Definiteness matters as a discourse cue in L1 and L2 processing of relative clauses

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This study explores how syntactic and discourse-based parsing principles direct English relative clause attachment preferences. Forty-nine highly advanced L1-Persian L2-English and thirty-six English native speakers completed a self-paced reading task involving temporarily ambiguous relative clauses that were semantically associated with either the first or the second noun phrase (NP) in a complex NP (NP1–of–NP2) (*The resident called the nurse*$_{\text{NP1}}$ *of the patient*$_{\text{NP2}}$ *who was injecting penicillin/coughing severely*). We manipulated the definiteness of the antecedent (*a/the nurse* & *a/the patient*) to examine the extent to which a discourse-based definiteness principle — which motivates attachment to a definite NP — impacts attachment preferences. The results showed no L1/L2 differences, and both groups preferred an NP2 interpretation in relative clauses with a definite antecedent but no strong preference in relative clauses with an indefinite antecedent. The findings highlight the significance of definiteness and cast doubt on the hypothesis that L1 and L2 processing are fundamentally different.

Keywords: relative clause disambiguation, L1-L2 differences, shallow structuring, discourse cues

1. Introduction

Successful language comprehension requires, among other things, attending to different information sources, including lexical semantic, syntactic, and discourse-based information. Keeping track of these different types of information can be difficult, even for native (L1) language users, but especially for second language (L2) users, and potential differences between L1 and L2 comprehension are widely debated (Clahsen & Felser 2006, 2018; Cunnings 2017; Hopp 2014). For illustration, consider (1), which is an instance of the classic relative clause

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(RC) ambiguity that has featured widely in the psycholinguistic literature (see, e.g., Cheng et al. 2021; Clahsen & Felser 2006; Goad et al. 2021; Hopp 2014).

(1) *The resident called the nurse* $_{NP1}$ *of the patient*$_{NP2}$ *who was injecting penicillin/coughing severely.*

In (1), *who was* is temporarily ambiguous in that it can modify either the first noun phrase (NP) *the nurse* or the second NP *the patient*. That is, both NP1 and NP2 can syntactically function as the antecedent of the RC. It is not until the reader reads the content of the RC that the ambiguity is semantically resolved either towards an NP1 interpretation (*the nurse injecting penicillin*) or an NP2 interpretation (*the patient coughing severely*). Preference for interpreting the RC as modifying NP1 is dubbed as NP1 attachment and preference for interpreting the RC as modifying NP2 is referred to as NP2 attachment.

A number of studies have found that L1-English readers preferentially attach ambiguous RCs to NP2 (Cuetos & Mitchell 1988; Frazier 1978; Frazier & Clifton 1996). This follows from the universal late closure (Frazier 1978) or recency principle (Gibson et al. 1996), according to which readers prefer to attach the incoming linguistic input to the phrase currently being processed, i.e. NP2.

However, the universality of NP2 attachment in English has been called into question with studies showing that in the presence of non-syntactic information, attachment preferences may be moderated to satisfy discourse-based constraints. For example, some studies have found that embedding ambiguous RCs in a context that creates an expectation for NP1 modification leads to NP1 attachment and presenting the ambiguous RC in a context that creates an expectation for NP2 modification leads to NP2 attachment (Crain & Steedman 1985; Pan et al. 2015; Solaimani et al. 2024). This is consistent with constraint-based models of parsing (see, e.g., Van Gompel et al. 2000; Warren & Gibson 2002), according to which both syntactic and non-syntactic information are used simultaneously during initial structure building. In addition, many studies have found a different attachment preference in languages other than English, such as in French (Dekydtspotter et al. 2008), Spanish (Cuetos & Mitchell 1988), and Persian (Arabmofrad & Marefat 2008), which display an NP1 preference. This further casts doubt on the universality of a recency principle to attach the ambiguous RC to NP2.

As for L2 processing, many previous studies have examined L1/L2 processing differences using RC ambiguities such as (1) (see, e.g., Cheng et al. 2021; Clahsen & Felser 2006, 2018; Cunnings 2017). On the one hand, according to the Shallow Structure Hypothesis (SSH; Clahsen & Felser, 2006, 2018), L2 readers are directed primarily by non-syntactic information such as discourse biases to interpret ambiguous RCs, in contrast to L1 readers who process these structures based on syntactically motivated principles such as recency. On the other hand, other researchers have shown that both L1 and L2 processing of RC ambiguities are affected by different types of information, including syntactic, lexical semantic, and discourse-based cues (Cunnings 2017; Solaimani et al. 2024). This view highlights that there is no fundamental difference between L1 and L2 processing, at least at an advanced proficiency level, in terms of the extent to which they are affected by different information sources.

It is important to note that in most previous studies on RC attachment preferences, both NP1 and NP2 were definite. Definite NPs typically refer to unique discourse entities that are familiar and identifiable to the reader(s) (Heim 1982), which aligns closely with the discourse function of restrictive RCs such as (1) above – to pick out a unique referent from among a possible set of referents in the discourse. Therefore, in ambiguous RCs such as (1) where both NP1 and NP2 are definite, a discourse-based strategy, which favours attachment to a definite NP to meet its uniqueness requirement (Heim 1982; Klein et al. 2013), does not differentially impact attachment to only one of the NPs.

As such, it is expected that a recency strategy dominates processing English RC ambiguities which are preceded by two definite NPs linked with *of* (NP1–of–NP2). This is indeed compatible with most previous studies reporting an NP2 preference in English, suggesting that a recency principle outweighs other parsing principles in RC disambiguation in cases where both NP1 and NP2 are definite (Van Gompel et al. 2000). However, it is possible that if the RC antecedent is an indefinite NP, while the competing NP is definite, attachment preferences are impacted based on the definiteness of the NPs. Specifically, while a recency principle favours NP2 attachment, a discourse-based principle may favour attachment to a definite NP1 to establish its uniqueness. Following previous research on RC disambiguation, we argue that the tendency to attach ambiguous restrictive RCs to a definite NP is motivated by a discourse-based principle (Klein et al. 2013), which we refer to as definiteness in the present study.

The present study reports a self-paced reading experiment to examine the role of definiteness in RC disambiguation, hypothesising that if attachment preferences are directed by both syntactic and discourse-based principles, temporarily ambiguous RCs in English with a definite antecedent should elicit an NP2 preference, as suggested by a recency principle. By contrast, this preference should be absent, or at least attenuated, in RC ambiguities with an indefinite antecedent. This is because indefinite NPs do not tend to refer to unique discourse entities (Klein et al. 2013), and as such, do not provide a match with the discourse function of restrictive RCs. In addition, this study reports data from both L1-English and highly advanced L1-Persian L2-English readers. Thus, this study not only provides novel insights on the role of definiteness in processing RC ambiguities but also examines the extent to which L1 and L2 processing of these structures are affected by different information sources.

2. Relative clause ambiguities in L2

Some studies examining L2 processing of RC ambiguities have reported null attachment, i.e. preference for neither NP1 nor NP2, even when the L1 has been reported to favour attachment to one of the NPs over the other (Papadopoulou & Clahsen 2003). This has led some researchers to argue that unlike L1 processing that involves attachment to either NP1 or NP2, L2 processing does not involve strong attachment preferences as it is not guided as much by syntactic principles such as recency (Felser 2019).

However, other studies have found that, given high proficiency, L2 readers converge on native-like RC attachment preferences (Fernández 1999; Frenck-Mestre 2002). For example, Frenck-Mestre (1997) recorded eye-movements while L1-English (NP2 language) and L1-Spanish (NP1 language) learners of L2 French (NP1 language) read French RC ambiguities. All participants were low-proficiency learners of L2 French (average self-ratings of overall proficiency at a level of 5 out of 10), and the results suggested that both Spanish and French readers preferred NP1 attachment, whereas English readers favoured NP2 attachment. According to Frenck-Mestre (1997), the readers transferred RC attachment preferences from their L1, Spanish readers favouring NP1 and English readers NP2 attachment. In a later study, however, Frenck-Mestre (2002) examined RC disambiguation in L2-French by highly proficient L1-English readers (self-ratings of overall proficiency at a level of 7 or higher out of 10) that enjoyed an average of 3 years immersion. The results suggested an NP1 attachment preference, the same pattern found in the L1-French group. Frenck-Mestre (2002) concluded that L2 readers may initially transfer attachment preferences from their L1 while reading RC ambiguities in L2, yet given sufficiently high proficiency, they converge on native-like processing preferences.

In addition, some previous studies have argued that in contrast to the L1 processing of RC ambiguities, L2 RC attachment preferences are variable based on the degree of modifiability of NP1 and NP2. According to the Referential Hypothesis (Crain & Steedman 1985), RC attachment is impacted by the expectation that one of the NPs is more likely to be modified than the other NP. Specifically, since restrictive RCs uniquely identify a discourse referent from among a set of referents introduced in the context, attachment to an NP that uniquely identifies a discourse referent is preferred to attachment to an NP that is associated with multiple discourse referents (Crain & Steedman 1985; Spivey & Tanenhaus 1998).

To examine the role of discourse-level information in L1 and L2 processing of RC ambiguities, Pan et al. (2015) used a self-paced reading task to investigate the impact of context on English RC attachment preferences by intermediate-to-advanced L1-German (NP1 language) and L1-Chinese (NP2 language) readers of L2-English. Half of their experimental sentences had context conditions that involved more than one referent for NP1 (NP1-supporting context), and the other half had context conditions that introduced more than one referent for NP2 (NP2-supporting context). According to Pan et al. (2015), their results showed that contextual manipulations influenced attachment preferences for the L2 group only, and unlike L1 readers, both L2 groups favoured NP1 attachment in an NP1-supporting context and NP2 attachment in an NP2-supporting context. Pan et al. (2015) interpreted their results in line with the SSH (Clahsen & Felser 2006), according to which L2 readers are more likely to recruit non-syntactic information in RC ambiguity resolution, in contrast to L1 readers.

However, the findings from Pan et al. (2015) should be interpreted with caution. First, an argument can be made that the L2 participants were not advanced enough to display native-like attachment preferences. Some studies have suggested that only highly advanced L2 participants might be capable of displaying native-like RC ambiguity resolution due to the additional processing load in L2 (Cheng et al. 2021; Frenck-Mestre 2002; Hopp 2006). In addition, Pan et al. (2015) reported a marginally significant interaction in the item analysis between attachment and context for the native controls ($F2(1,12) = 3.6$, $p = .08$) (Pan et al. 2015: 310). This suggests that RC attachment preferences by L1-English readers might have also been impacted by context biases, but this might have been statistically non-significant due to sample size issues.

In fact, in a larger sample replication, Solaimani et al. (2024) used the same materials as Pan et al.'s (2015) in a self-paced reading task to investigate L1 and L2 RC attachment preferences in English by L1-French, L1-Persian, and L1-English readers. The results showed that highly advanced L2 readers (regardless of L1) performed similarly to the L1-English readers, and RC attachment preferences were influenced by contextual manipulations for both L1 and L2 groups. In particular, contexts that created a bias to uniquely identify the referent for NP1 elicited an NP1-attached interpretation and contexts that created a bias towards NP2 attachment extracted an NP2-attached interpretation (2024).

It is important to note that most previous studies examining the impact of discourse-based information on RC attachment preferences embedded ambiguous RCs in different context conditions (Pan et al. 2015; Solaimani et al. 2024), namely contexts that introduced only one discourse referent for the RC antecedent, and contexts that introduced multiple referents. It is assumed that contexts with more than one referent for one of the NPs facilitates attachment to that NP in order to establish the uniqueness of the RC antecedent.

Extending this argument, it is also possible that since restrictive RCs serve the function of uniquely identifying the NP that they refer to, ambiguous RCs attach more strongly to a definite NP rather than an indefinite NP. This is because a definite NP that violates its uniqueness requirement disrupts comprehension (Cho 2017; Clifton & Ferreira 1989; Klein et al. 2013), and as such attaching ambiguous RCs such as (1) to a definite NP incurs less cost on the underlying processing mechanism. This is also compatible with accessibility hierarchies that place definite NPs higher on the hierarchy than indefinite NPs. According to different accessibility hierarchies, definite NPs are highly accessible compared to indefinite NPs, and as such, they are more likely to receive modification from an ambiguous RC. By contrast, indefinite NPs are more peripheral to the discourse and thus less accessible to serve as the antecedent of ambiguous RCs (Ariel 1990, 2001; Epstein 2002; Givón 1992). However, given that in previous studies investigating RC attachment preferences in context, both NP1 and NP2 were definite, their design does not allow to examine to what extent RC disambiguation is affected by the presence of multiple referents in the discourse as opposed to the definiteness of the RC antecedent.

3. Method

To bridge this gap, the present study examines the role of the definiteness of the RC antecedent in L1 and L2 processing of RC ambiguities. Ambiguous RCs provide an ideal test case to examine the impact of NP characteristics such as definiteness on processing preferences, since previous studies have shown that RC disambiguation strategies are a function of syntactic and non-syntactic information in both L1 and L2 (Crain & Steedman 1985; Pan et al. 2015; Solaimani et al. 2024). We hypothesise that if attachment preferences are facilitated by a definite antecedent, readers are expected to show variable attachment preferences, sometimes NP1 and other times NP2, depending on the definiteness of the antecedent NPs.

Specifically, we test two key disambiguation strategies in English RC ambiguities, one a recency strategy that favours attachment to NP2, and another a discourse-based definiteness strategy that favours attachment to a definite antecedent. We hypothesise that an NP2 attachment in English is stronger in cases where these two strategies concur — that is, in ambiguous RCs preceded by an indefinite NP1 and a definite NP2 — compared to cases where these two strategies result in opposing disambiguation preferences, that is, in cases where NP1 is definite and NP2 is indefinite. Furthermore, by analysing reaction time (RT) data from both L1 and L2 readers, the present study investigates the potential similarities and differences between L1 and L2 processing of RC ambiguities. If attachment preferences in L2 are more likely to be moderated by non-syntactic information, as assumed by the SSH, it is expected that the effect of definiteness on attachment preferences should be larger in L2 compared to L1. On the other hand, if the two groups are affected to the same extent by non-syntactic information, both L1 and L2 attachment preferences should be affected similarly by the definiteness of the antecedent.

3.1 Participants

Two groups of readers participated in this study. The first group consisted of 36 L1-English readers recruited online from the participant pool on Prolific (www.prolific.co). In addition, 49 L1-Persian readers, a relatively under-studied L1 background, took part in the study as the L2 group, of whom 29 were recruited in-person from the undergraduate student community at the University of Tehran, and 20 others were recruited through Prolific. All L2 participants reported to be L1 speakers of Persian who did not spend more than 3 months living in an English-speaking country but learned English predominantly in a classroom environment. Among the L1 group, all reported to be living in the UK at the time of the experiment and none were fluent in any language other than English. The Prolific participants were selected based on their previous successful submission rate (>90%). All participants were undergraduate students (age: mean = 20, range = 19 to 21) who did not report to have any visual impairments and were naive with respect to the purpose of the experiment.

To assess proficiency, a c-test (Ishihara et al. 2003) was administered. All Persian readers scored above 88 out of 100 (mean = 94.42, *SD* = 3.39), suggesting that they were advanced readers. There is considerable evidence that c-tests are a reliable and valid measure of general language proficiency, and some studies have suggested that c-tests tap into both lower and higher order processing skills (Trace 2020).

3.2 Materials

The materials appeared in short passages involving 72 fillers and 20 experimental items (5 instances per each condition). The fillers were similar to the experimental items in length and complexity but did not involve an ambiguous RC. Each experimental item included the critical sentence with the RC ambiguity (bold below) as well as preceding and subsequent sentences, to increase the naturalness of items and disguise the purpose of study. The context sentences provided a backdrop to the story and did not bias attachment to either NP1 or NP2. The critical manipulations crossed attachment (NP1, NP2) and definiteness (indefinite, definite) in the second sentence, yielding 4 experimental conditions:

NP1-attachment, indefinite antecedent

(4a) *They were all worried at the hospital.* ***The resident called a nurse of the patient who was injecting penicillin in room 305.*** *This patient had been suffering from liver cancer for 6 years.*

NP1-attachment, definite antecedent

(4b) *They were all worried at the hospital.* ***The resident called the nurse of a patient who was injecting penicillin in room 305.*** *This patient had been suffering from liver cancer for 6 years.*

NP2-attachment, indefinite antecedent

(4c) *They were all worried at the hospital.* ***The resident called the nurse of a patient who was coughing severely in room 305.*** *This patient had been suffering from liver cancer for 6 years.*

NP2-attachment, definite antecedent

(4d) *They were all worried at the hospital.* ***The resident called a nurse of the patient who was coughing severely in room 305.*** *This patient had been suffering from liver cancer for 6 years.*

All experimental items involved RC ambiguities with a complex NP (NP1–of–NP2), where either NP1 (*a/the nurse*) or NP2 (*a/the patient*) was semantically associated with the content of the RC. That is, (4a) and (4b) were expected to lead to an NP1-attachment interpretation, since a reading where *a/the nurse* (NP1) is *injecting penicillin* is more plausible than a reading where *a/the patient* is *injecting penicillin*. Similarly, (4b) and (4c) were expected to lead to an NP2-attachment interpretation as *a/the patient* being sick and *coughing severely* is more plausible than *a/the nurse coughing severely*. Semantic plausibility was assessed in a separate norming study, where 10 L1-English and 3 L1-Persian readers rated the semantic association between the RC content and the antecedent on a scale of 1 (no plausible association) to 7 (complete plausible association).[1] Items that were scored below 5 were replaced with revised items in which the association between the RC content and the antecedent was strong (>5). None of the

1. Even though all materials appeared in English, we included 3 L1-Persian L2-English readers in the norming study to ensure that the semantic association between the RC content and the antecedent was plausible to both L1-English and L1-Persian readers. This was intended to control for the possibility that the perception of plausibility might differ based on prior real-world experiences.

participants who took part in the norming study completed the self-paced reading task (plausibility for NP1-attached items: mean = 92.05, *SD* = 6.24; plausibility for NP2-attached items: mean = 94.33, *SD* = 5.82).

In addition, half of the experimental items involved a definite NP for the RC antecedent (*4b)* and *(4d)*, while the other half involved an indefinite NP *(4a)* and *(4c)*. In all experimental items, the non-antecedent NP was definite when the antecedent was indefinite, whereas it was indefinite when the antecedent was definite. This design allows us to examine the strength of recency and definiteness strategies independently of each other, since in cases where both NP1 and NP2 are definite, a possible NP2 preference may arise from a combination of recency (which favours NP2 attachment) and definiteness (which favours attachment to a definite NP).

The experimental items were distributed across 4 lists in a Latin square design and pseudorandomised. Each participant saw only one sentence from each set but read sentences from all conditions. The dependent variable was RT, and it was assumed that protracted RTs from a certain attachment condition relative to the other attachment condition indicates dispreferred attachment. If readers preferred one attachment condition to another, it was expected that they should have relatively faster RTs in the disambiguation region, i.e. the RC, and potentially in the spill-over region, i.e. the final adjunct.

3.3 Procedure

The participants were required to complete a self-paced reading task involving RC ambiguities such as (4). Those who took part in-person initially completed the c-test proficiency task on paper and then the self-paced reading task on the DMDX software (Forster & Forster 2003). By contrast, those who took part remotely completed the tasks in the same order on Ibex Farm (Zehr & Schwarz 2018).

The experiment was conducted using a moving window self-paced reading with non-cumulative region-by-region presentation. The first region (*they were all worried at the hospital*) introduced the backdrop to the sentence with the critical RC ambiguity, whereas the second region presented part of the next sentence which included the subject, the verb and the complex NP (*the resident called the nurse of the patient*). The third region involved the RC (*who was injecting penicillin/who was coughing severely*) while the fourth region included an adjunct prepositional phrase (*in room 305*). The next two regions, i.e. 5 *(this patient had been suffering from liver cancer*) and 6 *(for 6 years*), concluded the item by providing additional information unrelated to the resolution of RC ambiguity. The inclusion of the last two regions was to avoid end-of-sentence wrap-up effects to impact RC attachment preferences. Hence the critical and the spill-over regions, where RTs were compared, were regions 3 and 4. All experimental items and 46 out of the 72 fillers were followed by multiple-choice comprehension questions to make sure that participants were attentive to the task. None of the questions tapped into the disambiguation of the RC to avoid drawing attention to the critical ambiguity. For example, the comprehension question following *(4)* was *how was everyone feeling? (a) happy, (b)* ***worried****, (c) tired, (d) angry.*

3.4 Analysis

The average comprehension accuracy scores were 93.07% and 89.76% for the L1-English and L1-Persian readers, respectively, suggesting that the participants were attentive to the task. However, before conducting any statistical analysis on RTs, initially, data on experimental items whose accompanying comprehension questions were answered incorrectly were excluded. This led to a reduction of 7.83% of the whole RT data. Second, RTs beyond 3 SDs of the means of the corresponding attachment and definiteness conditions in each region were excluded, which resulted in the loss of 2.32% and 2.18% of remaining data in regions 3 and 4, respectively. Finally, data from one item was deleted due to a coding mistake, leading to the reduction of 4.12% of the remaining data.

As for statistical analysis, initially, raw RTs were log transformed to reduce skew, and then nested linear mixed effects models were constructed using the *lmerTest* package (Kuznetsova et al. 2017) in R (R Core Team 2020), which adds p-values to the output of the *lme4* package (Bates et al. 2015) using Satterthwaite's approximation of degrees of freedom. In addition, we used the *effectsize* package (Ben-Shachar et al. 2020) to estimate *Cohen's d* for each of the fixed effects. The models included length of the regions, L1, attachment, definiteness, and their interactions. All regions included the same number of words but NP1 and NP2 attachment conditions had different number of characters in region 3. As such, Length was added to account for differences in region length across the two attachment conditions, defined as the number of characters in each region. L1 (English, Persian) was included as an additional fixed effect to examine L1/L2 processing differences. All models involved the maximal random effects structure that converged (Barr et al. 2013), including by-participant and by-item adjustments to the intercept and slopes (data and analysis code can be found at https://osf.io/2r583/).

4. Predictions

If readers favoured attachment to one of the NPs over the other one, a main effect of attachment was predicted. On the other hand, if attachment preferences were affected by the definiteness of the RC antecedent, an interaction was expected between attachment and definiteness. Specifically, we expected NP2 attachment with a definite antecedent, but crucially not with an indefinite antecedent. Recall that a recency strategy motivates attachment to NP2 while a definiteness strategy motivates attachment to a definite NP (which could be either NP1 or NP2).

In (4a), NP1 is indefinite and NP2 is definite, and therefore both strategies motivate NP2 attachment, which goes against the semantic association between the RC content and the RC antecedent, i.e. NP1. Therefore, we expect reanalysis in region 3 in (4a), since both recency and definiteness favour NP2 attachment but this is inconsistent with the semantic information in region 3 which motivates NP1 attachment. In (4b) and (4c), NP1 is definite and NP2 is indefinite, and as such, the definiteness strategy favours NP1 attachment while recency favours NP2 attachment, resulting in competition between the two strategies. Thus, similar to (4a), we expect reanalysis in region 3 of (4b) and (4c), since at least one of recency and definiteness results in an attachment preference that is not consistent with the content of the RC. In (4d), however, NP1 is indefinite while NP2 is definite, and therefore, both recency and definiteness favour NP2 attachment, which is consistent with the semantic association between the RC content and the RC antecedent, i.e. NP2. Therefore, we do not expect similar reanalysis effects in (4d), i.e. an NP2 preference should be stronger in (4d) compared to (4b), whereas this preference should be absent, or at least attenuated, in (4c) compared to (4a). As for potential L1/L2 differences, an interaction was expected with L1 and the other fixed effects in case of reliable L1/L2 differences.

5. Results

Below we focus only on main effects of L1, attachment, definiteness, and their interaction, but we do not report length effects, as it was included in all models as a control measure.[2] Summary of reaction times per each condition and the results of the statistical analysis are presented in Tables 1 and 2, respectively.

Region 3 (who was injecting penicillin/who was coughing severely). There was a marginal main effect of L1 in this region (effect size = .40), with longer overall RTs for the L1-Persian readers (M = 2475 ms., SD = 1354), compared to the L1-English group (M = 1265 ms., SD = 823). In addition, there was a marginal main effect of attachment (effect size = .12), and NP2-attached conditions (M = 1983 ms., SD = 1371) were read faster than NP1-attached conditions (M = 2168 ms., SD = 1287).

2. For full results see https://osf.io/2r583/

Table 1. Summary of reaction times in milliseconds in self-paced reading task

Group		Region 3				Region 4			
		Definite		Indefinite		Definite		Indefinite	
		NP1	NP2	NP1	NP2	NP1	NP2	NP1	NP2
L1-English (N=36)	Mean	1813	914	1161	1174	1369	762	872	1028
	SD	1022	608	723	592	867	489	539	558
L1-Persian (N=49)	Mean	2653	2362	2355	2529	1526	1196	1387	1301
	SD	1336	1456	1255	1353	903	709	725	676

The main effect of definiteness was not significant. Similarly, the interaction between L1 and attachment was not significant, nor the interaction between L1 and definiteness. Importantly, the interaction between attachment and definiteness was significant (effect size = .27), but the three-way interaction between L1, attachment, definiteness was not significant. This suggests that attachment preferences in L1 and L2 were similarly affected by the definiteness of the RC antecedent. To explore the nature of the interaction between attachment and definiteness, we constructed two additional models on RCs with definite and indefinite antecedents, respectively. The results showed that in RCs with a definite antecedent, NP2-attached conditions were read significantly faster than NP1-attached conditions (estimate = .481, SE = .19, t = 2.53, p = .012, effect size = .24). By contrast, in RCs with an indefinite antecedent, no significant RT difference was observed between NP1 and NP2 attached conditions (t = .11, p = .901).

Region 4 (in room 305). The main effects of L1, attachment, and definiteness were not significant in this region, nor was the interaction between L1 and definiteness. However, the interaction between L1 and attachment was significant (both effect sizes = .05). Specifically, the L1-Persian readers had slower RTs on NP2 attached conditions than on NP1 attached conditions, compared to the L1-English readers. Importantly, there was also a significant interaction between attachment and definiteness (effect size = .29). Follow-up analysis showed that in RCs with a definite antecedent, NP2-attached conditions were read significantly faster than NP1-attached conditions (estimate = .324, SE = .16, t = 1.98, p = .048, effect size = .23). By contrast, in RCs with an indefinite antecedent, NP1-attached conditions were read marginally faster than NP2-attached conditions (estimate = .270, SE = .14, t = 1.95, p = .051). The 3-way interaction was not significant between L1, attachment, and definiteness, suggesting that the above interaction between attachment and definiteness equally applied to both L1-English and L1-Persian readers.

Table 2. Summary of the regression models in region 3 and region 4

	Region 3			Region 4		
	Estimate (SE)	*t*	*p*	*Estimate (SE)*	*t*	*p*
L1 (English vs. Persian)	−.263 (.15)	−1.72	.086	.050 (.12)	.42	.673
Attachment (NP1 vs. NP2)	.270 (.15)	1.77	.082	−.017 (.13)	−.12	.903
Definiteness (definite vs. indefinite)	−.208 (.12)	−.17	.863	.133 (.10)	1.32	.187
L1 * Attachment	.391 (.24)	1.60	.11	−.589 (.21)	−2.86	.004*
L1 * Definiteness	.235 (.24)	.97	.33	.113 (.20)	.555	.579
Attachment * Definiteness	.515 (.24)	2.14	.032*	.596 (.20)	2.92	.004*
L1 * Attachment * Definiteness	.183 (.48)	.38	.704	.581 (.41)	1.41	.158

Overall, the results showed that RC attachment preferences were moderated by the definiteness of the RC antecedent, which was true for both groups in region 3 (*who was injecting penicillin/who was coughing severely*) and region 4 (*in room 305*). Specifically, RCs with a definite antecedent elicited an NP2 preference, whereas no strong preference was found in RCs with an indefinite antecedent (see Figure 1).

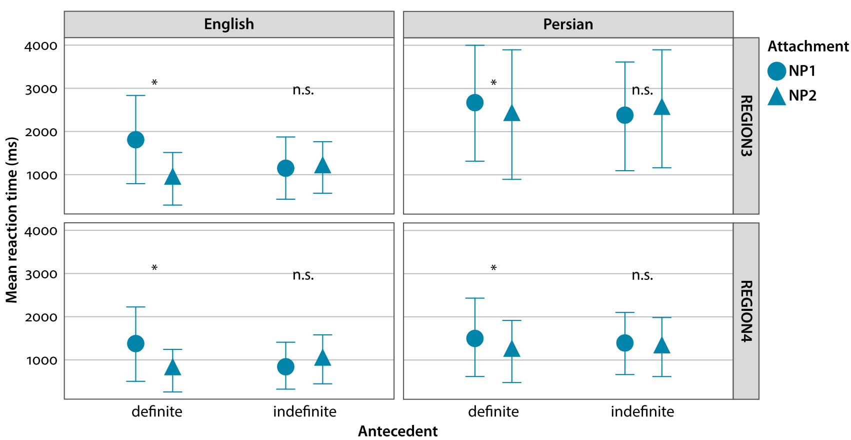

Figure 1. Error bars showing mean reaction times and standard deviations around the mean (+/− SD) per condition and participant group in regions 3 and 4. Both groups had significantly faster RTs on NP2 than NP1 attachment conditions for RCs that had a definite antecedent (indicated by asterisks). However, no significant difference was found between NP1 and NP2 attachment for RCs with an indefinite antecedent (indicated by 'n.s.')

6. Discussion

The present study investigated L1 and L2 processing of temporarily ambiguous RCs in English by examining the role of definiteness of the antecedent on RC attachment preferences. The results showed definiteness effects on L1 and L2 RC attachment preferences in both regions 3 and 4. Specifically, with definite RC antecedents, an NP2 preference was observed, which is compatible with previous studies showing a recency strategy in English. However, this preference was absent in RCs with an indefinite antecedent, as these conditions did not elicit a strong preference – neither NP1 nor NP2.

It may be argued that the L2 data in region 3 showed a numeric trend towards NP1 attachment in indefinite conditions (see Figure 1, top right). This might indicate that in conditions that did not involve the discourse-based definiteness cue on the antecedent, L2 readers were more likely to show an L1-based NP1 attachment preference. However, this trend was not statistically significant in any of the analyses, similar to the non-significant 3-way interaction between L1, attachment, and definiteness, suggesting that L1 and L2 attachment preferences were similarly affected by the definiteness manipulations.

Recall that in definite conditions, the RC antecedent was always definite while the competing NP was indefinite. By contrast, in indefinite conditions, the RC antecedent was indefinite while the competing NP was definite. Therefore, in (4d) which is semantically resolved towards NP2 attachment and where NP2 is definite while NP1 is indefinite, the semantically resolved NP2 interpretation is consistent with both a definiteness and recency strategy. On the other hand, in all other conditions (4a), (4b), and (4c), the recency and discourse-based strategy do not agree to the semantically resolved interpretation.

Specifically, either both strategies motivate attachment to an NP that is the opposite of the semantic association between the RC content and antecedent (as in 4a), or the definiteness strategy motivates NP1 attachment while the recency strategy motivates NP2 attachment (as in 4b and 4c). This explains why (4d), where both definiteness and recency favour the same attachment preference as the semantically resolved interpretation, was read faster than all other conditions, in which the semantically resolved interpretation was not consistent with both definiteness and recency.

As noted in Section 2, most previous studies reporting a recency strategy in English (i.e., NP2 attachment) involved ambiguous RCs preceded by two definite NPs. Therefore, it is not immediately clear to what extent the reported NP2 preference is the result of a definiteness strategy. This study manipulated the definiteness of the RC antecedent to tease apart the unique contribution of recency as opposed to definiteness. The results suggest that both strategies are actively employed by

L1 and L2 readers, since in cases where the two strategies do not agree to the same NP as the RC antecedent, no strong preference was found. By contrast, in cases where both strategies prefer NP2 attachment, a reliable NP2 preference was observed. It should be noted that the present study does not question recency in English but highlights the significance of a definiteness strategy to attach ambiguous RCs to a definite antecedent, which operates alongside recency. We found an NP2 preference only in those conditions which involved a definite antecedent, but our results did not indicate a strong NP2 preference in RCs with an indefinite antecedent.

As for L2 processing, we hypothesised that if L2 readers relied more heavily on non-syntactic information compared to L1 readers, different attachment preferences were expected in the two groups. However, our results showed that neither the L1 nor the L2 group had strong attachment preferences solely determined by recency, but the interaction with definiteness showed that both L1 and L2 processing were affected by the definiteness of the RC antecedent. This is consistent with previous L2 processing research that L1 and L2 processing of RC ambiguities are affected to the same extent by different information sources (Solaimani et al. 2024).

In particular, we found the interaction to be significant in both regions 3 (critical disambiguation region) and 4 (spillover region). As such, the results cast doubt on the argument that L2 disambiguation of RC ambiguities is more reliant on non-syntactic than syntactic information, compared to L1 disambiguation of these structures (Clahsen & Felser 2006; Cunnings 2017). This is because we did not find an overall NP2 preference for the L1 readers, but RC attachment preferences were moderated based on the definiteness of the antecedent NPs. Similarly for the L2 group, we found that in RCs with a definite antecedent, NP2 attachment was favoured to NP1 attachment, consistent with recency. By contrast, in RCs with an indefinite antecedent, no strong attachment was observed for either the L1 or L2 readers, as recency and definiteness did not agree to the same attachment decision. Furthermore, the 3-way interaction between definiteness, attachment, and L1 was not significant, suggesting that attachment prerferences were not differentially impacted by a definiteness strategy between the two groups.

Given that the effect of definiteness on RC attachment preferences was observed for both groups in regions 3 and 4, our results are also not consistent with the argument that L2 processing differs from L1 processing in the relative timing/weightings of different information sources (Clahsen & Felser 2018). Rather, the results are compatible with previous research on L2 processing that suggested processing preferences in L2 are not fundamentally different from processing preferences in L1, at an advanced proficiency level, since both are equally likely to be affected by different information sources (Hopp 2014; Solaimani et al.

2024). Even though previous studies had suggested an NP1 preference in Persian, we found that the L1-Persian readers did not show a strong NP1 preference, but displayed the same interaction with definiteness as the L1-English comparison group. In fact, where the RC antecedent was a definite NP, both groups showed an NP2 preference, unlike what would be expected under an L1-transfer account. This is consistent with previous findings in L2 processing literature that processing preferences in L2 are not transferred from L1 at a highly advanced proficiency level.

However, it is important to acknowledge that an explanation based on the SSH is not necessarily ruled out. Region 3 (critical disambiguating region) involved materials that were semantically associated with either NP1 or NP2. This is unlike the materials in most previous studies that involved a syntactic agreement relationship between the RC and the antecedent; e.g., via number agreement between the antecedent and an auxiliary (*the nurse of the patients who was/were*). It might well be the case that both L1 and L2 readers in this study resolved the ambiguity via semantic association rather than syntactic biases, as encouraged by the nature of the disambiguating information in region 3. Therefore, it can be argued that the lack of L1/L2 differences in the impact of definiteness is not all that informative regarding the degree to which L1 and L2 processing of these structures are influenced by syntactic principles such as recency.

In fact, we found a significant interaction in region 4 between L1 and attachment. The overall NP2 attachment preference in region 4 was weaker among the L2ers than L1ers, and therefore, the results do not necessarily rule out the SSH's claim that L2 disambiguation of RC ambiguities is less sensitive to syntactic biases such as recency. However, we remain cautious in drawing any strong conclusions from the significant L1 by attachment interaction, as both L1 and L2 attachment preferences were impacted to the same extent by definiteness. This was evidenced by the significant interaction between attachment and definiteness and non-significant 3-way interaction between L1, attachment, and definiteness. Therefore, while we agree that disambiguation via semantic association does not necessarily suggest operation of a recency strategy, we note that more research is required to investigate L1 and L2 processing of ambiguous structures, especially the extent to which the two are affected by syntactic as opposed to non-syntactic information.

7. Conclusion

This study employed a self-paced reading technique to investigate L1 and L2 processing of temporarily ambiguous RCs by examining the extent to which RC attachment preferences in English are affected by the definiteness of the RC antecedent. The results showed that both L1 and L2 processing of RC ambiguities were affected by the definiteness of the RC antecedent. In RCs with a definite antecedent, an NP2 preference was found for both groups, consistent with previous research showing an NP2 preference in English, while in RCs with an indefinite antecedent, RTs were not significantly different in NP1 and NP2 attached sentences, indicating no strong preference. It was argued that the lack of strong NP2 preference with an indefinite antecedent likely arises from the operation of discourse-based definiteness strategy, which competes with recency in cases where NP1 is definite while NP2 is indefinite.

Additionally, the observation that there were no L1/L2 differences casts doubt on the hypothesis that L2 readers are more sensitive to non-syntactic information such as the definiteness of the antecedent, when resolving ambiguous RCs. In fact, even though some previous studies reported an NP1 preference in Persian (Arabmofrad & Marefat 2008), the L1-Persian readers behaved similarly to the L1-English readers, in that their preferred attachment strategy was impacted by the definiteness of the antecedent in initial structure building. Overall, the results do not support the hypothesis that L1 and L2 processing of ambiguous RCs are fundamentally different in terms of drawing on different information sources (Clahsen & Felser 2006, 2018).

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