# Processing similarities between native speakers and non-balanced bilinguals


## **Abstract** (300 words)

**Aims and Objectives:** The study investigates human sentence processing and argues that information from multiple sources is equally considered in native and non-native languages. Non-syntactic information does not overrule the parsing decisions prompted by syntactic cues.

**Methodology:** The experiment used ambiguous relative clauses (RC) in a self-paced reading task with 20 native and 45 non-native adult speakers of English and Russian. The software Linger recorded the participants' answers to comprehension questions and the time they spent reading each word.

**Data and Analysis:** Mixed linear analysis performed in R checked for the effect of a matrix verb, RC length, social conventions, the native language and the language of testing on RC processing and interpretation.

**Findings:** Both native and non-native speakers followed social conventions in deciding on the interpretation of the RC. However, this information never overruled the attachment decision prompted by the matrix predicate or by the length of the RC which entails certain sentence prosody.

**Originality:** The study is innovative in investigating the extent to which each factor affected RC processing. It shows that social conventions enhance processing when they conspire with the structural parse prompted by linguistic cues. When they do not, syntactic information governs sentence parsing in both L1 and L2.

**Significance/Implications:** The study provides evidence that sentence processing uses linguistic structure as a first parsing hypothesis, which can then be adjusted to incorporate the incoming information from multiple sources.

**Limitations:** The findings need further support from testing L2 learners of Russian in various socio-cultural contexts.

**(248 words)**


## Introduction

The experimental study reported in this paper investigates psycholinguistic mechanisms underlying language processing by monolinguals and adult second language learners (L2ers) whose proficiency in their non-native languages is much lower than in their L1s. The study aims to contribute to the scholarly debate on the nature of non-native processing, which has been going on for fifteen years but has not been completely resolved yet (Dekydtspotter, Swartz & Sprouse 2006, Dekydtspotter & Renaud, 2014; Clahsen & Felser, 2006, 2018).

The debate concerns the interpretation of behavioral differences attested in multiple processing studies comparing native and non-native speakers (Felser & Cunnings, 2012; Felser, Sato & Bertenshaw, 2009; Felser, Marinis & Clahsen, 2003; Felser, Roberts, Gross, & Marinis, 2003). The disputed question is to what extent behavioral differences index fundamental differences in L1 and L2 processing. One position, the Shallow Structure Hypothesis (SSH, Clahsen & Felser, 2006) argues for such a fundamental difference in processing, based in non-nativelike linguistic representations. According to the updated version of the hypothesis (Clahsen & Felser, 2018), L2ers exhibit different processing routines even if their representations are not different from native speakers.' The opposite position, the Full Transfer/Full Access/Full Parse proposal (FT/FA/FP, Dekydtspotter et al., 2006) asserts that human processing implements the same routines in native and non-native languages, and L2ers are capable of processing their L2 in a target-like manner. In the latter approach, the attested differences in behavior occur either due to retrieval difficulties in language processing (Cunnings, 2017), or individual differences of non-linguistic nature (Hopp, 2014a, 2014b); as well as due to the fallacy of direct comparisons between monolinguals and L2ers (Sprouse, 2011; Dekydtspotter et al., 2006).

Our study extends the main theoretical assumptions developed for monolingual processing to the field of L2 processing. It has been established that in order to process a sentence, the comprehender creates its mental structural description (Phillips, 1996). To do so, the parser works bit-by-bit, incorporating the incoming constituents into the existing structural slots. If incorporation is not possible, the parser re-analyzes the information already processed and generates a new minimally needed node (Crocker, 1999; see also Fodor 1998, Frazier 1990, Frazier & Fodor, 1978).

The capability of the human parser to check back to the already processed information in order to predict the upcoming structure motivated a body of research on how exactly a parsing decision is made. The main debate concerns the question of whether structural parsing is sensitive to other types of linguistic information and whether it can be adjusted online. There is experimental evidence that information from multiple sources is available to the human parser at all stages of processing (Tannenhaus, Spivey-Knowlton, Eberhardt & Sedivy, 1995). For example, lexical-semantic information shows its effect in the cases of structural ambiguity, where it prompts a certain parsing decision (Trueswell & Tanenhaus, 1994). Using the information from multiple sources, the human parser decides on which structure is supported by most of them and generates its projection to process the upcoming sentence (van Gompel, Pickering & Traxler, 2000). The structure anticipated at the beginning shapes the parsing of the rest of the sentence if there is no grammatical conflict with the incoming information (Phillips 2013, 2003, Phillips & Schneider, 2000).

To address the theoretical issues of human (both native and non-native) language processing stated above, this study uses ambiguous relative clauses (RC) to investigate whether their interpretation depends on either structural or non-structural information, and whether the effects will be different in the L1 and L2. The linguistic target of the experiment is a globally ambiguous RC as in English (1a) and Russian (1b). The ambiguity of the RC [*that was talking about cosmetics*] shows through the preferred answer to the comprehension question in (2):

(1) a. Maria arrested [$_{NP}$ the mother of [$_{NP}$ the woman]] [$_{RC}$ that was talking about cosmetics].

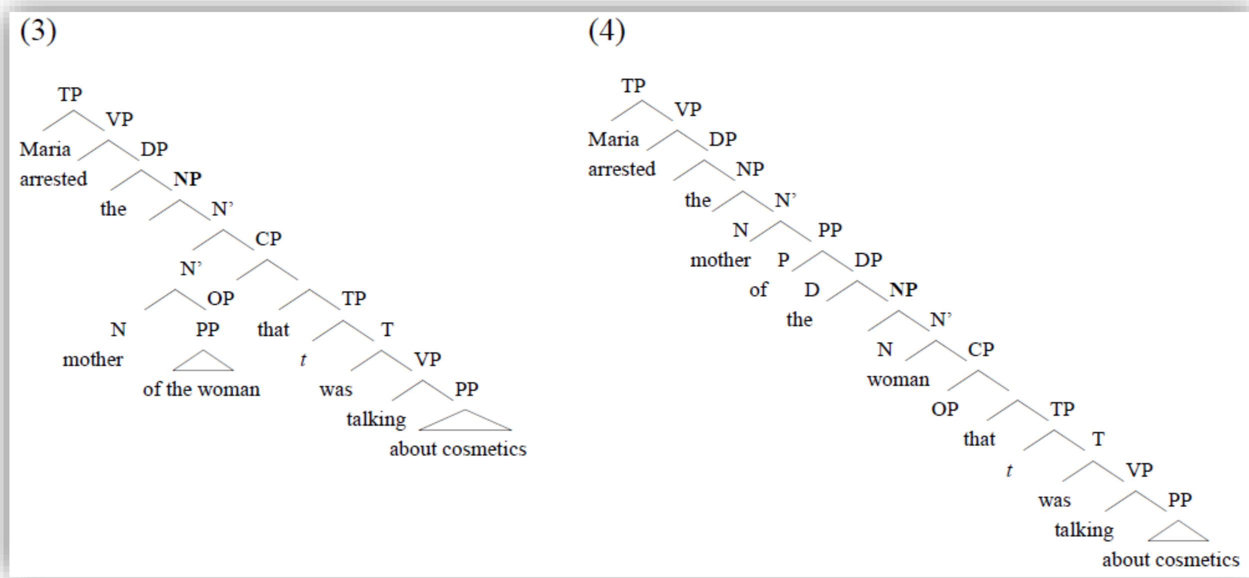
| | | | | |
|---|---|---|---|---|
| b. Maria | arestovala | mamu | ženščin-y, | kotor-aya |
| *Maria-NOM* | *arrested-PAST.fem.sg* | *mother-ACC.* | *woman-GEN* | *who-NOM.fem.sg* |

| | | |
|---|---|---|
| govori-la | pro | kosmetik-u. |
| *talk-PAST.fem.sg* | *about* | *cosmetics-PREP* |

'Maria arrested the mother of the woman that was talking about cosmetics.'

(2) Who was talking about cosmetics?
a) the mother (HA) b) the woman (LA)

Both answers, (2a) and (2b), are grammatical. When answer (2a) is preferred, the RC modifies the higher NP (HA, high attachment), as illustrated by the tree in (3). For answer (2b) to be chosen, the RC must modify the lower NP (LA, low attachment), shown by the tree in (4).




Despite syntactic equivalence between English and Russian, ambiguous RCs as in (1a, b) demonstrate cross-linguistic variation in attachment preferences. Native speakers (NS) of Russian, French, Dutch, German, Greek, and Italian prefer the syntactic modification in (3) and choose HA, or interpretation (2a) (Cuetos & Mitchel, 1988; Hemforth, Konieczny, & Scheepers, 1998; Zagar, Pynte, & Rativeau, 1997). At the same time, NSs of English, Norwegian, Romanian, and Swedish follow the syntactic structure provided in (4) and prefer LA, or answer (2b) (Fernandez, 1999; Fodor, 2002).

Cross-linguistic variation allows for comparisons between the patterns of RC resolution preferred by native speakers and L2ers in English and Russian. Besides, the RC structural flexibility makes its parsing adjustable to either linguistic or non-linguistic prompts. It is theoretically relevant to examine a) whether a structural anticipation triggered by the matrix verb shapes RC resolution (to be explained in detail below); b) whether the length of the RC forces prosodic breaks at certain places and influences RC attachment; or c) whether lexical information activates social conventions in the comprehends' minds and define RC interpretation. Most importantly, the use of ambiguous RCs makes it possible to investigate whether any of the factors enumerated above has a universal effect or only works in one of the languages, and whether these factors affect L2ers in a different way than native speakers.

The study used a self-paced reading experiment with adult native and non-native speakers of English and Russian to investigate the predictions of the two main approaches to non-native processing, the SSH and the FT/FA/FP. The second aim of the study was to add to the current scholarly understanding of the nature and functions of the human parser and the psycholinguistic mechanisms underlying human sentence processing.

## Theoretical Predictions

This study captures early stages of L2 acquisition and investigates whether there are general human parsing strategies that account for processing in both L1 and L2. Among such parsing strategies are language-specific linguistic prompts which the parser develops sensitivity to. Next, we describe three factors that are expected to shape RC interpretation: the role of the matrix predicate, the length of the RC and the effect of social conventions. The section provides theoretical motivation, makes predictions on the participants' behavior and explains how the anticipated behavior addresses theoretical issues in the field of human language processing.

### Social Bias

Social bias is a factor based on lexical-semantic information, which may influence RC interpretation. Speakers entertain perceptions on what actions are most likely performed by certain social groups depending on gender and social norms. For example, it is considered more likely for women to talk about cosmetics than for children; an adult man is more likely to wear a tie than a boy. Thus, the example in (5) favors LA and the one in (6)—HA.

(5) Maria called the grandson of the man that was wearing a tie.

Who was wearing a tie?

The man *(more likely choice)*

(6) Maria called the mother of the boy that was talking about cosmetics.

Who was talking about cosmetics?

The mother *(more likely choice)*

In the target sentences (5) and (6), the animate head nouns present two possible doers of the activities expressed by the embedded verb. Social conventions can override HA or LA preferences in each language and favor different attachment sites for RC.

If the assumptions of the SSH hold true, social conventions may shape RC resolution in the L2. This is because "even highly proficient L2 speakers tend to have problems building or manipulating abstract syntactic representations in real time and are guided more strongly than native speakers by semantic, pragmatic, probabilistic, or surface-level information" (Clahsen & Felser 2018, p. 2). Such an approach predicts different results in native and non-native RC resolution, with L2ers more often picking interpretations prompted by social conventions, while native speakers implementing purely structural parsing.

Under the FT/FA/FP approach advocated by Dekydtspotter et al (2008, 2006), comprehends perform mental structure building in both L1 and L2 processing. In Russian, the parser prefers structure (3) and favors HA (2a). In English, structure (4) ensures LA (2b). Social conventions should not overrule a certain structural preference typical for a given language. Therefore, RC resolution is predicted to have a language-specific pattern: HA in Russian and LA in English.

Dekydtspotter & Renaud (2014) and Dekydtspotter et al. (2006) argue that L2ers are sensitive to the internal linguistic organization of their target language from the early stages of acquisition. If this holds true, the prediction based on the FT/FA/FP can be extended. One would expect RC resolution to follow a language-specific pattern in both English and Russian. L2ers should process the experimental RCs in a target-like manner by demonstrating preference for HA in Russian and LA in English.

**RC-length**

The factor RC-length investigates whether structural parsing relies on prosodic information in RC resolution. The effect of prosody was studied by Dekydtspotter *et al.* (2008). The researchers tested NSs of English as well as L2 learners of French at low-intermediate level of proficiency. Dekydtspotter *et al.* (2008) followed the Implicit Prosody Hypothesis (IPH, Fodor, 2002), which argues that prosodic information is implicitly used in sentence processing, even in silent reading tasks, and its effect could explain cross-linguistic variation in RC resolution. Therefore, HA preference in RC resolution in French implies that there is a default prosodic break right before the RC. This break ensures processing of the RC as a separate unit, attached higher in the tree. At the same time, the prosodic structure in English is different. A default prosodic pause separates the second head noun and joins it together with the RC in one prosodic unit. This prosodic structure favours LA of the RC. Dekydtspotter *el al.* (2008) attested a switch to HA preferences in RC resolution in L2-French when the participants were NSs of English. They argued that L2ers were sensitive to the default prosody of the target language from early stages of acquisition and parsed the RCs accordingly.

At the second stage of the experiment, Dekydtspotter *el al.* (2008) manipulated the length of the RC. In doing so, they extended the assumptions by the IPH and claimed that longer RCs formed a separate prosodic unit and had a prosodic pause before them. Shorter RCs were expected to pattern in the opposite way. They joined to the lower DP and had no prosodic break between the lower noun and the RC. Therefore, long RCs would always return HA preference in RC resolution and shorter RCs would result in LA. The results of Dekydtspotter *et al.* (2008) supported this prediction. Both native and non-native speakers attached shorter RCs to the lower noun in the tree, whereas the longer RC were attached to the higher noun.

Building on the results by Dekydtspotter *et al.* (2008), we argue that native and non-native processing uses similar strategies and shows sensitivity to the same effects. Furthermore, we would like to assume that RC-length is a universal processing cue that informs the structural parser and prompts certain parsing decisions. If this assumption is correct, both native and non-native speakers would attach longer RCs higher in the tree while short RCs will return to LA preference. If, on the other hand, we find differences in how native and non-native speakers behave with RCs of different lengths, this would constitute evidence in favour of the SSH.

If sentence processing is insensitive to the prosodic information, RC resolution would return a language-specific pattern. This will mean that the placement of a prosodic break favoured by the length of the RC is not a universal processing cue.

**Matrix Verb**

The matrix verb factor is aimed at adding evidence supporting structural parsing in both native and non-native languages. Using different types of the matrix predicate (perception vs. non-perception verb) the study checks whether they would trigger different structural anticipations resulting in different patterns of RC resolution.

The capability of the human parser to generate a structural projection from the beginning of the sentence was studied by Phillips (2003) and Phillips & Schneider (2000), among others. These scholars claimed that a generated projection shaped sentence parsing from beginning to end in case the incoming constituents did not contradict the hierarchical organization of the anticipated structure. These assumptions can be specified by the Race model of sentence processing (van Gompel et al., 2000). At the beginning of the sentence, the parser can expect multiple variants of structural continuations. However, only one structure is selected. The parser considers various types of linguistic information and picks the structure that would be supported by multiple sources.

Following the Race model, the target sentences of the experiment can be parsed differently depending on the type of the matrix predicate, perception or non-perception verb.

The effect of a perception verb on RC resolution in Romance languages was studied by Grillo & Costa (2014). Its effect on English monolinguals was investigated by Grillo et al. (2015) and on L2 and L3 speakers by Sokolova and Slabakova (2019). The scholars argued that a perception verb as in (7) and a non-perception verb as in (8) had different potentials for structural realization.

(7) a. Marina **saw** (who?) the mother of the boy [$_{RC}$ that was talking about cosmetics].

b. Marina **saw** (what?) [$_{CP}$ that the mother of the boy was talking about cosmetics].

(8) Marina **arrested** (who?) the mother of the boy [$_{RC}$ that was talking about cosmetics]

Alongside the RC (7a), a perception verb in (7b) can trigger a projection for an eventive complement in the form of a Complementizer Phrase (CP). No alternative structure is possible in (8).

The eventive CP-complement (7b) is non-ambiguous and only the higher noun *the mother* can be a grammatically licensed doer of the action of *talking* expressed by the embedded verb. Grillo *et al.* (2015) argued that a perception verb placed in the matrix clause of the RC as in (7a) favored HA preference even in a LA-language, like English. Their results showed that adult English monolinguals preferred HA much more often after a perception verb in the matrix clause.

In accordance with the Race model, the parser considers the selectional properties of the matrix predicate before it generates a possible structure for the up-coming sentence. Grillo and Costa (2014) claim that an eventive complement is easier for the parser that a restrictive RC. Relying on the reported effect of a perception verb in monolingual (Grillo *et al.*, 2015) and multilingual speakers of English and Russian (Sokolova & Slabakova, 2019), we expect an eventive complement (7b) to be a preferred structural anticipation for the up-coming sentence. Right after the matrix verb *saw* is processed, a structure for (7b) is generated in both Russian and English. The preference for (7b) will result in an overall preference for HA in the sentences with a perception verb in both English and Russian. Sentences with non-perception matrix predicates will maintain a language-specific pattern of RC resolution. If this holds true, selectional properties of the verb will prove to be a universal parsing cue.

In both English and Russian, the structural realization for an eventive complement is different from the structure of the RC in either (7a) or (8). Therefore, an overall potential to favor HA triggers a projection that needs to be recognized as erroneous and amended towards the RC mid-sentence. The latter translates in increased processing difficulty at certain segments.

Processing patterns in Russian and English are going to be different. First, Russian is a HA-language to start with, where a perception verb is expected to confirm the initial preference for HA in RC resolution. In English, a perception verb has a potential to override the preference for LA initially adopted by NSs.

Second, Russian and English allow a different number of structural realizations of an eventive complement (9). In Russian, only the CP (9a) is possible. In English, a CP (9b) as well as a Small Clause (SC) as in (9c) are possible.

(9) a. Maria **videl-a** [$_{CP}$ čto mama malčika govorila
*Maria-NOM saw-PAST.fem.sg that mother-NOM boy-GEN talk-PAST.fem.sg*
pro kosmetiku]
*about cosmetics-PREP*
'Maria saw that the mother of the boy was talking about cosmetics'

b. Maria **saw** [$_{CP}$ that the mother of the boy was talking about cosmetics]

c. Maria **saw** [$_{SC}$ the mother of the boy talking about cosmetics]

When comprehenders process the target RC as in (7a), the originally generated projection for an eventive complement as in (9a) or (9b) will be ruled out relatively early in the sentence, whereas the projection for (9c) has more structural overlap with (7a) and it will remain valid till the complementizer for the RC is encountered. Since Russian can only have a subordinate clause eventive complement (9a), the effect of a structural conflict will show earlier in Russian than in English.

In the projection for (9a / 9b), the parser will anticipate the complementizer of the subordinate clause to appear right after the perception verb. However, the target sentences with the RC as in (7a) have an empty position at the anticipated beginning of the subordinate clause (10).

(10) Maria **videla** [$_{CP}$ (what?) __**X**__ → (who?) [$_{DP}$ mamu malchika…]]

*Maria-NOM saw-PAST.fem.sg mother-ACC boy-GEN*
'Maria saw the mother of the boy……..'

The processing pattern in (10) rules out the CP-complement when the higher noun *the mother* is processed. This is going to be all for Russian. Afterwards, the parser knows that only an entity complement can follow. It generates a structure for the NP *[the mother]*. In a detailed analysis, there can be a surprisal effect when the parser needs to extend the head NP *[the mother]* to accommodate the continuation *[of the woman]* into a full complex head DP *[the mother of the woman]*. Another spot for a structural surprise is when the parser realizes that the complex DP does not finish the sentence and it is followed by the restrictive RC. To check for all possible effects of a perception verb is beyond the limits of the current study. We are assuming that a processing effect occurs earlier in Russian than in English. Therefore, we compare the reading time (RT) and the complementizer and at the embedded verb and investigate whether there is a language effect in how an eventive complement is ruled out in Russian and English.

The RT at the embedded verb in a crucial processing area in English. The CP-complement in English will affect RC processing in the way described above for Russian. However, English can also have an eventive complement in the form of a SC (11a), which looks identical to the target sentence (11b) till the complementizer of the RC is encountered.

(11) a. Maria **saw** [$_{SC}$ the mother of the boy <u>talking</u> about cosmetics].
b. Maria **saw** [$_{DP}$ the mother of the boy [$_{RC}$ <u>that</u> was talking about cosmetics]].

When the parser has processed the head DP *[the mother of the boy]*, it still anticipates a verbal element *<u>talking</u>* to follow. Therefore, a processing conflict occurs only when the complementizer *<u>that</u>* of the RC (11b) is processed. At this moment, the SC projection for an eventive complement is ruled out and gets replaced by the projection for the restrictive RC. This structural readjustment increases the processing load at the following area of the embedded verb.

Narrowing down the scope of the processing part of our study to the area of the complementizer and the embedded verb, we expect an increase in processing load to occur earlier in Russian than in English.

**Research Questions**

The general predictions will be tested by the following set of the Research Questions (RQ).

RQ 1: Is processing in the L1 different from processing in the L2?

RQ 1.1: Are non-native speakers sensitive to the effect of social bias more than native speakers?

RQ 1.2: Are there differences in how the length of the RC influences native and non-native speakers?

RQ 1.3: Does a structural prediction for an eventive complement have a different effect on native and non-native speakers?

RQ 2: Is structural parsing sensitive to non-structural information?

RQ 2.1: Does the sentence prosodic structure prompted by the length of the RC override the effects of the matrix predicate and social bias?

RQ 2.2: Does the effect of social bias overrule the effects of RC-length or of the structural prediction of a perception verb?

## Experiment

### *Procedure*

The study was conducted in accordance with the ethical norms for behavioral experiments with human subjects. The procedure was approved by IRB-IUB for protocol title "Relative Clause Processing by L2 and L3 Learners", study # 1602915700.

A self-paced-reading experiment was administered through the Linger software for psycholinguistics studies. In experiments of this type, the participants see one word on the screen at a time and make their parsing decisions at the time of processing. The way the sentence has been parsed is reflected by a comprehension question that follows the target sentence. Since, the participants cannot reread the target sentences to reconsider their parsing decisions online, a self-paced reading experiment closely imitates real-life processing.

In the study, the participants were asked to read a set of sentences on a computer screen and select answers to comprehension questions. Every comprehension question offered two answer choices reflecting the participants' preference in RC attachment. To retrieve a new word, the participants were instructed to press the space key. They used keys "F" or "J" to select answers, "F" for the answer on the left, "J" for the answer on the right.

The experiment began with an introductory text explaining how to navigate the design. It was followed by a practice block, where the respondents had an opportunity to start using the navigation keys. The program registered the participants' answer choices and recorded their reading time at every word in the target sentences. The participants were not paid for the study and volunteered their time and effort.

### *Stimuli*

The experiment had a two-by-three-by-three design in each language, English and Russian. The stimuli manipulated the type of the matrix verb, the length of the RC, and social bias.

The experimental items for checking the social bias factor were created based on the results of a survey taken by young adults at a mid-Western American University and in Russia. The survey contained two lists of 20 items each. List 1 presented 20 activities, like playing with a kitten, playing football, wearing a tie, talking about cosmetics, etc. List 2 presented possible doers of these activities: a man, a woman, a boy, a girl, an adult, a child, a professional, a doctor, etc. The respondents were asked to pick a noun indicating the most likely doer of an activity. Combinations such as *play with a kitten – child*, were used in the stimuli design if they were selected more than 85% of the time.

The Social Bias factor had three levels: Favoring HA (12 sentences), Favoring LA (12 sentences) and Neutral (16 sentences). The matrix verb (Verb Type) factor had two levels – a perception vs. a non-perception verb – with 20 sentences per level. An example of experimental sentences manipulating Verb Type and Social Bias is given in *Table 1*.

***Table 1. Sample experimental items by verb type and social bias***

| Conditions | Favoring HA | Favoring LA | Neutral |
|---|---|---|---|
| perception | Maria **saw** *the mother of the boy* that was talking about cosmetics. | Maria **saw** *the son of the woman* that was talking about cosmetics. | Maria **saw** *the sister of the neighbor* that was participating in a social project. |
| non-perception | The police **arrested** *the mother of the boy* that was talking about cosmetics. | The police **arrested** *the son of the woman* that was talking about cosmetics. | The police **arrested** *the sister of the neighbor* that was participating in a social project. |

The third factor – RC length – had three levels: Long, Medium and Short. *Table 2* shows that a short RC ended after a complement of the embedded verb. A medium-length sentence had an adjunct PP following the complement of the embedded verb. In a long RC, a complement of the embedded verb was followed by two adjunct PPs. In total, there were 8 short, 16 medium and 16 long RCs.

***Table 2. Sample experimental items by RC length***

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Short | Maria saw | the grandson of the man | that was wearing | a tie. | | |
| Medium | Maria saw | the grandson of the man | that was playing | football | in the yard. | |
| Long | Maria saw | the grandson of the man | that was buying | flowers | on the corner | of the street. |

A full list of experimental items included 40 target sentences (10 quadruples) and 40 distractors. All the target stimuli contained ambiguous RCs. The distractors were lengthy sentences with subordinate clauses and non-ambiguous RCs. The total number of experimental sentences presented to each participant was 80. The order of the target sentences and distractors was randomized by Linger so that every participant saw a unique sequence of items.

***Participants***

The respondents of the study were non-balanced bilinguals and adult monolingual native speakers of English and Russian. They were tested in the USA and in Russia, respectively. The participants were divided into six groups: 1) monolingual speakers of Russian (NR); 2) monolingual speakers of English (NE); 3) L2-speakers of Russian, tested in their L2-Russian (ER-R); 4) L2-speakers of Russian, tested in their L1-English (ER-E), 5) L2 speakers of English, tested in their L2-English (RE-E); 6) L2 speakers of English, tested in their L1-Russian (RE-R).

The grouping of the participants implemented in the study allows us to tease apart possible behavioral difference between monolinguals and L2ers, and in this way test for the effect of bilingualism. The background information of the participants is given in *Table 3.*

***Table 3. Background information about the subjects of the study***

****Notice, that all bilingual participants completed a language proficiency measure in their L2.***

| *group* / *characteristic* | **NE** | **NR** | **ER-R** | **ER-E** | **RE-E** | **RE-R** |
|---|---|---|---|---|---|---|
| Foreign languages | none | none | Russian | Russian | English | English |
| Language proficiency | native | native | intermediate | intermediate | intermediate | intermediate |

| | | | | | | |
|---|---|---|---|---|---|---|
| C-test, % correct | 99% | 99% | 38% | 37% | 45% | 45% |
| Exposure to L2 | no | no | 2 years (4 h / week) | 2 years (4 h / week) | 3-4 years (2 h / week) | 3-4 years (2 h / week) |
| Number of participants | 10 | 10 | 14 | 7 | 14 | 7 |
| Mean age | 40 | 29 | 21 | 21 | 29 | 29 |

The groups were homogenous and well matched. None of the monolingual participants had any exposure to a foreign language for more than one non-intensive course in high school and none of them had any exposure to a foreign language afterwards. Both bilingual populations were adult learners who started their systematic learning of the L2 in college. All bilingual participants reported using their L2 to read, watch videos or communicate with friends for an hour per day on average.

The target population of the experiment were adult L2 learners with no exposure to the target language in the childhood. Heritage speakers of Russian, who are the majority of L2-Russian learners in colleges in the USA, were not included in the study. The latter reduced the number of the participants in groups ER-R and ER-E. The mirror image groups RE-E and RE-R maintained the same number of the respondents.

***Data Analysis***

The data were analyzed with R version 3.6.3. Sentence processing is investigated through the analysis of the preferred answer choices to comprehension questions and the reading time at the embedded verb and the complementizer. The analysis checked for random effects of Item and Participant.

The selected answer choice reflected the type of RC attachment resolution preferred by a participant. For RC resolution, Mixed Linear analysis with binomial distribution was used. The analysis had a dependent variable – answer choice (Nchoice), and the type of matrix verb (Verb Type), Group, Social bias, RC length, the language of testing (Language) and native language of the participants (NL) were independent variables.

A Generalized Mixed Linear model was used to analyze the reading time (RT) at the complementizer (RT_comp) and the embedded verb (RT_emb). The analyses checked whether a perception verb caused any increase in processing load mid-sentence. The RT_comp and the RT_emb were the dependent variables and the Verb Type was an independent variable. The verb type effect was double-checked in the analysis with Language, Social bias, RC length and NL factors.

The statistical analysis follows the following significance code from 0 to 1: “0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1”. The data in the Results section is presented with HA of the RC as a reference category.

## Results

This section begins with the data on RC resolution: Group effect, Verb Type effect, the effect of RC-length and Social Bias. Afterwards, the factors influencing an increase in processing load at complementizer and the embedded verb are presented.

### RC attachment resolution:

Preference for RC resolution varies by Group. Table 4 shows the baseline preference for a certain type of RC resolution in every group. Group, as a factor, has 5 levels. In the analysis, group results are calculated in the following order: level 1 – NE vs. ERE+REE+ERR+RER+NR; level 2 – NE+ERE vs. REE+ERR+RER+NR, level 3 – NE+ERE+REE vs. ERR+RER+NR, level 4 – NE+ERE+REE+ERR vs. RER+NR, level 5 – NE+ERE REE+ERR+RER vs. NR. The significant contrasts within the Group factor are at level 2 – NE+ERE vs. REE+ERR+RER+NR and at level 4 – NE+ERE+REE+ERR, shaded in Table 4. The difference is significant between native speakers of English (both monolingual and bilingual), L2ers tested in the L2, and native speakers of Russian (both monolingual and bilingual).

***Table 4. Percentage of HA choices per group for all test conditions***

```
model.biling = glmer(PctNoun1 ~ Group_factor + (1 |Participant) + (1|Item), data = data_all, family = "binomial")
Fixed effects:      Estimate     Std. Error   z value   Pr(>|z|)
Group_factor2       -1.627687    0.433332     -3.756    0.000173 ***
Group_factor4       -1.335722    0.378364     -3.530    0.000415 ***
```

| Group | NE | ERE | REE | ERR | RER | NR |
|---|---|---|---|---|---|---|
| HA choice, % | 29% | 35% | 57% | 50% | 79% | 69% |

**Effect of a perception verb.** There is a significant effect of Verb Type on RC resolution, see Table 5. The effect of verb type is also shown by group. This is done for illustrative purposes, as there was no significant interaction Verb Type*Group and a perception verb had the same effect across all experimental groups – it favored HA.

***Table 5. RC resolution: Verb Type Effect***

model.biling = glmer(PctNoun1 ~ VerbType_factor*Group_factor + (1 |Participant) + (1|Item), data = data_all, family = "binomial")

**Random effects:**

| Groups | Name | Variance | Std.Dev. |
|---|---|---|---|
| Participant | (Intercept) | 0.9388 | 0.9689 |
| Item | (Intercept) | 0.1143 | 0.3380 |

*Number of obs: 2440, groups: Participant, 61; Item, 40*

| **Fixed effects:** | Estimate | Std. Error | z value | Pr(>\|z\|) |
|---|---|---|---|---|
| (Intercept) | 0.1122 | 0.1812 | 0.619 | 0.5358 |
| VerbType_factor | 0.2855 | 0.1419 | 2.011 | 0.0443 * |
| VerbType_factor:Group_factor | 0.204410 | 0.310550 | 0.658 | 0.510397 |

**Verb Type Effect**

| | **Perception Verb** | **Non-Perception Verb** |
|---|---|---|
| **Preference for HA** | 55% | 50% |

**Verb Type*Group: descriptive statistics**
**Preference for HA**

| **Group** | **Perception Verb** | |
|---|---|---|
| NE | 32% | 25% |
| ERE | 40% | 29% |
| REE | 60% | 54% |
| ERR | 52% | 49% |
| RER | 80% | 76% |
| NR | 69% | 68% |

In Table 5, shading separates the participants tested in English from the participants tested in Russian. Group statistics is descriptive, and it is used for illustrative purposes. However, it is noticeable that the respondents tested in English show higher sensitivity to the effect of a perception verb, i.e. native and non-native speakers of English react to a perception verb when its effect overrides the original preference for LA.

**Effect of Social Bias and the length of the RC.** Table 6 shows that both RC-Length and Social bias are significant as simple effects and in interactions, RC-length*Social Bias, RC-length*Group, Social Bias*Group. Both RC-length and Social Bias are 2-level factors. The 5 levels of the Group factor, preserved in this analysis, is described above.

For RC-Length, level 1 is *Long vs. Medium + Short*, level 2 is *Long + Medium vs. Short*. For Social Bias, level 1 is *Favoring LA vs. Favoring HA + Neutral*, level 2 is *Favoring LA + Favoring HA vs. Neutral*. Shaded areas in Table 6 show significant levels of interaction. The results marked in red indicate the results incongruent to the predicted effect.

***Table 6. RC resolution: RC-length and Social Bias***

model.biling = glmer(PctNoun1 ~ RC_Length_factor*Social_factor + (1 |Participant) + (1|Item), data = data_all, family = "binomial")

**Random effects:**

| Groups | Name | Variance | Std.Dev. |
|---|---|---|---|
| Participant | (Intercept) | 1.68392 | 1.2977 |
| Item | (Intercept) | 0.04426 | 0.2104 |

*Number of obs: 2440, groups: Participant, 61; Item, 40*

| **Fixed effects:** | Estimate | Std. Error | z value | Pr(>\|z\|) |
|---|---|---|---|---|
| RC_Length_factor | -0.6519 | 0.1453 | -4.487 | 7.24e-06 *** |
| Social_factor | 0.6334 | 0.1256 | 5.041 | 4.64e-07 *** |
| RC_Length_factor:Social_factor | 1.1214 | 0.3200 | 3.505 | 0.000457 *** |

**RC-length**

| | **Long** | **Medium** | **Short** |
|---|---|---|---|
| **Preference for HA** | 65% | 48% | 43% |

**Social Bias**

| | **Favoring HA** | **Favoring LA** | **Neutral** |
|---|---|---|---|
| **Preference for HA** | 61% | 42% | 54% |

**RC-length*Social Bias**
**Preference for HA**

| | **Favoring HA** | **Favoring LA** | **Neutral** |
|---|---|---|---|
| **Long** | 67% | 62% | 59% |
| **Medium** | 54% | 41% | 51% |
| **Short** | 61% | 30% | 64% |

**RC-length*Group**
**Preference for HA**

| **Group** | **Long** | **Medium** | **Short** |
|---|---|---|---|
| NE | 43% | 27% | 20% |

| | | | |
|---|---|---|---|
| ERE | 59% | 28% | 30% |
| REE | 72% | 56% | 46% |
| ERR | 59% | 43% | 55% |
| RER | 84% | 73% | 82% |
| NR | 77% | 63% | 68% |

As can be seen in Table 6, long RCs facilitate HA resolution, whereas, medium and short RCs are more likely to result in LA. There is an overall effect of Social Bias on RC processing in all groups. However, the interaction RC-length*Social Bias suggests that long RCs force HA overriding the LA prompted by Social Bias. Short RCs are susceptible to the effect of social bias when HA is favored. In the Neutral social bias, HA is still preferred on short RCs. The latter partly correlates with the Group effect. The difference by group is only significant for short RCs. Participants generally demonstrate a language-specific preference for RC-resolution, HA in Russian and LA in English. That is, the language of testing may be a stronger predictor for RC resolution than the factor RC-length. This assumption is checked in the next stage of the analysis.

**Effects of the language of testing (Language).** The factor Language divides the data pool into two groups: the participants tested in English and the participants tested in Russian. The former comprises groups NE, ERE and REE, the latter – groups NR, RER and REE, thus joining native and non-native speakers of a given language.

Table 7 shows the effect of Language on RC resolution. RC resolution is different depending on whether the sentence is processed in Russian or in English. The Language factor also interacts significantly with RC-length and Social Bias. There is no significant interaction with the factor Verb Type.

Shaded areas in Table 7 show significant levels of interaction, the percentage choices in red contradict the theoretical predictions.

***Table 7. RC resolution: Language (of testing) effect***

```
model.biling = glmer(PctNoun1 ~ Language_factor*Social_factor*RC_Length_factor + (1 |Participant) + (1|Item), data = data_all, family = "binomial")
```

**Random effects:**

| Groups | Name | Variance | Std.Dev. |
|---|---|---|---|
| Participant | (Intercept) | 0.046788 | 0.21631 |

| | | | | |
|---|---|---|---|---|
| Item | (Intercept) | 0.002394 | | 0.04893 |
| *Number of obs: 2440, groups: Participant, 61; Item, 40* | | | | |
| **Fixed effects:** | Estimate | Std. Error | t value | Pr(>\|z\|) |
| (Intercept) | 0.53236 | 0.03100 | 17.173 | < 2e-16 *** |
| RC_Length_factor1:Language_factor | 0.13093 | 0.05316 | 2.463 | 0.01503 * |
| RC_Length_factor2:Language_factor | 0.15263 | 0.05838 | 2.615 | 0.00912 ** |
| Social_factor2:Language_factor | 0.11164 | 0.05043 | 2.214 | 0.02747 * |

| **Language Effect** | | |
|---|---|---|
| | **English** | **Russian** |
| **Preference for HA** | 43% | 63% |
| **Language*RC-length Preference for HA** | | |
| **RC-length** | **English** | **Russian** |
| Long | 60% | 70% |
| Medium | 40% | 56% |
| Short | 34% | 65% |
| **Language*Social Bias Preference for HA** | | |
| **Social Bias** | **English** | **Russian** |
| Favoring HA | 54% | 67% |
| Favoring LA | 32% | 53% |
| Neutral | 41% | 65% |

As can be gathered from Table7, English is a LA-language and Russian is a HA-language for both native and non-native speakers. The Language effect overrules the potential of short RCs to be attached lower in the tree. Likewise, an effect of the Social Bias favoring LA is overridden by the Language – Russian.

A strong effect of the Language factor invites for a preliminary conclusion that L2ers process their non-native languages in the target-like manner. This needs to be double-checked in the analysis of the effect of native language on RC resolution.

**Effect of Native Language (NL).** The factor NL groups all native speakers of English (NE, ERE, ERR), be they tested in their L1 or their L2, in one group and compares their performance to the three groups of native speakers of Russian (NR, RER, REE). NL factor comes out significant as a simple effect and in the interaction NL*Social Bias (Table 8). There is no significant interactions NL*RC-length or NL*Verb Type.

***Table 8. RC-resolution: NL effect***

model.biling = glmer(PctNoun1 ~ NLe_factor*Social_factor + (1 |Participant) + (1|Item), data = data_all, family = "binomial" )

**Random effects:**

| Groups | Name | Variance | Std.Dev. |
|---|---|---|---|
| Participant | (Intercept) | 0.039089 | 0.19771 |
| Item | (Intercept) | 0.002472 | 0.04972 |

*Number of obs: 2440, groups: Participant, 61; Item, 40*

<table>
<tr><th>Fixed effects:</th><th>Estimate</th><th>Std. Error</th><th>t value</th><th>Pr(>|z|)</th></tr>
<tr><td>(Intercept)</td><td>0.52591</td><td>0.02790</td><td>18.853</td><td>< 2e-16 ***</td></tr>
<tr><td>NL_factor</td><td>0.25671</td><td>0.05354</td><td>4.795</td><td>1.09e-05 ***</td></tr>
<tr><td>Social_factor1:NL_factor</td><td>0.08150</td><td>0.03755</td><td>2.170</td><td>0.0301 *</td></tr>
</table>

**NL Effect**

| | **English** | **Russian** |
|---|---|---|
| **Preference for HA** | 40% | 66% |

**NL*Social Bias**
**Preference for HA**

| **Social Bias** | **English** | **Russian** |
|---|---|---|
| Favoring HA | 45% | 78% |
| Favoring LA | 31% | 52% |
| Neutral | 42% | 67% |

Table 8 shows that NL has an influence on RC resolution, which may seem contradictory to the Language effect reported in Table 7. At the same time, 2/3 of the population in each subgroup by NL are native speakers of the language in focus. The inconsistencies may only concern L2ers and can be explained by the significant differences in RC resolution by Group, shown in Table 4 above. All in all, L2ers show a preference for RC resolution that is already statistically different from their L1 but not quite like their L2 yet, thus demonstrating the influence of the NL. Besides, an effect of Social Bias influences all the participants, but it does not override the effect of the NL.

**Processing load (RT):**

The increase of processing load is measured through the increased reading time (RT) at the complemetizer and at the embedded verb. Table 9 shows significant simple effects and interactions. The anticipated effect of a perception verb on the RT mid-sentence was not attested. However, there is an effect of the Language factor on both the RT at complementizer and at the embedded verb. The RT at the embedded verb is influenced by significant interactions RC-length*Social Bias.

***Table 9 RT at the complementizer and the embedded verb***

model.biling = lmer(RT_comp ~ Social_factor*VerbType_factor*Language_factor*NL_factor*RC_Length_factor + (1 | Participant) + (1 | Item), data = data_all, REML = FALSE)

**Random effects:**

| Groups | Name | Variance | Std.Dev. |
|---|---|---|---|
| Participant | (Intercept) | 158883 | 398.6 |
| Item | (Intercept) | 18336 | 135.4 |
| Residual | | 438551 | 662.2 |

*Number of obs: 2440, groups: Participant, 61; Item, 40*

| **Fixed effects:** | Estimate | Std. Error | df | t value | Pr(>\|z\|) |
|---|---|---|---|---|---|
| (Intercept) | 770.815 | 38.730 | 62.029 | 19.902 | <2e-16 *** |
| Language_factor | 235.091 | 76.873 | 60.997 | 3.058 | 0.0033 ** |

model.biling = lmer(RT_V2 ~ Social_factor*VerbType_factor*Language_factor*NL_factor*RC_Length_factor + (1 | Participant) + (1 | Item), data = data_all, REML = FALSE)

| **Fixed effects:** | Estimate | Std. Error | df | t value | Pr(>\|z\|) |
|---|---|---|---|---|---|
| (Intercept) | 753.42 | 121.68 | 312.25 | 6.192 | 1.87e-09 *** |
| Language_factor | -221.21 | 104.14 | 60.95 | -2.124 | 0.0377 * |
| RC_Length_factorShort | 601.07 | 157.12 | 293.34 | 3.826 | 0.000159 *** |
| Gender_factorNeutral | -161.10 | 48.85 | 919.97 | -3.298 | 0.00101 ** |
| Gender_factorNeutral:RC_Length_factorShort | -1061.25 | 237.84 | 174.77 | -4.462 | 1.45e-05 *** |

| **RT complementizer: Language Effect** | | |
|---|---|---|
| | **English** | **Russian** |
| **Reading Time, ms** | 655 | 890 |

| **RT embedded verb: Language Effect** | | |
|---|---|---|
| | **English** | **Russian** |
| **Reading Time, ms** | 900 | 680 |

| **RC-length Effect RT embedded verb, ms** | |
|---|---|
| Long | 719 |
| Medium | 714 |
| Short | 1041 |

| **Social Bias Effect RT embedded verb, ms** | |
|---|---|
| Favoring HA | 845 |
| Favoring LA | 854 |
| Neutral | 685 |

**RC-length Effect * Social Bias**

| RT embedded verb, ms | | | |
|---|---|---|---|
| | Favoring HA | Favoring LA | Neutral |
| Long | 655 | 690 | 815 |
| Medium | 708 | 721 | 716 |
| Short | 1330 | 1376 | 413 |

Table 9 reports that increased processing load mid-sentence has a language-specific effect. In Russian, there is a slowdown at the complementizer, while in English—at the embedded verb. The Neutral, or fully ambiguous, condition for Social Bias shows the fastest RTs. This effect is supported by the interaction RC-length*Social Bias, also showing that short RCs in the fully ambiguous condition are the easiest to process. Meanwhile, short RCs are read the slowest in the full analysis by RC-length, i.e. where the effect of Social Bias is not sorted out.

## Discussion

The study reported in this paper investigated the processing of ambiguous RCs by native and non-native speakers. It tested the effects of 1) a perception verb in the matrix clause; 2) the placement of prosodic pauses in relation to the length of the RC; 3) lexical information that triggers social bias in RC interpretation. The study investigated whether native and non-native processing were fundamentally different. The results of the experiment demonstrate no differences between how native speakers and L2ers incorporated the information from different sources in online sentence processing. There was no factor that influenced L2ers but had no effect on the participants tested in their L1s.

The only analysis where the contrast 'native–non-native' came out significantly different was RC resolution by Group (Table 4). L2ers in both Russian and English showed RC resolution patterns between the HA attested in Russian and the LA shown in English. Similar results were obtained in early studies by the proponents of the SSH (Felser *et al.*, 2003; Clahsen & Felser, 2006; among others). At this point, our study agrees with these earlier findings and acknowledges that the pattern of RC resolution at an intermediate level of L2 proficiency is different from either the L1 or the L2 of the speakers. However, the deeper analysis conducted in this paper provides evidence that these results may have a more complex explanation.

First, social conventions were expected to have a stronger effect on non-native than native speakers. This prediction was not confirmed, since no significant interaction of the factors Social Bias and Group was observed. Social conventions influenced both native and non-native processing, and this effect was similar across all experimental groups. Dividing the factor Social Bias into three levels—favouring HA, favouring LA and Neutral—the study showed that in the Neutral condition, the participants demonstrated 54% preference for HA. These results support the SSH claim that L2ers perform at chance in the absence of a strong non-structural prompt. However, our study also highlights the similar performance demonstrated by native speakers of Russian and English.

A further piece of evidence for L1–L2 processing similarity comes from the analysis of the length of the RC. The general assumption that RC-length entails a certain prosodic structure of the sentence and defines RC resolution was supported by our results. This effect was displayed in the preference for HA in long RCs and a tendency to attach short and medium RCs low. In the interaction of RC-length with social bias, the parsing motivated by prosody takes the upper hand in long RCs. The results were less clear for short RCs, which were expected to favour LA. In the condition when social bias prompted HA, even short sentences were attached high. Short RCs exhibited HA in Neutral social bias as well. These inconsistencies suggest that both prosody and social bias were taken into account in sentence processing. It is important to notice that there was no difference in how native and non-native speakers used prosodic information or social conventions.

The effects of RC-length and social biases suggest that both structural and non-structural information were equally available for native and non-native speakers. A potential for long RCs to make a separate prosodic unit, thus, favouring HA can be considered a universal processing cue. However, RC-length cannot exhaustively explain RC resolution. When the results of RC-length were presented by group, a significant contrast separated the participants tested in English from the participants tested in Russian. This observation was supported by the analysis of the effect of the language of testing in Table 7. Even though the participants were sensitive to both RC-length and social bias, the change in RC resolution prompted by these factors occurred within the range 0–50% HA in English and 50–100% HA in Russian. A strong language effect was also shown in the analysis of the effect of the native language. With 2/3 of the participants being tested in their L1s, this brings additional support for language-specific preference in RC resolution. In summary, the findings indicate that all the effects shaping RC resolution work within the scope of the general preference for LA in English and for HA in Russian.

The analysis of the preferred patterns of RC resolution clearly demonstrates that L2ers were sensitive to the same linguistic and non-linguistic prompts as native speakers. Similar findings come from the effect of the perception verb. First, a perception verb favoured HA resolution in both language and in all groups. The effect of a perception verb shown by group suggests that English, where LA needs to be overridden by the effect of a perception verb, was more sensitive to its influence than Russian.

A perception verb does not directly influence reading time mid-sentence. However, the analysis of language effect showed that the complementizer was read slower in Russian, whereas, processing in English slowed down at the embedded verb. Thus, these results support our assumption that a perception verb would trigger a structural projection for an eventive complement. This projection was the preferred parsing hypothesis in both Russian and English. However, the two languages dealt with the processing effects of this erroneous structural anticipation differently.

## Conclusions

The study investigated processing patterns for RC resolution in native and non-native languages. It established that both RC prosody and a perception verb were universal processing cues that shaped human language processing. Our finding showed that fully ambiguous RCs were the easiest to process. It patterns with psycholinguistics research in monolinguals (see van Gompel et al. 2000). The study established that native and non-native speakers began their sentence processing with structural predictions. The generated projection was sensitive to linguistic and non-linguistic information and could be amended online in accordance with the incoming prompts. Both native and non-native speakers were sensitive to non-structural information. However, its effects did not overrule the effects of structural prompts.

The study demonstrates that general findings in the field of monolingual processing are applicable when investigating non-native language processing. There are processing universals that shape sentence parsing across languages. At the same time, the processing costs of those universal prompts may vary from language to language.

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