular, to eliminate the possibility of successfully using subject-verb agreement information to disambiguate who did what to whom in the experimental items.

Eight German native speakers, none of whom participated in the eye-tracking experiment, judged the plausibility of each noun-verb-noun combination (e.g., *Welche Ingenieurin traf den Chemiker?* 'Which engineer met the chemist?', *Welche Ingenieurin traf der Chemiker?* 'Which engineer did the chemist meet?') on a 7-point scale (1 = very plausible; 7 = totally implausible). Sentences in which the difference in the mean rating for the subject-first and object-first versions was greater than 1.25 were modified and then the entire set of target sentences were evaluated by an additional four German native speakers, who determined that all of the target sentences were equally plausible in their subject-first and object-first versions. This was done to ensure that both versions of the target sentences were equally plausible, thereby limiting the po-

tential impact semantic plausibility could have on how participants processed the experimental items.

The second variable manipulated in the target sentences was verb tense (simple past vs. present perfect).[3] In simple-past tense sentences, the lexical verb (i.e., *traf* 'met') appeared prior to the disambiguating region, making lexical information (i.e., the "what" of "who did what to whom") immediately available to readers. In the present-perfect tense sentences, however, this information did not appear until the end of the sentence, after the disambiguating noun phrase. Finally, an additional adverbial or prepositional phrase was added to simple-past tense sentences so that the overall length of the target sentences was comparable, regardless of verb tense.

The experiment contained 40 target sentences – 10 for each of the four experimental conditions shown in example sentences (5)–(8). These experimental items were counterbalanced across four lists, such that all participants were exposed to the four conditions but no participant read more than one version of any given target sentence. These four lists were then randomized across all participants. The target sentences were presented in a semi-randomized order along with 80 filler items. Similar to Jackson (2008), the filler items were also single-clause *wh*-questions, including *which*-questions that were disambiguated via verbal inflection or that contained intransitive verbs (see examples (9) and (10) below), along with items containing a variety of other *wh*-words, such as example (11) below.

(9) *Welche* *Pilotin* *hat* *die* *Passagiere*
which$_{NOM/ACC}$ pilot$_{SG}$ has$_{SG}$ the$_{NOM/ACC}$ passengers$_{PL}$
während *des* *Fluges* *angeschrien?*
during the flight screamed-at?
'Which pilot screamed at the passengers during the flight?'

(10) *Welche Nonnen wohnen schon seit Jahren in diesem Kloster in den Alpen?*
'Which nuns have been living in this cloister in the Alps for years?'

(11) *Wie erklärten die Journalisten den Krieg in den Artikeln?*
'How did the journalists explain the war in the articles?'

The filler items contained subject-first and object-first word orders, a variety of verb tense forms, including present tense, simple-past and present-perfect tense, and items containing modal verbs.

3. There is considerably less semantic difference between the simple-past and present-perfect tense in German, compared to English. The differences between these two verb tenses are more stylistic in nature, with the simple past being used more often in written texts and the present perfect being used more often in spoken discourse, although both tenses can and do occur in both written and spoken form (Zifonun et al. 1997).

After each experimental item, a true-false verification statement was presented and participants were instructed to decide whether the statement corresponded to the meaning of the original sentence. Given that the explicitness with which accompanying verification statements can influence on-line processing, especially among L2 populations (e.g., Havik et al. 2009), in line with many monolingual processing studies (e.g., Mak et al. 2006), these statements were designed so as not to draw explicit attention to the assignment of grammatical roles, as seen in example statement (12), designed for experimental items (5)–(8).

(12) *Der Chemiker und eine Ingenieurin haben einander gesehen.*
'The chemist and an engineer saw one another.'

2.3. *Apparatus*

All eye-tracking movements were recorded using a video-based Eyelink eye tracking system from SR Research. The system provides a 0.25˚–0.5˚ average accuracy and samples at a rate of 500 Hz (2 ms temporal resolution). Stimuli were presented in 32 point font on a color 17-inch ViewSonic 17PS monitor. The critical region of the target sentences always appeared on the first line of the sentence and it was never the last word in the line. Participants were seated 70 cm from the monitor. A nine-point calibration, followed by a nine-point calibration accuracy test, was performed with each participant at the beginning of the experimental session, after a short break, and towards the end of the experiment. Before each trial, a black fixation target appeared on the left side of the computer screen, in the same position where the first word of the sentence would be displayed. The participant fixated this target and the reported gaze position was used to correct any post-calibration drift errors.

2.4. *Procedure*

All participants were tested individually in a quiet room. After participants were seated, the equipment was calibrated prior to the start of the experiment. This process took approximately five minutes. During the experiment, participants were instructed to look at a fixation point indicating the first character position for each sentence. Once the participant was looking at the fixation point, the experimenter pressed a button and the fixation point was replaced by a stimulus item. Participants read each sentence at their own pace and then pressed a button on a hand-held button device, causing the sentence to disappear and the true/false verification statement to appear on the screen. After responding to the verification statement by pressing "R" for *richtig* 'true' or

"F" for *falsch* 'false' on the hand-held button device, a new fixation point appeared on the screen. Participants were instructed to answer the verification statements as quickly and accurately as possible. At the beginning of the experiment, participants read 10 practice sentences to become familiar with the task procedure. This was followed by the experiment itself, which contained the 40 experimental items and 80 filler items. Half way through the experiment, a screen appeared informing participants that they had read the first half of the stimulus set and offered the possibility of pausing for a short break. All participants opted to continue with the experiment, which lasted approximately one hour.

3. Results

3.1. *Data analysis*

For the L2 participants, mean comprehension accuracy on the task overall – as defined by their accuracy in answering the true/false verification statements presented after every item – was 86.0 %, and 82.7 % on the experimental stimuli, and all participants responded correctly to the true/false verification statement on at least 70 % of the target sentences. The mean comprehension accuracy for the German native speakers was 92.9 % on the task overall and 90.2 % on the experimental stimuli. All German native speakers responded to the comprehension statement correctly on at least 80 % of the target items. This indicates that the participants in both groups read the sentences carefully and paid attention during the task. Eye-tracking results based only on items in which the participants responded to the verification statement correctly exhibited the same pattern of reading times across conditions as analyses including the data from all experimental items for all participants.[4] Therefore, reading time data from all items, regardless of whether participants responded correctly to the verification statement, were included in the analyses reported below (see Hopp 2006a, 2006b; Mak et al. 2006; Traxler et al. 2002 for similar treatment of data).

For all experimental items, four fixation measures at the disambiguating region – defined here as the determiner and the noun of the second noun phrase (e.g., *den Chemiker* 'the chemist') are reported. Because the determiner contained crucial grammatical information, namely the disambiguating case-marking information, the determiner was analyzed separately from the second noun. Paralleling Jackson (2008), we also analyzed fixations on the last word in

4. The results of the statistical analyses for the accurate-only data are available as supplemental material online (http://www.personal.psu.edu/cnj1/Publications.htm).

the sentence (e.g., *Café* 'cafe'). The first fixation measure reported, *gaze duration*, is defined as the sum of all left-to-right eye-fixations (in milliseconds) on a word until leaving this word the first time it is read. Gaze duration is equal to first-pass reading times when the critical region is a single word; as such, both measures reflect the initial phase of processing the target segment. The second measure, *second-pass reading time*, is defined as the sum of all fixations on a word the first time participants return to a critical word after having left this word. In instances in which a participant did not return to a critical word, the second-pass reading time for that word was set to 0ms.[5] The third measure, *total reading time*, is defined as the sum of all fixations on a word at any time, including any regressions back to that word. Finally, we also calculated the percentage of items in which participants regressed back to a critical word after they had exited this word to the right. These latter measures – second-pass reading times and percentage of regressions – reflect later stages of processing (Boland 2004), while total reading times represent the cumulative time participants spent on a particular word.[6] For all reading time measures, reading times less than 100 ms were excluded from the dataset, as readers are assumed not to be able to process information in such a short period (Rayner et al. 1989). For the L2 learners, this eliminated 3.7 % of the gaze durations and 2.6 % of the second-pass reading times. For the German native speakers, this trimming procedure eliminated 2.5 % of the gaze durations and 1.5 % of the second-pass reading times. A summary of these reading time measures on the determiner, the second noun and the last word are presented in Table 2.

Across all participants and all items, the L2 participants skipped the determiner 8.6 % of the time, the second noun 2.1 % of the time, and the last word 7.3 % of the time. When participants skipped a critical word entirely, this was treated as missing data. However, there were at least three observations per condition for each participant on each of the three critical words, thereby eliminating the chance that participants' means for a given condition were based on a single outlier reading time.

5. The percentage of second-pass reading times was 55.3 % for the determiner, 65.1 % for the second noun and 52.4 % for the last word among the L2 learners. The percentage of second-pass reading times among the German native speakers was 42.0 % for the determiner, 44.3 % for the second noun and 26.2 % for the last word. Given the relatively low percentage of second-pass reading times for both participant groups, any significant results for this measure should be interpreted with caution.
6. The importance given to early or late measures derived from the recording of eye movements depends in large part on the research question being investigated. For studies which aim to adjudicate between theories that make specific commitments about when particular types of information become available to the reader, the distinction between early and late measures is crucial. Studies that examine, say, the final interpretation of sentences are less concerned with such distinctions.

Table 2. *Mean fixation times (standard deviations)*

	Gaze duration (ms)	Second-pass (ms)	Total reading time (ms)	Regressions (%)
L2 learners				
Determiner				
Sub-first; Sim. past	270(54)	132(60)	507(159)	57(22)
Obj-first; Sim. past	256(64)	102(49)	427(167)	48(21)
Sub-first; Pres. perf.	257(65)	114(49)	433(93)	55(21)
Obj-first; Pres. perf.	226(42)	125(60)	414(135)	57(23)
Second noun				
Sub-first; Sim. past	357(106)	209(114)	759(267)	67(24)
Obj-first; Sim. past	372(128)	214(113)	775(320)	65(21)
Sub-first; Pres. perf.	395(147)	197(94)	724(237)	63(21)
Obj-first; Pres. perf.	373(129)	193(96)	738(296)	64(24)
Last word				
Sub-first; Sim. past	413(150)	230(121)	742(263)	54(21)
Obj-first; Sim. past	403(163)	203(106)	716(269)	52(19)
Sub-first; Pres. perf.	564(186)	228(173)	895(363)	48(27)
Obj-first; Pres. perf.	550(182)	237(177)	891(361)	52(28)
German native speakers				
Determiner				
Sub-first; Sim. past	218(51)	92(71)	375(144)	41(19)
Obj-first; Sim. past	238(41)	93(47)	375(121)	40(19)
Sub-first; Pres. perf.	207(33)	105(67)	376(175)	42(14)
Obj-first; Pres. perf.	227(48)	104(46)	353(97)	46(15)
Second noun				
Sub-first; Sim. past	264(64)	85(39)	373(115)	40(19)
Obj-first; Sim. past	258(59)	115(58)	422(141)	51(15)
Sub-first; Pres. perf.	245(92)	98(58)	381(153)	42(22)
Obj-first; Pres. perf.	237(57)	95(58)	363(109)	41(18)
Last word				
Sub-first; Sim. past	305(115)	58(76)	376(188)	19(17)
Obj-first; Sim. past	257(64)	60(46)	333(80)	27(15)
Sub-first; Pres. perf.	303(81)	74(87)	400(144)	28(23)
Obj-first; Pres. perf.	312(96)	74(54)	393(108)	26(16)

Skip rates among the German native speakers were higher overall than the L2 learners, but still relatively low. The German native speakers skipped the disambiguating determiner 17.0 % of the time, the second noun 8.6 % of the time, and the last word in the sentence 7.5 % of the time. Closer inspection of individual participants' data revealed that one German native speaker skipped the determiner for all 10 target sentences in one condition. Therefore, this par-

ticipant's data were excluded from the analyses of the determiner. For all other participants, there were at least three observations per condition on each of the three critical words.

2×2 repeated-measures ANOVAs, treating word order (subject-first vs. object-first) and verb tense (simple past vs. present perfect) as within-participants variables, were calculated for the determiner, the noun and the last word of the sentence for each fixation measure. Analyses were conducted treating both participants (*F1*) and items (*F2*) as random variables. Because there was a large difference in the number of L2 learner participants ($n = 24$) versus German native speaker participants ($n = 14$), and because the L2 learners' data exhibited greater variation compared to the German native speaker data, combining the data from the L2 and German native speaker participant groups could have masked potential effects and interactions among the L2 learners. Therefore, no direct statistical comparisons were made between the L2 participant data and the German native speaker data (see Dekydtspotter et al. 2008; Fender 2003; Juffs 2005 for similar treatment of L2 vs. native speaker data).

3.2. *L2 learners*

3.2.1. *Disambiguating determiner.* On the determiner there was a main effect of verb tense for gaze duration ($F1(1,23) = 5.23$, $p = .032$; $F2(1,39) = 5.00$, $p = .031$) because gaze durations on the determiner were longer on simple-past tense sentences ($M = 263$ ms) than present-perfect tense sentences ($M = 242$ ms). There was also a main effect of word order ($F1(1,23) = 7.81$, $p = .010$; $F2(1,39) = 6.98$, $p = .012$) because reading times on subject-first sentences ($M = 264$ ms) were longer than on object-first sentences ($M = 241$ ms). For gaze duration there was no significant interaction between verb tense and word order ($F1 < 1$; $F2(1,39) = 1.28$, $p = .265$).

With regard to measures of later stages of processing, there were no main effects of verb tense or word order but there was a significant interaction between verb tense and word order in second-pass reading times (verb tense: all Fs < 1; word order: $F1(1,23) = 2.30$, $p = .143$; $F2(1,39) = 1.83$, $p = .184$; verb tense x word order: $F1(1,23) = 4.39$, $p = .047$; $F2(1,39) = 7.05$, $p = .011$). Simple effects tests revealed that second-pass reading times on subject-first sentences were significantly longer than object-first sentences in the simple-past tense ($F1(1,23) = 9.91$, $p = .004$; $F2(1,39) = 8.33$, $p = .006$). However, there was no significant difference in second-pass reading times according to word order in present-perfect tense sentences ($F1 < 1$; $F2(1,39) = 1.28$, $p = .264$). In the analysis of total reading times, the main effect of verb tense approached significance ($F1(1,23) = 3.15$, $p = .089$; $F2(1,39) = 3.00$, $p = .091$). There was a main effect of word order ($F1(1,23) = 7.39$, $p = .012$; $F2(1,39) =$

9.57, $p = .004$) in that reading times on subject-first sentences ($M = 470$ ms) were longer than on object-first sentences ($M = 421$ ms). There was no significant interaction between verb tense and word order ($F1(1,23) = 2.71$, $p = .113$; $F2(1,39) = 3.93$, $p = .054$). Finally, for the percentage of regressions back to the determiner, there were no main effects or interaction (verb tense: $F1 < 1$; $F2(1,39) = 1.88$, $p = .178$; word order: $F1(1,23) = 2.37$, $p = .138$; $F2(1,39) = 1.54$, $p = .222$; verb tense x word order: $F1(1,23) = 2.57$, $p = .122$; $F2(1,39) = 4.11$, $p = .050$).

3.2.2. *Second noun.* ANOVAs on the four reading time measures revealed no significant effects or interactions (gaze duration: verb tense: $F1(1,23) = 1.32$, $p = .263$; $F2(1,39) = 1.94$, $p = .171$; word order: both Fs < 1; verb tense $\times$ word order: $F1(1,23) = 2.15$, $p = .156$; $F2(1,39) = 1.39$, $p = .245$; second-pass reading times: verb tense: $F1(1,23) = 1.70$, $p = .205$; $F2(1,39) = 1.39$, $p = .246$; all other Fs < 1; total reading times: verb tense: $F1(1,23) = 1.59$, $p = .220$; $F2 < 1$; all other Fs < 1; percentage of regressions: all Fs < 1).

3.2.3. *Last word.* At the last word there was a main effect of verb tense for gaze duration ($F1(1,23) = 28.34$, $p < .001$; $F2(1,39) = 16.22$, $p < .001$) because reading times were longer on present-perfect tense sentences ($M = 557$ ms) than simple-past tense sentences ($M = 408$ ms). However, there was no main effect of word order and no significant interaction between verb tense and word order (all Fs < 1).

The analysis of second-pass reading times at the last word revealed no main effects or interaction (all Fs < 1). For total reading times there was a main effect of verb tense ($F1(1,23) = 14.89$, $p = .001$; $F2(1,39) = 8.02$, $p = .007$) because total reading times on the last word were longer on present-perfect tense sentences ($M = 893$ ms) than simple-past tense sentences ($M = 729$ ms). However, there was no main effect of word order or a significant interaction between verb tense and word order (all Fs < 1). Finally, the analysis of the frequency with which participants returned to the last word revealed no main effects or interaction (all Fs < 1).

3.3. *German native speakers*

3.3.1. *Disambiguating determiner.* At the determiner the analysis of gaze duration revealed no main effect of verb tense ($F1(1,12) = 1.52$, $p = .241$; $F2 < 1$).[7] However, there was a main effect of word order ($F1(1,12) = 10.65$,

7. For four experimental items, the determiner and the last word were skipped by all of the

$p = .007$; $F2(1,35) = 4.41$, $p = .043$) because reading times were longer on sentences that disambiguated to an object-first order ($M = 232$ ms) than sentences that disambiguated to a subject-first order ($M = 212$ ms). There was no significant interaction between verb tense and word order (all Fs < 1).

In contrast, measures of later processing stages revealed no main effects or interactions on the determiner (second-pass reading times: verb tense: $F1(1,12) = 1.83$, $p = .201$; $F2(1,35) = 1.59$, $p = .216$; all other Fs < 1; total reading times: all Fs < 1). With regard to the percentage of regressions back to the determiner, there was no main effect of verb tense or word order (verb tense: $F1(1,12) = 1.34$, $p = .270$; $F2 < 1$; word order: both Fs < 1). There was no interaction between verb tense and word order in the participants analysis, but this interaction was significant in the items analysis ($F1 < 1$; $F2(1,35) = 4.33$, $p = .045$). However, simple-effects tests revealed no significant differences in subject-first versus object-first sentences as a function of verb tense (simple-past tense: both Fs < 1; present-perfect tense: $F1 < 1$; $F2(1,35) = 2.74$, $p = .107$).

3.3.2. *Second noun.* For gaze duration on the second noun there was no main effect of verb tense in the participants analysis but this effect was significant in the items analysis ($F1(1,13) = 2.83$, $p = .116$; $F2(1,39) = 4.39$, $p = .043$), indicating that reading times were longer on simple-past tense sentences ($M = 261$ ms) than on present-perfect tense sentences ($M = 241$ ms). The main effect of word order was not significant nor was there a significant interaction between verb tense and word order (all Fs < 1).

For all other processing measures, there were no main effects or interactions at the second noun (second-pass reading times: verb tense: both Fs < 1; word order: $F1(1,13) = 2.31$, $p = .153$; $F2 < 1$; verb tense $\times$ word order: $F1(1,13) = 2.41$, $p = .144$; $F2 < 1$; total reading times: verb tense: $F1(1,13) = 1.45$, $p = .250$; $F2 < 1$; word order: $F1(1,13) = 1.05$, $p = .323$; $F2 < 1$; verb tense x word order: $F1(1,13) = 1.43$, $p = .253$; $F2(1,39) = 1.33$, $p = .256$; percentage of regressions: verb tense: both Fs < 1; word order: $F1(1,13) = 1.64$, $p = .223$; $F2 < 1$; verb tense x word order: $F1(1,13) = 3.72$, $p = .076$; $F2(1,13) = 1.34$, $p = .255$).

3.3.3. *Last word.* At the last word in the sentence, the analysis of gaze duration revealed no main effect of verb tense or word order (verb tense: $F1(1,13) = 2.97$, $p = .109$; $F2 < 1$; word order: $F1(1,13) = 2.15$, $p = .167$; $F2(1,35) = 2.02$, $p = .164$). There was no significant interaction between verb tense and

German native speaker participants in at least one condition. Thus, the items analyses for the determiner and the last word are based on the remaining 36 items.

word order in the participants analysis but this interaction was significant in the items analysis ($F1(1,13) = 2.39$, $p = .146$; $F2(1,35) = 4.17$, $p = .049$). However, simple effects tests revealed no significant difference in gaze duration as a function of word order for either simple-past tense or present-perfect tense sentences (simple-past tense: $F1(1,13) = 2.51$, $p = .137$; $F2(1,35) = 4.04$, $p = .052$; present-perfect tense: all Fs < 1).

For all other processing measures, there were no main effects or interactions at the last word (second-pass reading times: verb tense: all Fs < 1; word order: $F1 < 1$; $F2(1,35) = 1.03$, $p = .318$; verb tense $\times$ word order: all Fs < 1; total reading times: verb tense: $F1(1,13) = 4.40$, $p = .056$; $F2 < 1$; word order: $F1 < 1$; $F2(1,35) = 2.66$, $p = .112$; verb tense $\times$ word order: all Fs < 1; percentage of regressions: verb tense: all Fs < 1; word order: $F1(1,13) = 1.46$, $p = .249$; $F2 < 1$; verb tense x word order: $F1(1,13) = 1.61$, $p = .227$; $F2(1,35) = 1.77$, $p = .192$).

3.4. *Post-hoc analyses*

One of the primary research questions under investigation in the present study is whether intermediate L2 learners of German use case-marking information to assign grammatical roles during real-time language processing. In line with a more general preference for subject-first sentences in German, we hypothesized that if the L2 learners assigned grammatical roles in an incremental fashion, they would exhibit greater processing difficulties on object-first sentences than subject-first sentences upon reading the disambiguating noun phrase. The analysis of the L2 learners' reading times at the disambiguating region did not reveal this pattern. However, it is possible that processing difficulties on object-first sentences would be revealed not in first-pass reading times at the disambiguating region itself, but rather in what the L2 learners did next, after they had initially processed the case-marking information at the disambiguating determiner and read the second noun. To explore this possibility we conducted a post-hoc analysis in which we calculated the percentage of times participants returned to an earlier segment in the sentence immediately following first pass reading through the disambiguating determiner and the second noun. The summary of these results is presented in Table 3. As with the primary analyses, we ran separate analyses for the L2 learners and the German native speakers. The data were analyzed using a repeated-measure ANOVA, treating word order (subject-first vs. object-first) and verb-tense (simple-past vs. present-perfect) as within-participants variables.

Among the L2 learners, the analysis of the proportion of regressions from the disambiguating determiner back to earlier segments revealed a main effect of verb tense that approached significance in the participants-analysis and

Table 3. *Percentage of regressions from critical region back to earlier segments (standard deviations)*

	L2 learners	German native speakers
Determiner		
Sub-first; Sim. past	13 (13)	12 (11)
Obj-first; Sim. past	13 (12)	16 (15)
Sub-first; Pres. perf.	18 (19)	10 (14)
Obj-first; Pres. perf.	23 (24)	17 (11)
Second noun		
Sub-first; Sim. past	35 (22)	21 (13)
Obj-first; Sim. past	34 (25)	32 (18)
Sub-first; Pres. perf.	30 (21)	19 (17)
Obj-first; Pres. perf.	29 (29)	23 (17)

was significant in the items-analysis ($F1(1,23) = 3.33$, $p = .081$; $F2(1,39) = 6.18$, $p = .017$), indicating that the L2 learners were more likely to regress from the disambiguating determiner to previous segments in the sentence in present-perfect tense sentences ($M = 20.2$) than simple-past tense sentences ($M = 13.2$). However, there was no main effect of word order nor was there a significant interaction between verb tense and word order (word order: Fs < 1; verb tense x word order: $F1(1,23) = 1.80$, $p = .193$; $F2(1,39) = 1.41$, $p = .242$). At the second noun, there were no main effects or interaction (verb tense: $F1(1,23) = 1.44$, $p = .242$; $F2(1,39) = 2.71$, $p = .108$; all other Fs < 1).

Among the German native speakers, the analysis of the proportion of regressions from the disambiguating determiner to earlier segments revealed no main effects or interaction (verb tense: Fs < 1; word order: $F1(1,12) = 2.15$, $p = .169$; $F2(1,35) = 3.66$, $p = .064$; verb tense $\times$ word order: Fs < 1).[8] The analysis of the proportion of regressions from the second noun back to earlier segments revealed no main effect of verb tense ($F1(1,13) = 1.90$, $p = .192$; $F2 < 1$). The main effect of word order was significant in the participants analysis but was not significant in the items analysis ($F1(1,13) = 6.35$, $p = .026$; $F2(1,39) = 2.05$, $p = .160$), indicating that the German native speakers were more likely to regress from the second noun back to earlier segments in object-

8. As with the primary analyses, the post-hoc analysis of the disambiguating determiner excluded the one German native speaker who skipped the determiner for all 10 target sentences in one condition. Similarly, in four experimental items, the determiner was skipped by all of the German native speaker participants in at least one condition. Thus, the items analysis for the determiner is based on the remaining 36 items.

first sentences ($M = 27.8$) than subject-first sentences ($M = 20.0$). There was no significant interaction between verb tense and word order at the second noun ($F1(1,13) = 1.07$, $p = .320$; $F2 < 1$).

4. General discussion

In the present study we used eye-tracking methodology to explore whether intermediate L2 learners of German (English L1) would use case-marking information to assign grammatical roles when reading temporarily ambiguous *wh*-questions in German. Results showed that the intermediate L2 learners in the present study were sensitive to case-marking information immediately at the disambiguating determiner. With regard to early measures of on-line processing, the L2 learners exhibited longer gaze durations on the accusative-marked determiner *den* in subject-first sentences compared to the nominative-marked *der* in object-first sentences. There was also an immediate effect of verb tense in gaze durations at the determiner, with longer gaze durations on simple-past tense sentences than present-perfect tense sentences. As for later stages of processing, the L2 learners' second-pass reading times at the disambiguating determiner were longer on subject-first sentences than object-first sentences in the simple-past tense, but there was no difference according to word order on sentences in the present-perfect tense. Finally, the L2 learners exhibited an effect of word order in total reading times on the determiner that was not modulated by verb tense. Similar to their gaze durations, their total reading times for the determiner were longer on subject-first compared to object-first sentences.

The German native speakers exhibited the reverse effect at the disambiguating determiner, with longer gaze durations on sentences that disambiguated to an object-first order than sentences that disambiguated to a subject-first order. However, later processing measures on the disambiguating determiner revealed no significant effects of word order.

At the second noun there were no reliable effects for either the L2 learners or the German native speakers in any of the reading time measures. Similarly, there were no reliable effects on the last word of the sentence for the German native speakers. However, at the last word in the sentence for the L2 learners, both gaze durations and total reading times were longer on present-perfect tense sentences than simple-past tense sentences, regardless of word order.

While the present eye-tracking results from the German native speakers parallel the self-paced reading results reported by Jackson (2008), in which the German native speakers exhibited longer reading times at the critical noun phrase on object-first sentences than subject-first sentences, the present eye-tracking results from the L2 learners are decidedly different from the self-paced reading results from the intermediate L2 learners in Jackson's original study.

Whereas the intermediate L2 learners in the original self-paced reading study did not exhibit significant differences in reading times until the final segment of the sentence, at which point reading times were longer on object-first sentences than subject-first sentences, the intermediate L2 learners in the present study showed sensitivity to case-marking information immediately at the disambiguating determiner, albeit in the opposite direction. Further, at the last word in the sentence, the intermediate L2 learners in the present study exhibited longer gaze durations and total reading times for present-perfect tense sentences, in which the last word was the past participle, than simple-past tense sentences, in which the last word was the final word of a prepositional or adverbial phrase—an effect that was not modulated by word order. Admittedly, there are inherent differences in the level of semantic integration that occurs upon reading a lexical verb versus reading a prepositional phrase, differences that could be compounded by more generalized sentence wrap-up effects. Nevertheless, the present findings on the last word more closely parallel the self-paced reading results from the advanced L2 learners of German reported by Jackson, who also exhibited longer reading times on the past participle in present-perfect tense sentences, compared to the sentence-final adverbial or prepositional phrase in simple-past tense sentences.

Without running an additional study, in which the same participants read target sentences using both eye-tracking and self-paced reading, one must be cautious in drawing direct comparisons between these two different methodologies. However, given that the participants in both the present study and in Jackson (2008) were recruited from similar populations, the eye-tracking results suggest that at least with intermediate-level L2 learners, the choice of research methodology can impact how L2 learners process L2 input in real time. Specifically, the ability to freely move their eyes across the sentence and reread earlier segments of a sentence, as afforded by eye-tracking methodology, allowed the intermediate L2 learners to process the target sentences in a more natural manner. Under such circumstances, their reading time patterns revealed that they did not wait until they had read the entire sentence to piece together its meaning, but rather they processed critical lexical and morphosyntactic information, like case-marking information at the disambiguating determiner and the lexical-semantic information provided by the past participle, the first time they encountered it, leading to longer gaze durations when this information was unexpected or more difficult to process.

4.1. *Sensitivity to L2 morphosyntactic information*

Turning first to the effect of verb tense in gaze duration at the determiner for the L2 learners, this was likely a spillover effect from processing the previous

verb. Specifically, in simple-past tense sentences the determiner was preceded by the lexical verb, which was both longer and contained more semantic information than the auxiliary verb (i.e., *hat* 'has'), which preceded the determiner in present-perfect tense sentences. Because this pattern does not relate directly to the central research questions under investigation, it will not be discussed further.

Returning to the central finding from the present experiment, namely the main effect of word order on the determiner, these results indicate that the intermediate-level L2 learners in the present study immediately processed case-marking information. How they used this information, and which word order they found easier to process may not have corresponded with the predicted subject-first preference found in previous L1 and L2 German research (e.g., Bader and Meng 1999; Hopp 2006a, 2006b; Jackson 2008; Schlesewsky et al. 2000). Specifically, the L2 learners spent more time reading and re-reading the accusative-marked determiner *den* compared to the nominative-marked determiner *der*, even though *den*, as the determiner used to indicate that the subsequent masculine noun was a direct object, actually appeared in conjunction with subject-first sentences. However, one cannot argue that they did not detect and process case-marking information while reading the target sentences. Had the participants not paid any attention to this morphological cue, there should have been no significant effects at the determiner.

Furthermore, the word order effects at the determiner in the present experiment appeared in gaze duration, the first time participants encountered the determiner. This suggests that the L2 learners in the present study were immediately sensitive to case-marking information when reading the target sentences.[9] Thus, even though these L2 learners' overall grammatical knowledge of German was in the intermediate range, they had reached a level of L2 proficiency in which they differentiated *den* from *der* in the input, raising the possibility that they had made the form-meaning connection between German case-marking information and its importance for identifying argument structure in German

9. We recognize that when they first encountered the determiner, the L2 learners had not yet read and identified the second noun as masculine singular. Therefore, the determiner *den* could not yet unambiguously identify the second noun phrase as an accusative-marked direct object, as *den* also identifies plural nouns in the dative case. Similarly, feminine nouns in the dative or genitive case and plural nouns in the genitive case are identified by the determiner *der* – the same determiner used to identify the second noun as the nominative-marked subject in the target sentences. However, given that there was a robust effect of word order in total reading times for the L2 learners – such that this effect also appeared after they had read and processed the second noun – case ambiguity cannot be the sole explanation for this finding. Furthermore, the potential ambiguity of the determiner *den* does not change the more general conclusion that by spending significantly more time processing the determiner *den* relative to the determiner *der*, both initially and overall, the L2 learners demonstrated an immediate sensitivity to case-marking information when they read the determiner.

(see also Jackson 2008; VanPatten et al. 2004). In this regard, the results from the present study contrast with Bernhardt's (1984, 1991) eye-tracking studies, in which the intermediate L2 German readers, who had similar language histories to the L2 participants in this study, tended to skip function words, such as determiners, when reading German texts.

This is not to say that the L2 learners used case-marking information in the same way as German native speakers. Whereas measures of earlier stages of on-line processing among the German native speakers reflected greater processing difficulties on sentences that disambiguated to an object-first order, in line with a more generalized subject-first preference in German (e.g., Bader and Meng 1999; Schlesewsky et al. 2000), this pattern was reversed among the L2 learners of German. This difference in the direction of the word order effect among the L2 learners of German compared to the German native speakers suggests that intermediate-level L2 learners' processing of L2 sentences may be shallower and result in less detailed syntactic structures overall as compared to native speakers. However, the significant difference in gaze duration between object-first and subject-first sentences at the determiner of the disambiguating noun phrase demonstrates that the L2 learners in the present study processed case-marking information at the earliest stages of on-line processing. This finding highlights that even intermediate-level L2 learners can identify L2 morphological information rapidly in real time—a fact that may not become apparent through less-sensitive measures of on-line processing, such as self-paced reading.

One possible explanation for the results among the L2 learners is that unlike the German native speakers, the L2 learners had an overall preference for object-first sentences that manifested itself in early processing measures on the determiner. Even the German native speakers recovered rapidly from their initial processing difficulties on object-first sentences, as evidenced by the lack of any robust effects at the second noun. Other previous research has also suggested that the subject-first preference in German may not be as strong for *wh*-questions as for other constructions (e.g., Bader and Meng 1999). Thus, a weaker subject-first preference in German for this type of *wh*-question could have resulted in the L2 learners not adopting a subject-first preference when processing the target *wh*-questions in the present study.

However, such an explanation still does not satisfactorily explain why the L2 learners exhibited significantly longer gaze durations and total reading times on the determiner in subject-first sentences, as opposed to simply showing no on-line preference for one word order over the other. In addition, English still has an overall processing preference for subject-first sentences (e.g., King and Kutas 1995; Traxler et al. 2002), meaning that subject-first sentences should induce fewer processing costs than object-first sentences, and research has shown that beginning and intermediate L2 learners rely on this subject-first preference

when interpreting sentences in the L2, even when such an approach is not optimal for the L2 in question (e.g., Henry et al. 2009; Kempe and MacWhinney 1998; VanPatten 2004). Jackson (2008) also reported that intermediate-level L2 learners of German showed a general subject-first preference in German, as measured by end-of-sentence reading times, suggesting that at least when assessed via more course-grained processing measures, intermediate L2 learners of German still exhibit the expected subject-first preference when reading German *wh*-questions.

Therefore, an alternative explanation is that when the L2 learners encountered *der*, they interpreted it as a type of "default determiner", whereas upon reading *den* they identified it as different from the default determiner *der*, perhaps recognizing *den* as carrying crucial information about grammatical role assignment. This is not to say that *der* does not contain critical case-marking information, as it is used, among other functions, to identify nominative-marked masculine nouns. Rather, the L2 learners may have treated *der* as the German determiner most often associated with masculine nouns regardless of a noun's specific grammatical role in a sentence, whereas they associated *den* as a determiner specifically associated with grammatical role assignment. Along similar lines, the L2 learners may have spent more time reading *den* because it is overall less frequent compared to *der*, precisely because it is a determiner used to identify accusative-marked masculine nouns, among other functions, rather than a determiner for nominative-marked nouns.

Drawing a parallel between the present results and recent neurophysiological studies in which even beginning-level L2 learners have shown a sensitivity to grammatical violations in the L2 when measured by more sensitive ERP methods (e.g., Osterhout et al. 2006; Tokowicz and MacWhinney 2005), we hypothesize that the L2 learners in the present study immediately detected the case-marking information on the disambiguating determiner. When this case-marking information was carried by the less frequent determiner, *den*, the L2 learners' reading times increased, parallel to the enhanced ERP effects exhibited by beginning and intermediate L2 learners when they encounter grammatical violations while reading L2 sentences (Osterhout et al. 2006; Tokowicz and MacWhinney 2005). In this regard, the processing costs exhibited by the L2 learners at the determiner did not arise from the fact that the case-marking information encoded on the determiner violated their expectations regarding the grammatical roles of upcoming arguments. Further evidence to suggest that the L2 learners' processing differences on *den* versus *der* do not reflect a revision of earlier assumptions about the assignment of grammatical roles comes from the post-hoc analyses, in which the L2 learners were no more likely to regress back to earlier words in the sentence after they had initially read the disambiguating determiner and the second noun on object-first than subject-first sentences.

It is possible that the L2 learners in the present study looked longer at *den* than *der* simply because *den* caught their attention as a determiner that deviated from the default determiner *der*, rather than because they recognized that case-marking information is important for assigning grammatical roles in German. However, the intermediate L2 learners of German in Jackson (2008) exhibited a preference for subject-first sentences in sentence-final reading times, when case-marking information was the only means of identifying who did what to whom in the sentence, suggesting that the similarly-proficient L2 learners in that study possessed some level of sensitivity to the grammatical function case-marking information plays in German. Further, using an off-line grammar task, Ritterbusch et al. (2006) reported that upper-division American L2 learners of German – also arguably of similar L2 German proficiency as the learners in the present study – could provide the appropriate determiner in sentences containing three nominal arguments, even in non-canonical object-first sentences. Without comparable off-line data, it is impossible to say for certain whether the L2 learners in the present study possessed similar abilities to use case-marking information to assign grammatical roles. However, in light of these other studies, we would argue that the greater processing costs exhibited by the L2 learners in the present study on the determiner *den*, relative to *der*, reflect not only their surprise at encountering *den*, but that they also recognized the importance of processing this critical morphosyntactic information for comprehending the target sentences in the first place.

4.2. *The importance of the lexical verb*

Additional evidence that the L2 learners' processing difficulties on *den* did not stem solely from their surprise at encountering a less-frequent form of the determiner come from the analysis of second-pass reading times on the determiner, in which the L2 learners' difficulty processing the determiner *den* relative to the determiner *der* persisted longer on simple-past tense sentences than present-perfect tense sentences. Such effects must be interpreted with caution given that the L2 learners did not return to the determiner a second time in close to 50 % of the items. However, they suggest that the L2 learners were more likely to devote additional processing time to the determiner in subject-first sentences than in object-first sentences in the simple-past tense, in which the lexical verb appeared prior to the disambiguating region. In contrast, there was no significant difference in second-pass reading times as a function of word order for present-perfect tense sentences, in which the lexical verb appeared in sentence-final position. If the L2 learners spent longer reading the determiner *den* relative to *der* only because *den* is less frequent in German, one would not expect to see any differences in second-pass reading times as a function

of verb tense. Moreover, the L2 learners' second-pass reading times on the disambiguating determiner cannot simply reflect greater difficulty processing simple-past tense sentences in general, as one would then predict to see a main effect of verb tense that was not modulated by word order. Therefore, similar to the advanced L2 learners of German in Jackson (2008), who had greater difficulty recovering from an initial misanalysis of object-first sentences in the simple-past than in the present-perfect tense, the most plausible explanation for the interaction between verb tense and word order on second-pass reading times among the intermediate L2 learners in the present study can also be traced to how the on-line assignment of grammatical roles may vary as a function of the location of the lexical verb among English L2 learners of German. In essence, the presence of the lexical verb early on in the sentence influenced the point at which the L2 learners attempted to assign grammatical roles to the nouns in simple-past tense sentences, thereby elevating second-pass reading times on the accusative-marked determiner *den* – precisely the determiner that they more closely associated with providing unique case-marking information in the first place.

Further, the evidence for this interaction between word order and verb tense at the determiner did not appear in the L2 learners' initial processing of the determiner, but rather in the time they spent re-reading the determiner after they had read subsequent words in the sentence. This raises the possibility that the L2 learners' difficulty with simple-past tense sentences lay less in their initial processing of the determiner and more at the point they attempted to integrate nominal arguments with the lexical verb. Although this hypothesis must remain speculative at present, especially considering that the fixations included in second-pass reading times are quite "late" because the reader may have repeatedly fixated to early portions of the sentence (see Pickering et al. 2004), this highlights the importance of the lexical-semantic information supplied by the verb in L2 processing.

4.3. *Conclusion*

The on-line reading time patterns from the L2 learners in the present study, as compared to relevant findings from previous research investigating how intermediate L2 speakers of German process case-marking information and subject-object ambiguities in German, illuminate important methodological and theoretical issues for L2 researchers. The findings reported here suggest that the intermediate L2 learners in the present study had achieved a critical first step towards more native-like processing, in that they could identify particular L2 morphosyntactic information and could process such information in real time. Further, there was indirect evidence from the second-pass reading

time results that the L2 learners not only recognized and paid attention to the morphosyntactic case-marking information on the disambiguating determiner, but that they realized the important role this information plays in assigning grammatical roles in German. Only after they establish this basic relationship between grammatical form and semantic meaning can L2 learners then harness such knowledge and learn to use critical morphosyntactic information to predict upcoming sentential arguments, as has been shown by some studies to occur among highly proficient L2 speakers and native speakers of a language (e.g., Dussias and Cramer 2008; Frenck-Mestre and Pynte 1997; Schlesewsky et al. 2000; Wilson and Garnsey 2009). As such, the present study underscores the importance of expanding the scope of L2 processing research to include more studies with less proficient L2 learners. However, the present results also highlight that the choice of research methodology can have a critical impact on our ability to detect less proficient learners' sensitivity to L2 grammatical information during on-line processing (see also Frenck-Mestre 2005; Osterhout et al. 2006; Tokowicz and MacWhinney 2005). Especially as researchers expand the use of on-line psycholinguistic research tools to explore the connection between on-line processing and L2 learners' developing L2 linguistic systems, this latter point is of particular importance, as without it, we run the risk of underestimating L2 learners' knowledge of L2 linguistic structures, and their ability to process this knowledge in real time.

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