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Animacy affects the processing of subject–object ambiguities in the second language: Evidence from self-paced reading with German second language learners of Dutch

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ABSTRACT
The results of a self-paced reading study with German second language (L2) learners of Dutch showed that noun animacy affected the learners' on-line commitments when comprehending relative clauses in their L2. Earlier research has found that German L2 learners of Dutch do not show an on-line preference for subject–object word order in temporarily ambiguous relative clauses when no disambiguating material is available prior to the auxiliary verb. We investigated whether manipulating the animacy of the ambiguous noun phrases would push the learners to make an on-line commitment to either a subject- or object-first analysis. Results showed they performed like Dutch native speakers in that their reading times reflected an interaction between topichood and animacy in the on-line assignment of grammatical roles.

A number of recent studies have explored how second-language (L2) learners process morphosyntactic information in their nonnative language during on-line sentence processing (for two recent reviews, see Frenck-Mestre, 2005; Papadopoulou, 2005). The results from these studies are mixed, with L2 learners' processing exhibiting varying degrees of similarity to that of native speakers depending on the morphosyntactic structure in question, specific task demands, and individual learner variables (e.g., Havik, Roberts, van Hout, Schreuder, & Haverkort, 2009; Hoover & Dwivedi, 1998; Hopp, 2006; Juffs, 2005). To account for many of these findings, Clahsen and Felser (2006) proposed the *shallow structure hypothesis*,

suggesting that L2 learners may not incrementally build the structure of a sentence to the same syntactic detail as native speakers of a language, and that their processing is driven primarily by lexical–semantic and pragmatic information (see also Felser, Roberts, Marinis, & Gross, 2003; Papadopoulou & Clahsen, 2003). Studies have examined how L2 learners use verb–subcategorization information or plausibility constraints during on-line language comprehension (e.g., Dussias & Cramer, 2008; Dussias & Pinar, in press; Frenck-Mestre & Pynte, 1997; Juffs, 1998; Roberts & Felser, 2010; Williams, 2006; Williams, Möbius & Kim, 2001), but L2 sentence processing research has yet to consider how lexical–semantic information in the form of noun animacy may or may not interact with morphosyntactic information, such as word order, to build the argument structure of a sentence in real time. Given that argument structure rapidly influences language processing, and animacy plays a central role in many explanatory models of how different languages assign grammatical and thematic roles (e.g., Bornkessel & Schlesewsky, 2006; Primus, 1998), this factor is an important variable to consider with regard to L2 processing.[1]

The present study addresses this question by examining how L2 learners of Dutch with German as their first language (L1) process subject versus object relative clauses (RCs) when the animacy of the antecedent noun phrase (NP) and the RC-internal NP is manipulated. Furthermore, given that all verbal information appears at the end of the clause in Dutch RCs, the present study also explores the extent to which L2 learners will incrementally assign grammatical roles prior to encountering crucial lexical and morphosyntactic information provided by the lexical verb and its auxiliary.

ACCESSING LEXICAL–SEMANTIC INFORMATION DURING L1 AND L2 PROCESSING

Clahsen and Felser (2006) recently proposed that L2 learners rely heavily on lexical–semantic and pragmatic information during on-line processing. In the absence of such information, L2 learners may not make the same types of incremental structural commitments when they read temporarily ambiguous sentences, leading to fewer signs of on-line reanalysis. At the same time, many L1-based models of the human parsing mechanism also stress the importance of nonsyntactic information in early stages of processing (e.g., Cuetos & Mitchell, 1988; Hemforth, Konieczny & Scheepers, 2000; MacDonald, Pearlmutter, & Seidenberg, 1994), and that lexical–semantic and plausibility information can impact the severity of reanalysis (e.g., Traxler & Pickering, 1996). Thus, in light of research that has shown that L2 learners, like native speakers, rapidly access and use lexical–semantic information during on-line processing, and such information can strongly influence syntactic analysis and reanalysis (Dussias & Pinar, in press; Juffs, 1998; Roberts & Felser, 2010; Williams, 2006; Williams et al., 2001), the following question is perhaps more important than whether L2 learners rely on lexical–semantic information during on-line processing: even in the presence of critical lexical–semantic cues, will L2 learners use nonsyntactic information in the same manner as native speakers to process L2 input incrementally and potentially recover from initial misparses?

In a related vein, the majority of L2 sentence processing research that has found more nativelike processing strategies among L2 learners, especially with regard to their ability to predict upcoming arguments in a sentence, has looked at languages like English, Spanish, or French, in which the lexical verb appears early in the sentence (e.g., Dussias & Cramer, 2008; Frenck-Mestre & Pynte, 1997). However, as it relates to L2 learners' ability to construct filler–gap relationships on-line (e.g., Dussias & Pinar, in press; Juffs, 2005; Williams, 2006; Williams et al., 2001), Clahsen and Felser (2006) point out that, even though on-line evidence favors an account in which L2 learners can posit gaps, such effects may stem from a verb-driven rather than a structure-based gap-filling strategy (see also Marinis, Roberts, Felser, & Clahsen, 2005).

Studies that have examined how L2 learners process temporarily ambiguous input in verb-final constructions have shown that only at near-native speaker levels may L2 learners make early commitments, such as assigning grammatical or thematic roles, prior to encountering the lexical verb (cf. Havik et al., 2009; Hopp, 2006; Jackson, 2008). For example, Jackson (2008) found that English L2 learners of German exhibited processing difficulties while reading less preferred object-first temporarily ambiguous *wh*-questions when the lexical verb appeared prior to the disambiguating region (e.g., *Welche Ingenieurin traf den Chemiker gestern Nachmittag im Café?* "Which engineer met the chemist yesterday afternoon in the café?"), but not with similar sentences in the present perfect tense where the lexical verb appeared at the end of the sentence. This suggests that early access to the lexical verb can influence the strength of L2 learners' commitment to a particular sentence interpretation, and thus the relative difficulty of reanalysis when later information disambiguates the sentence to a less preferred structure. This is in contrast to a large body of L1 sentence processing research suggesting that native speakers of verb-final languages incrementally interpret sentences and assign grammatical and thematic roles independently of the lexical verb (e.g., Frazier, 1987; Frazier & Flores d'Arcais, 1989; Friederici & Frisch, 2000; Konieczny, Hemforth, Scheepers, & Strube, 1997).

Additional evidence that L2 learners may not always commit to a particular interpretation when reading temporarily ambiguous sentences comes from a study conducted by Havik et al. (2009). The authors investigated whether German L2 learners of Dutch would show an on-line preference for subject-first word order when reading temporarily ambiguous subject- and object-RC constructions, which are illustrated in Example 1, as native speakers of both German and Dutch do (e.g., Kaan, 1997; Schriefers, Friederici, & Kühn, 1995).

1. Daar is de machinist die de conducteurs heeft/hebben bevrijd uit het brandende treinstel.
   There is the train-driver$_{SG}$ who the conductors$_{PL}$ has$_{SG}$/have$_{PL}$ freed from the burning train-carriage.
   "There is the train driver who has freed the conductors/who the conductors have freed from the burning train carriage."

Only the native Dutch group found the less preferred object-resolved RCs more difficult to process: the L2 learners had no such on-line processing difficulty with

object RCs, even though off-line, they displayed a preference for subject-resolved items, like the native speakers. This suggests that in the absence of biasing lexical–semantic information prior to syntactic disambiguation, the L2 learners did not make an on-line commitment to an analysis, even though the constructions under investigation are maximally comparable between the L1 and the L2 (see also Felser et al., 2003; Papadopoulou & Clahsen, 2003).

Although the studies reported here, along with other L1 sentence-processing research, point to a subject preference in both Dutch and German (e.g., Frazier, 1987; Frazier & Flores d' Arcais, 1989; Gorell, 2000; Kaan, 1997; Schriefers et al.,1995), recent work by Mak, Vonk, and Schriefers (2002, 2006) suggests that this subject-first preference in Dutch is modulated by noun animacy. When participants in Mak et al. (2006) read subject RCs (SubjRC) and object RCs (ObjRC) containing either an animate subject or an inanimate subject, like Examples 2–5, their reading times were longer at the past participle and subsequent segments (italicized below) on object RCs containing an inanimate subject, like Example 5, compared to subject RCs containing an inanimate subject, like Example 4. In contrast, there were no significant differences in reading times according to word order for sentences containing an animate subject, such as Examples 2 and 3.

2. In het dorp zijn de wandelaars, die de rots *weggerold hebben*, *het* gesprek van de dag. (SubjRC, animate subject)
   In the town are the hikers$_{PL}$ that the rock$_{SG}$ rolled-away have$_{PL}$ the talk of the day
   "In the town the hikers, that have rolled away the rock, are the talk of the day."
3. In het dorp is de rots, die de wandelaars *weggerold hebben, het* gesprek van de dag. (ObjRC, animate subject)
   In the town is the rock$_{SG}$ that the hikers$_{PL}$ rolled-away have$_{PL}$ the talk of the day
   "In the town the rock, that the hikers have rolled away, is the talk of the day."
4. In het dorp is de rots, die de wandelaars *verpletterd heeft, het* gesprek van de dag. (SubjRC, inanimate subject)
   In the town is the rock that the hikers$_{PL}$ crushed has$_{SG}$ the talk of the day
   "In the town the rock, that has crushed the hikers, is the talk of the day."
5. In het dorp zijn de wandelaars, die de rots *verpletterd heeft, het* gesprek van de dag. (ObjRC, inanimate subject)
   In the town are the hikers$_{PL}$ that the rock$_{SG}$ crushed has$_{SG}$ the talk of the day
   "In the town the hikers, that the rock has crushed, are the talk of the day."

Because syntax-first accounts of the human parsing mechanism, such as the active filler strategy (cf. Frazier, 1987), assume that the processor will always build

a subject RC (object RCs therefore always induce reanalysis), the absence of a processing cost difference between the two conditions with an animate subject (Examples 2 and 3) led Mak et al. to conclude that additional types of nonsyntactic information must be available early in on-line processing (for parallel results in English, see also Traxler, Morris, & Seeley, 2002; Traxler, Williams, Blozis, & Morris, 2005).[2]

The question is then precisely *how* semantic information, like animacy, influences the processing of such temporary ambiguities. In their first experiment, Mak et al. (2006) used only *inanimate* NPs, and their readers displayed the same preference for subject over object RCs. Therefore, it appears that the processor does not use the animacy information of the antecedent NP per se to build initial structure, but rather it is the *difference* in animacy between the antecedent and the RC-internal NP that underlies the observed effects. Mak et al. (2006) go on to argue that, overall, readers prefer animate subjects over inanimate subjects. Similarly, readers prefer that the relative pronoun be the subject of the RC, because the RC provides additional information about the antecedent, making the antecedent the topic of the RC. Thus, in conditions where both noun animacy and topicality coincide, as in sentences like Example 2, readers immediately assign grammatical roles to each NP and no reanalysis is necessary. Grammatical roles are also immediately assigned in sentences like Example 5, in which readers encounter an animate antecedent followed by an inanimate RC-internal NP, because animacy and topicality again coincide. However, this leads to greater processing costs in the disambiguating region when morphosyntactic and semantic information in the verb cluster force a reanalysis of this initial interpretation. In contrast, in conditions where preferences based on noun animacy and topicality contradict one another, as in sentence Examples 3 and 4, readers postpone assigning grammatical roles until they read the disambiguating auxiliary verb or the past participle, leading to no processing difficulties regardless of word order.

PRESENT STUDY

Using sentences similar to those employed by Mak et al. (2006), the present study explores whether German L2 learners of Dutch use noun animacy and topicality to incrementally assign grammatical roles when reading temporarily ambiguous subject and object RCs in Dutch. If the L2 learners rely on both noun animacy and topicality to assign grammatical roles while reading the target sentences, then reading times at the critical regions should be longest on object RCs containing an inanimate subject, as has been found in previous monolingual research (e.g., Mak et al., 2002, 2006; Traxler et al., 2002, 2005). If, however, the L2 learners rely *only* on semantic information and noun animacy to assign grammatical roles, then reading times at the disambiguating region should be longer on sentences containing an inanimate subject, regardless of word order. In contrast, if the L2 learners do not use either type of information to assign grammatical roles prior to the disambiguating region, then there should be little or no evidence of on-line reanalysis at the disambiguating auxiliary verb or the past participle (cf. Havik

Table 1. *Second language (L2) learners' biographical information and results of proficiency measures*

L2 Learners	Age (years)	Age of First Exposure (years)	Proficiency Scores (%)	Self-Reported Proficiency Scores[a]
Mean	22.9	19.2	79.3	23.2
Range	19–31	15–24	61–95	19–27
SD	3.1	2.1	8.9	2.5

[a]Out of 30.

et al., 2009). Finally, by placing the auxiliary verb before the past participle (*Voor de kinderen is de clown, die de taarten heeft gegooid* . . . "For the children is the clown that the pies has thrown . . ."), as opposed to after the past participle, as was done by Mak et al. (2006), the present study also assesses whether L2 learners use verb-agreement information to disambiguate temporarily ambiguous sentences independent of the lexical–semantic information provided by the past participle.

METHOD

Participants

Twenty German L2 learners of Dutch (17 women) and 29 Dutch native speakers (24 women) participated in the experiment and were paid a small fee. All participants were recruited from the Radboud University, Nijmegen, and all had normal or corrected to normal vision. Even though the L2 learners had passed a university entrance exam that allowed them to follow university courses in Dutch, they undertook a Dutch cloze test containing 60 gaps to provide an additional measure of L2 proficiency. The L2 learners also filled out a language background questionnaire to elicit information about their language use, and self-rate their proficiency in Dutch on a scale from 0 to 5 (0 = *no proficiency*, 5 = *highly proficient*) in reading, writing, speaking, pronunciation, spelling, and grammar to give a total possible maximum score of 30. The L2 learners' biographical data and proficiency test results are shown in Table 1.

The learners reported experience with languages other than German and Dutch (French, English), but none reported that they were early bilinguals. Furthermore, their self-ratings of L2 proficiency in Dutch were higher than their self-ratings for any other L2, indicating that they all considered Dutch to be their dominant L2.[3]

Materials

Twenty-four experimental RC constructions were adopted from those used by Mak et al. (2006) so as to include only vocabulary items that would be familiar to the L2 participants.[4] All target sentences contained one animate NP and one

inanimate NP. One of these nouns was singular and one was plural, such that the target sentences were ambiguous until number information on the auxiliary verb determined their grammatical role. In half of the target items, the animate noun was singular and the inanimate noun was plural and in half of the target items this pattern was reversed, thus eliminating any potential confound between animacy and number information. It is important that, unlike the original sentences used by Mak et al. (2006), the auxiliary verb appeared prior to the past participle, such that participants encountered the disambiguating syntactic information before reading the lexical verb. Although less preferred overall, both auxiliary–past participle and past participle–auxiliary verb orders are common and licit structures in Dutch (Geerts, Haeseryn, de Rooij, & van den Toorn, 1984; Vandeweghe, 2000).

6. Voor de kinderen is de clown, die de taarten heeft gegooid, het hoogtepunt van de voorstelling. (SubjRC, animate subject)
   For the children is the clown_{SG} that the pies_{PL} has_{SG} thrown the highlight of the performance
   "For the children the clown, that threw the pies, was the highlight of the performance."
7. Voor de kinderen zijn de taarten, die de clown heeft gegooid, het hoogtepunt van de voorstelling. (ObjRC, animate subject)
   For the children are the pies_{PL} that the clown_{SG} has_{SG} thrown the highlight of the performance
   "For the children the pies, that the clown threw, were the highlight of the performance."
8. Voor de kinderen zijn de taarten, die de clown hebben geraakt, het hoogtepunt van de voorstelling. (SubjRC, inanimate subject)
   For the children are the pies_{PL} that the clown_{SG} have_{PL} hit the highlight of the performance
   "For the children the pies, that hit the clown, were the highlight of the performance."
9. Voor de kinderen is de clown, die de taarten hebben geraakt, het hoogtepunt van de voorstelling. (ObjRC, inanimate subject)
   For the children is the clown_{SG} that the pies_{PL} have_{PL} hit the highlight of the performance
   "For the children the clown, that the pies hit, was the highlight of the performance."

Thus, the two variables under investigation were clause type (SubjRC vs. ObjRC) and animacy (animate subject vs. inanimate subject). The mean length of the animate nouns was 7.96 letters and the mean length of the inanimate nouns was 7.67, a difference that was not statistically significant, $t\,(23) = 0.43$, $p = .669$. The mean log frequency from the Dutch CELEX database (Baayen, Piepenbrock, & Gulikers, 1995) for the animate and inanimate nouns was also comparable (animate nouns: $M = 1.16$; inanimate nouns: $M = 0.99$), $t\,(23) = 0.73$, $p = .471$. The mean length of the past participles in the animate-subject conditions was 8.33 letters compared to a mean length of 9.29 letters for the inanimate-subject conditions, a difference that was not statistically significant, $t\,(23) = 1.65$, $p = .113$. However, there was a significant difference in the mean log frequency of the past participles, $t\,(23) = 2.91$, $p < .01$, because, on average, the verbs used in the animate-subject conditions were more frequent ($M = 1.55$) than those used in the inanimate-subject conditions ($M = 1.19$). Similar to the original target sentences

used by Mak et al. (2006), this difference in frequency stems from the nature of the manipulation of subject animacy. In relying on nouns that could only be interpreted as inanimate entities (in contrast to nouns like *organization*), the choice of possible verbs was limited, especially given the added consideration that the target words should be familiar to the L2 learners. Although this difference limits the ability to interpret any main effect of animacy from the past participle onward, it should not impact the interpretation of any effects prior to the past participle. Of more importance, it should not limit the ability to interpret any significant interactions between animacy and word order, because the crucial comparison would be between subject and object RCs within the animate-subject and within the inanimate-subject conditions, which is a comparison that could not be explained by differences in the relative frequency of the past participles themselves.

The 24 target sentences were split into four lists, such that every participant saw 6 sentences in each condition, but no one sentence more than once. These 24 target sentences were then presented in a pseudorandomized order along with 60 filler items.

Tasks and procedure

Self-paced reading task. Each participant was tested individually and sat in a dedicated experiment booth. During the self-paced reading task, the participants sat approximately 60 cm in front of a computer screen on which the experimental sentences were displayed, one word at a time. Each word appeared in the center of the screen and the participant pushed a button on a push-button box to bring up the next word, which replaced the former in the center of the screen. The final word of each sentence was indicated by a full stop. To keep participants on task, a verification statement requiring either a "yes" or a "no" response, equally distributed among all items, was presented after each of the experimental items and after half of the filler items (e.g., *De kinderen zijn bij een voorstelling.* "The children are at a performance."). These verification statements never probed the experimental manipulation, namely, the subject–object roles of the ambiguous NPs. After each item (and verification statement if present) the participant pushed a button to bring up the next sentence and the participant was able to rest between trials if they wished to do so.

Acceptability judgment task. After completing the self-paced reading task, all participants completed an acceptability judgment task to measure their sensitivity to the experimental manipulations in an off-line task. Participants were prompted to rate sentences on a 1–6 scale (1 = *least acceptable*, 6 = *most acceptable*). Exactly the same experimental and filler items were used in both the self-paced reading and the acceptability judgment task, except that in the latter, five additional filler items were included that involved ungrammaticalities achieved via the wrong number agreement between the subject and the verb (e.g., **Linda* ***komen*** *deze winter naar Nederland om te schaatsen op het ijs en te wandelen in de sneeuw* "*Linda come this winter to The Netherlands to skate on the ice and to hike in the snow"). These items should be given a very low acceptability rating and were included so that we could select only those L2 learners who would be able to detect

Table 2. *Mean acceptability judgments (standard deviations)*

	Animate Subject		Inanimate Subject	
	SubjRC	ObjRC	SubjRC	ObjRC
L2 learners	4.93 (0.71)	5.02 (0.86)	4.98 (0.77)	4.08 (0.98)
Dutch native speakers	4.51 (0.98)	4.1 (1.60)	4.34 (0.72)	3.23 (1.10)

Note: Maximum score is 6, with 1 = *least acceptable* and 6 = *most acceptable*. SubjRC, subject relative clause; ObjRC, object relative clause; L2, second language.

number-agreement violations, given that this was the method of disambiguation to be used in the self-paced reading task.

RESULTS

Accuracy scores on the verification statements following the experimental items from the self-paced reading task were very high overall, with the L2 learners scoring 91.7% ($SD = 7.5$) and the native speakers 91.5% ($SD = 8.4$), and no significant difference between the two groups' scores, $t\,(47) = 0.61$, $p = .95$. This indicates that the participants paid attention during the self-paced reading task and were able to comprehend the target sentences.

The judgment data from the acceptability judgment task and the reading time data from the self-paced reading task were subjected to the same analysis: an analysis of variance (ANOVA) with the within-subjects factors clause type (SubjRC vs. ObjRC) and animacy (animate subject vs. inanimate subject), and the between-participants factor group (L2 learners of Dutch vs. Dutch native speakers), which was treated as a within-items factor in the items analyses. Although all participants undertook the judgment task after the self-paced reading task, the results of the former are presented first for ease of exposition.

Acceptability judgments

Table 2 shows the mean acceptability ratings given to the experimental items in each of the four conditions. The pattern of judgments was similar across the two groups (the factor group did not interact with any other factor, all ps $> .06$), but the native Dutch group was harsher in their judgments overall than the L2 learners, as indicated by a main effect of group, $F_1\,(1, 47) = 13.28$, $p < .01$, partial $\eta^2 = 0.22$; $F_2\,(1, 23) = 29.35$, $p < .001$; partial $\eta^2 = 0.56$.

There was a main effect of clause type, $F_1\,(1, 47) = 42.41$, $p < .001$, partial $\eta^2 = 0.47$; $F_2\,(1, 23) = 27.38$, $p < .001$, partial $\eta^2 = 0.54$, because both groups found the subject-relative conditions more acceptable than the object-relative conditions overall. There was also a main effect of animacy, $F_1\,(1, 47) = 9.66$, $p < .01$,

partial $\eta^2 = 0.14$; F_2 (1, 23) = 30.23, $p < .001$, partial $\eta^2 = 0.57$, because, overall, items with animate subjects were rated more acceptable than those with inanimate subjects. There was a significant interaction between animacy and clause type, F_1 (1, 47) = 12.45, $p < .01$, partial $\eta^2 = 0.21$; F_2 (1, 23) = 40.64, $p < .001$, partial $\eta^2 = 0.64$. Our *t* test comparisons found that this interaction was because the ObjRC-inanimate subject condition elicited the lowest acceptability ratings ($M = 3.57$), differing significantly from the ObjRC-animate subject condition ($M = 4.47$), t_1 (48) = −3.56, $p < .01$; t_2 (23) = −5.83, $p < .001$, from the SubjRC-inanimate subject condition ($M = 4.59$), t_1 (48) = −6.32, $p < .001$; t_2 (23) = −7.06, $p < .001$, and from the SubjRC-animate subject condition ($M = 4.93$), t_1 (48) = −5.93, $p < .001$; t_2 (23) = −7.12, $p < .001$. In other words, the L2 learners patterned very similarly to the native speakers, showing a general dispreference for object RCs, unless the subject was animate, which then dramatically improved the rating of the sentence.

Self-paced reading study

We analyzed three consecutive segments in the self-paced reading study: the critical auxiliary verb (aux), where syntactic disambiguation takes place via number information; the lexical verb (aux+1), where semantic information indicates the NPs' likely grammatical roles; and the immediately following word (aux+2) to pick up any delayed effects, as has been observed in other reading time studies, especially for L2 learners (e.g., Marinis et al., 2005). Before performing the statistical analyses, reading times above 3 s were removed (affecting 1.8% of the L2 learner and 1.3% of the native Dutch data) and individual reading times beyond 2 *SD* of each individual's mean per condition, affecting 0.79% of the L2 learner and 1.09% of the native Dutch data. Figure 1 and Figure 2 show the L2 learners' and native speakers' mean reading times across the three critical segments, following this procedure to remove outlying reading times.

On the first critical segment, the auxiliary verb where syntactic disambiguation takes place, there was a main effect of animacy, F_1 (1, 47) = 4.96, $p < .05$, partial $\eta^2 = 0.10$; F_2 (1, 23) = 2.84, $p = .106$, partial $\eta^2 = 0.11$, and group, F_1 (1, 47) = 9.47, $p < .01$, partial $\eta^2 = 0.17$; F_2 (1, 23) = 10.55, $p < .001$, partial $\eta^2 = 0.83$, and a significant interaction between animacy and group, F_1 (1, 47) = 4.50, $p < .04$, partial $\eta^2 = 0.09$; F_2 (1, 23) = 4.99, $p < .05$, partial $\eta^2 = 0.18$. This interaction appeared to be driven by differences in the L2 learners' reading times, in that the inanimate-subject conditions elicited longer reading times overall ($M = 679$ ms) than the animate-subject conditions ($M = 600$ ms), whereas no such effect was visible in the native speakers' reading times (434 vs. 432 ms). There was no main effect of clause type ($ps > .2$) nor interactions between clause type and either group ($ps > .2$) or animacy ($ps > .07$). However, on this segment there was a significant three-way interaction between animacy, clause type, and group in the participant analysis, F_1 (1, 47) = 4.18, $p < .05$; partial $\eta^2 = 0.08$; F_2 (1, 23) = 2.68, $p = .12$, partial $\eta^2 = 0.10$. To explore the significant three-way interaction ANOVAs and *t* tests were conducted within each group. For the native speakers there were no significant effects (all $ps > .2$). For the L2 learners there was no

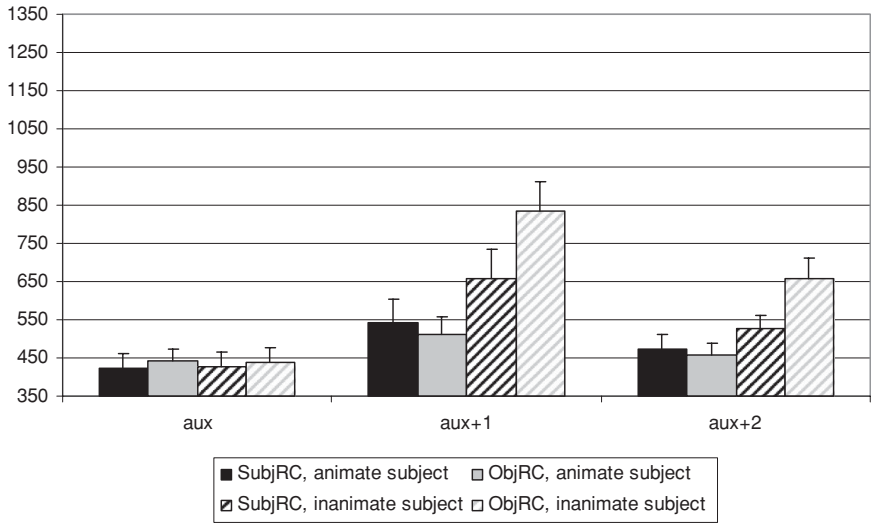

Figure 1. Dutch native speakers' ($n = 29$) mean reading times (ms) on the three critical segments following syntactic disambiguation.

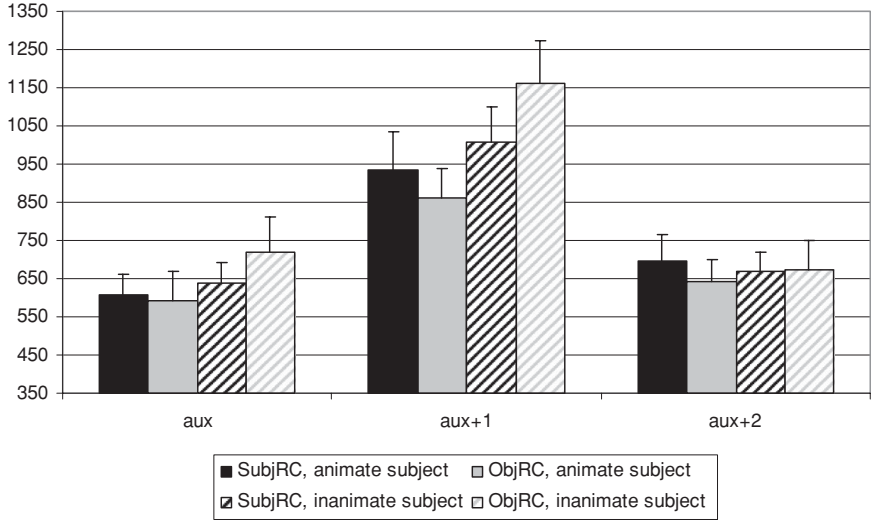

Figure 2. Second language learners' ($n = 20$) mean reading times (ms) on the three critical segments following syntactic disambiguation.

main effect of clause type ($ps > .2$), but there was a main effect of animacy, F_1 (1, 19) = 4.89, $p < .05$, partial $\eta^2 = 0.20$; F_2 (1, 23) = 4.88, $p < .04$, partial $\eta^2 = 0.18$; and the interaction between clause type and animacy was marginally significant by participants, F_1 (1, 19) = 3.42, $p = .08$, partial $\eta^2 = 0.15$; F_2 (1, 23) = 1.53,

$p = .23$, partial $\eta^2 = 0.06$. Among the L2 learners, *t* tests did not reveal any significant differences between the SubjRC-animate subject and the ObjRC-animate subject condition (*p*s > .6) or between the SubjRC-inanimate subject and the ObjRC-inanimate subject condition (*p*s > .2). However, *t* tests comparing clause type as a function of animacy showed that the animacy effect was stronger between the two ObjRC conditions, animate subject versus inanimate subject, t_1 (19) = −2.52, $p < .05$; t_2 (23) = −2.10, $p < .05$, than the two SubjRC conditions (*p*s > .1). Therefore, at the point of disambiguation, only the L2 learners slowed down when reading the conditions with inanimate subjects in general. Furthermore, only the ObjRC-inanimate subject condition appeared to elicit a significant processing cost relative to the SubjRC-inanimate subject condition. No differences according to clause type were apparent when the subject of the RC was animate.

In the next segment (aux+1), the lexical verb was presented and semantic information was available to indicate the grammatical roles of the ambiguous NPs. The pattern in the two groups' reading times did not differ because there was no interaction between group and any other factor (*p*s > .5), although the learners were slower overall, as reflected by a main effect of group, F_1 (1, 47) = 12.93, $p < .001$, partial $\eta^2 = 0.22$; F_2 (1, 23) = 150.55, $p < .001$, partial $\eta^2 = 0.87$. There was also a main effect of clause type in the participant analysis, F_1 (1, 47) = 4.20, $p < .05$, partial $\eta^2 = 0.08$; F_2 (1, 23) = 2.13, $p = .16$, partial $\eta^2 = 0.08$; a main effect of animacy, F_1 (1, 47) = 34.06, $p < .001$, partial $\eta^2 = 0.42$; F_2 (1, 23) = 32.95, $p < .0001$, partial $\eta^2 = 0.59$; and an interaction between clause type and animacy, F_1 (1, 47) = 16.17, $p < .001$, partial $\eta^2 = 0.26$; F_2 (1, 23) = 4.47, $p < .05$, partial $\eta^2 = 0.16$. The interaction occurred because, in both subject and object RCs, sentences with an animate subject were read more quickly than those with an inanimate subject: SubjRC-animate subject (*M* = 704 ms) versus SubjRC-inanimate subject (*M* = 801 ms): t_1 (48) = −2.45, $p < .05$; t_2 (23) = −2.20, $p < .05$; ObjRC-animate subject (*M* = 653 ms) versus ObjRC-inanimate subject (*M* = 969 ms): t_1 (48) = −6.45, $p < .001$; t_2 (23) = −5.21, $p < .001$; but the effect of clause type was evident only in the comparison between the two inanimate conditions, t_1 (48) = −4.45, $p < .001$; t_2 (23) = −2.49, $p < .05$. The comparison between the two animate-subject conditions was not significant (*p*s > .1). Therefore, the pattern observed on the previous segment for the L2 learners alone was now in evidence for both groups: the conditions with inanimate subjects took longer to read overall, with the greatest processing cost observed in the ObjRC-inanimate subject condition, and no difference in processing costs in the two animate-subject conditions, regardless of clause type.

The next segment (aux+2) was again read more slowly by the L2 learners, as indicated by a main effect of group, F_1 (1, 47) = 5.33, $p < .05$, partial $\eta^2 = 0.10$; F_2 (1, 23) = 37.32, $p < .001$, partial $\eta^2 = 0.62$. There was also a main effect of animacy, F_1 (1, 47) = 7.88, $p < .01$, partial $\eta^2 = 0.14$; F_2 (1, 23) = 7.37, $p < .05$, partial $\eta^2 = 0.24$; and an interaction between animacy and group, F_1 (1, 47) = 7.48, $p < .01$, partial $\eta^2 = 0.14$; F_2 (1, 23) = 6.52, $p < .05$, partial $\eta^2 = 0.22$, because the native speakers read the items with animate subjects more quickly (*M* = 465 ms) than those with inanimate subjects (*M* = 593 ms); but there was no difference in the L2 learners' data as a function of animacy (670 vs. 671 ms). There was no main effect of clause type (*p*s > .5) or an interaction between clause

Table 3. *Mean reading times (ms) for antecedent nouns and RC-internal nouns (standard deviations)*

	Native Speakers	L2 Learners
Antecedent noun		
Animate	510	834
	(248)	(338)
Inanimate	499	908
	(221)	(386)
RC-internal noun		
Animate	468	710
	(222)	(267)
Inanimate	484	690
	(261)	(263)

Note: RC, relative clause; L2, second language.

type and group ($ps > .07$), but there was a two-way interaction between animacy and clause type, significant by participants, F_1 (1, 47) = 5.32, $p < .05$, partial $\eta^2 = 0.22$; F_2 (1, 23) = 2.42, $p = .13$, partial $\eta^2 = 0.10$, which appeared to be driven by longer reading times for the ObjRC-inanimate subject condition ($M =$ 665 ms) compared to both the ObjRC-animate condition ($M = 533$ ms): t_1 (48) = 3.76, $p < .001$; t_2 (23) = −3.16, $p < .01$, and the SubjRC-inanimate subject condition in the by-participants analysis ($M = 584$ ms): t_1 (48) = −2.39, $p < .05$; t_2 (23) = −2.00, $p = .057$. Although there was no significant three-way interaction among animacy, clause type, and group ($ps > .3$), a visual inspection of Figure 1 and Figure 2 suggest that this Animacy × Clause Type interaction was driven predominately by the Dutch native speakers' reading times. In sum, the effects visible on earlier segments were no longer visible in the L2 learners' data, and were weakened overall for the native speakers, although they still showed longer reading times for the dispreferred ObjRC-inanimate subject condition.

Post hoc analysis. One of the research questions of the current study was whether animacy information would be used on-line by the L2 learners to commit to an analysis. The above results show that indeed this is the case. However, because the animacy information was available on the NPs before their grammatical roles became evident at the auxiliary verb, we examined the participants' reading times (Table 3) in a post hoc analysis to see whether any differences according to the animacy factor (animate vs. inanimate) appeared prior to disambiguation. For the purposes of these analyses, reading times on the antecedent nouns[5] and RC-internal nouns[6] were collapsed across clause type because whether the resulting sentence was a subject or an object RC was not apparent to the reader until the auxiliary verb.

Two separate analyses were run according to the linear position of the nouns (antecedent noun vs. RC-internal noun), with the within-participants factor animacy (animate noun vs. inanimate noun) and the between-participants factor

group (L2 learners of Dutch vs. Dutch native speakers), which was treated as a within-participants factor in the items analysis. Apart from a main effect of group for both analyses, antecedent nouns: F_1 (1, 47) = 19.16, $p < .0001$, partial $\eta^2 = 0.29$; F_2 (1, 23) = 101.11, $p < .001$, partial $\eta^2 = 0.82$; RC-internal nouns: F_1 (1, 47) = 9.81, $p < .0001$, partial $\eta^2 = 0.17$; F_2 (1, 23) = 619.85, $p < .001$, partial $\eta^2 = 0.96$, the only effect was found in the comparison between the two antecedent nouns, where there was an interaction between group and animacy in the participant analysis, antecedent noun: F_1 (1, 47) = 6.36, $p < .05$, partial $\eta^2 = 0.12$; F_2 (1, 23) = 1.51, $p = .23$, partial $\eta^2 = 0.06$; RC-internal noun: ps > .1. There was no difference in the native speakers' reading times on the two antecedent nouns, but the L2 learners found the inanimate antecedent noun more difficult to process than the animate antecedent noun, t_1 (19) = −2.24, $p < .05$; t_2 (23) = −1.24, $p = .229$. This indicates that the L2 learners were indeed sensitive to the animacy of the NPs in the current experiment, and that they may have had a stronger preference than the native speakers for the antecedent NP to be animate.

DISCUSSION

The L2 learners of Dutch and the Dutch native speakers performed similarly in the off-line acceptability judgment task. Subject RCs were preferred overall for both groups, as were the target sentences with animate subjects, compared to those with inanimate subjects. Both groups found object RCs with an inanimate subject the least acceptable. Thus, like native speakers, the L2 learners' preference for subject over object RCs disappeared when the subject was animate.

In the self-paced reading task, the ObjRC-inanimate subject condition elicited the longest reading times for both the L2 learners and the Dutch native speakers. However, there was evidence to suggest this effect appeared immediately at the disambiguating auxiliary verb among the L2 learners, whereas it was delayed until the next segment among the native speakers.

Following disambiguation the effect was qualitatively similar in both groups and in line both with the results of the acceptability judgment task and with previously reported results with Dutch native speakers (Mak et al., 2006). That is, no reading time differences were observed between subject and object RCs when the subject was animate and the object was inanimate.

Prior to disambiguation, the two groups' reading time patterns differed, such that only the L2 learners showed a processing cost difference in the region of the ambiguous NPs. Specifically, inanimate antecedent NPs were read more slowly than animate antecedent NPs. No differences were observed in processing cost between the animate and inanimate RC-internal NPs for either group.

We now discuss these findings in relation to the predictions based on earlier studies and the research questions presented above.

The interaction of lexical–semantic and structural information in on-line processing

The results of an earlier study with German L2 learners of Dutch (Havik et al., 2009) showed that unlike native speakers of both the learners' L1 (German) and

their L2 (Dutch), processing object-resolved RCs did not elicit higher processing costs in comparison to subject-resolved RCs when sentences were fully ambiguous until morphosyntactic information on the auxiliary verb was encountered. This lack of visible reanalysis effects suggested to the authors that the L2 learners did not incrementally assign subject and object roles to the ambiguous NPs prior to disambiguation at the auxiliary verb, even though, like native speakers, they appeared to have a preference for subject-first constructions off-line. In light of other on-line reading studies that have shown that, compared to native speakers, L2 learners may rely more on lexical–semantic and less on purely structural information when making on-line processing decisions (e.g., Felser et al., 2003; Papadopoulou & Clahsen, 2003), the question raised in the present study was whether L2 learners *never* make such on-line structural commitments when processing subject–object ambiguities or whether they would do so when lexical–semantic information is available on which to base an analysis.

In contrast to the L2 learners in Havik et al. (2009), the L2 learners in the current study showed an on-line processing disadvantage following disambiguation in object versus subject RCs, which is in line with their off-line preferences. Given that the participants were sampled from the same pool as those in the earlier study and were of a comparable age and educational background, this suggests that it is unlikely that the background of the L2 learners was responsible for this difference in performance. It is instead more likely that the presence of semantic information, in the form of noun animacy, underlies the observed effect.

However, the L2 learners did not prefer the subject-resolved sentences overall. The preference for subject RCs disappeared in sentences where the subject was animate and the object was inanimate (SubjRC-inanimate subject, ObjRC-inanimate subject). At the same time, animacy alone did not drive the L2 learners to assign grammatical roles to the ambiguous NPs. If *only* animacy information enabled participants to assign grammatical roles to the ambiguous NPs in an incremental manner, then one would expect that the conditions containing an inanimate subject (SubjRC-inanimate subject, ObjRC-inanimate subject) would have been more difficult to process at and beyond disambiguation, regardless of word order. That is, if participants constructed an object RC on the basis of animacy alone, then reanalysis effects would have been apparent in the SubjRC-inanimate condition, and this was not the case. Instead, mirroring findings reported by Mak et al. (2006), the pattern of reading times in the disambiguating region and beyond was the same for the L2 learners and the native speakers, with the ObjRC-inanimate subject condition eliciting the longest reading times of all.

This lack of reanalysis effects in the ObjRC-animate subject condition is not predicted by a syntax-first account of the human parsing mechanism, such as the active filler strategy (e.g., Frazier, 1987), because such an account assumes that a subject RC is always constructed, independent of semantic information. Similarly, working memory based accounts that would predict greater difficulty on object RCs because of the memory load costs associated with constructing object RCs (e.g., Gibson, 1998), cannot account for the present findings.

As hypothesized by Mak et al. (2006), our results support the possibility that for both the L2 learners and the Dutch native speakers, two interacting factors are at work when they process subject and object RCs in which the ambiguous NPs differ

in animacy: the topicality of the antecedent NP and noun animacy. When there is conflict between these two factors, as in SubjRC-inanimate subject and ObjRC-animate subject conditions, the assignment of grammatical roles is postponed. Grammatical role assignment takes place only when both topichood and animacy coincide, that is, when the antecedent NP is animate and the RC-internal NP is inanimate (i.e., SubjRC-animate subject and ObjRC-inanimate subject conditions). Although this is the correct assignment in the SubjRC-animate subject condition, leading to no need for reanalysis at the disambiguating region, reanalysis must take place in the ObjRC-inanimate subject condition at the point of disambiguation. As such, the present results favor a parsing model in which multiple constraints, including discourse-level and lexical–semantic expectations, influence on-line parsing commitments and the relative difficulty both native speakers and L2 learners encounter when processing structures like object RCs, even when such structures should be more difficult based solely on syntactic criteria (cf. Gibson, Desmet, Grodner, Watson, & Ko, 2005; Gordon, Hendrick, & Johnson, 2004; Kaan, 2001).

The interaction between animacy and clause type evidenced here could also be accounted for by the tuning hypothesis (e.g., Desmet, De Baecke, Drieghe, Brysbaert, & Vonk, 2006). Specifically, although RCs with animate and inanimate antecedents are equally frequent in both Dutch and German, inanimate antecedents are more often followed by object RCs, whereas animate antecedents are more often followed by subject RCs (Mak et al., 2002). This possibility is reinforced by the relatively low acceptability ratings for all of the target sentences, and especially the ObjRC-inanimate subject sentences. L2 learners, in particular, may be sensitive to the statistical frequency with which certain constructions occur in the L2 (e.g., Dussias & Sagarra, 2007), such that a tuning account of the current results cannot be ruled out. Regardless of the ultimate root of this interaction, what is important is that the L2 learners in the present study were able to use lexical–semantic information in conjunction with a more structurally based processing strategy favoring subject first constructions and, in so doing, closely approximate the strategies demonstrated by native speakers.

Further evidence for the L2 learners' sensitivity to the interaction between topichood and animacy is observed in their reading times on the antecedent NP, in which reading times were longer for inanimate antecedent nouns compared to animate antecedent nouns. Working under the assumption that there is a general preference to build a subject RC based on topichood and that animate entities make better subjects, the interaction of these two factors would have led to an overall preference for animate antecedent nouns as the L2 learners anticipated the subsequent RC (cf. MacWhinney, 2005; Weckerly & Kutas, 1999). In contrast to the L2 learners and Dutch native speaker results reported by Mak et al. (2006), the native speakers in the present study exhibited no such preference for animate antecedents overall. One possible explanation for this difference between the L2 learners and the Dutch native speakers in the present study is that the native speakers exhibited no measurable sign of difficulty at earlier points in the sentence because of overall reading speed. Alternatively, the presence of an animacy effect at the antecedent noun for the L2 learners may signal that L2 learners are more sensitive overall to such semantic factors in their on-line processing compared to native speakers (e.g., Roberts & Felser, 2010).[7]

Resolving ambiguity without the lexical verb

Although the overall reading time effects were similar between the L2 learners and the Dutch native speakers, exactly where the first sign of on-line reanalysis appeared was different for the two groups. Specifically, there was evidence to suggest that the interaction between animacy and clause type began to have an impact immediately at the disambiguating auxiliary among the L2 learners, whereas the native speakers only showed this effect at the next segment, on the lexical verb, once semantic information was available for use in disambiguation. It is certainly possible that earlier processing difficulties among the Dutch native speakers were camouflaged by overall reading speed, although an ANOVA with mean reading speed as a covariate factor failed to find any significant effects. A second possibility is that the preferred word order in Dutch is to place the auxiliary verb after the past participle (cf. Geerts et al., 1984; Vandeweghe, 2000), and this is the only licit order in German.[8] Thus, it is possible that encountering the auxiliary verb prior to the past participle may have led the L2 learners to pay more attention to the auxiliary than they might have otherwise, whereas the Dutch native speakers may have processed the verbal cluster all together at the end of the RC.[9]

The finding that the L2 learners exhibited longer reading times on ObjRC-inanimate subject sentences immediately at the disambiguating auxiliary is striking because it appears that, under the right circumstances, L2 learners not only apply the same parsing strategies as native speakers but also can make use of morphosyntactic information alone to disambiguate ambiguous material. Furthermore, they did so even though their reading times overall were significantly slower than the Dutch native speakers, suggesting that their L2 Dutch had not yet reached asymptote at the time of testing. To the best of our knowledge, this is the first study to find that L2 learners can make on-line decisions when reading temporarily ambiguous sentences in the absence of the lexical verb, as well as the first study that has found an effect immediately at the auxiliary verb in the processing of RCs in Dutch. As such, it calls into question a strong version of a verb-driven parsing strategy, as proposed by Clahsen and Felser (2006), because the present results suggest that in the presence of sufficient lexical–semantic information, L2 learners can make early parsing commitments and show signs of on-line reanalysis independently of the lexical verb.

CONCLUSION

The results of the current study show that L2 learners parse ambiguous subject and object RCs like native speakers in the presence of semantic information, operationalized here via the animacy of the ambiguous NPs. Furthermore, once pushed to make an on-line commitment to a subject or object-first interpretation, L2 learners are able to use morphosyntactic information in the form of number agreement on the auxiliary verb to disambiguate temporarily ambiguous sentences, instead of waiting until the subsequent past participle forces disambiguation via semantic information and plausibility constraints alone. As such, the present study highlights ways in which lexical and syntactic information interact during even the early stages of on-line processing among both L2 learners and native speakers

and, when sufficient semantic information is available, L2 learners have the ability to parse L2 sentences in ways that are remarkably similar to native speakers of a language.

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NOTES

1. Within the framework of the competition model (for a recent review, see MacWhinney, 2005) the use of cues such as "animacy" in sentence interpretation has been extensively investigated. However, we do not use this framework in the context of the current study, because our question involves how readers put various types of information to use in real time, rather than how they might use various (competing) cues for interpretation.
2. Similar results have also been reported for English using event-related potentials and neuroimaging techniques (e.g., Caplan, Stanczak, & Waters, 2008; Chen, West, Waters, & Caplan, 2006; Kuperberg, Kreher, Sitnikova, Caplan, & Holcomb, 2007; Weckerly & Kutas, 1999).
3. Participants also completed a Dutch version of the Daneman and Carpenter Reading Span Task (Daneman & Carpenter, 1980). The mean working memory span score for the Dutch natives was 90.7 ($SD = 7.6$) and for the L2 learners it was 86.0 ($SD = 8.5$). As a group, the L2 learners had a relatively high working memory span, but their scores were still lower overall than the native speakers, although not significantly so, $U\,(48) = -1.87$, $p = .062$. Because working memory span scores did not affect performance on either the judgment or the self-paced reading task for either the L2 learners of Dutch or the Dutch native speakers, the results from this task will not be discussed further.
4. A complete list of stimuli is available from the first author upon request.
5. We are aware that technically the antecedent NP is not an antecedent at this point, but we will keep this label for ease of exposition.
6. This analysis involves only reading times on the nouns themselves (not on the determiners).
7. One reviewer raised the possibility that the effect of animacy on the antecedent noun among the L2 learners could reflect that the L2 learners were less familiar with the inanimate nouns than the animate nouns. Although this is possible, one would then expect to see a similar animacy effect at the RC-internal noun, because the same animate and inanimate nouns were used in each condition. However, this was not the case.
8. Although in the geographic region in which the present study took place, the auxiliary-past participle order is the more common word order.

9. We thank an anonymous reviewer for pointing out this possibility.

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