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# Processing similarities between native speakers and non-balanced bilinguals

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## Abstract

**Aims and objectives:** The study investigates human sentence processing and argues that information from multiple sources is considered equally 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 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.

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## 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 15 years but has not yet been completely resolved (Clahsen & Felser, 2006, 2018; Dekydtspotter & Renaud, 2014; Dekydtspotter et al., 2006).

The debate concerns the interpretation of behavioral differences attested in multiple processing studies comparing native and non-native speakers (Felser & Cunnings, 2012; Felser et al., 2003a, 2003b, 2009; Papadopolou & Clahsen, 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. According to the updated version of the hypothesis, even 'learners who demonstrate nativelike grammatical knowledge are sometimes found to show non-nativelike processing patterns. This indicates that L2 speakers have difficulty putting their grammatical knowledge to use during real-time processing' (Clahsen & Felser, 2018, p. 4). 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 a non-linguistic nature (Hopp, 2014a, 2014b); as well as due to the fallacy of direct comparisons between monolinguals and L2ers (Dekydtspotter et al., 2006; Sprouse, 2011).

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 reanalyzes the information already processed and generates a new minimally needed node (Crocker, 1999; see also Fodor, 1998; Frazier, 1990; Frazier & Fodor, 1978).

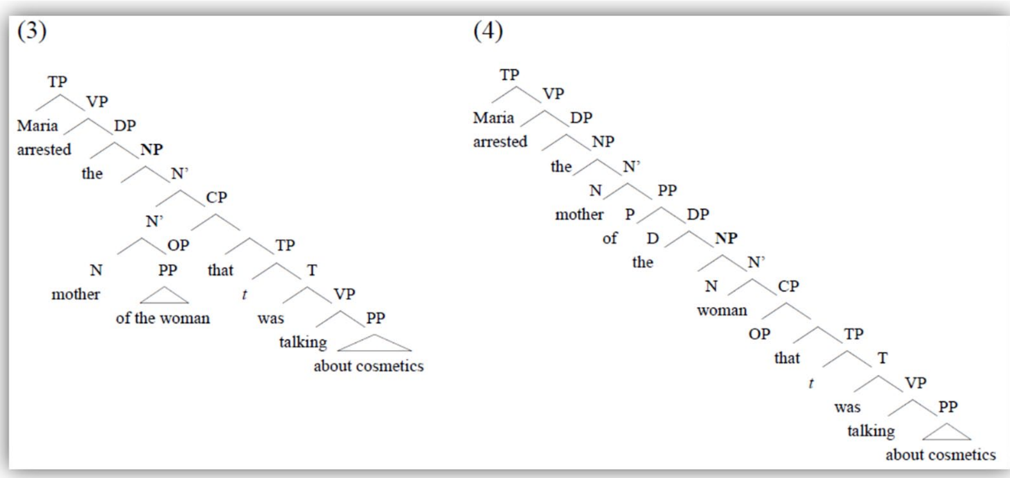
The capability of the human parser to check back to the already processed information in order to predict the upcoming structure has motivated a body of research on how exactly a parsing decision is made. The main debate concerns the question of whether structural parsing is sensitive to other types 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 (MacDonald et al., 1994; Tanenhaus et al., 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 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 et al., 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, 2003, 2013; 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) and investigates whether their interpretation depends on structural or non-structural information, and whether the effects will be different in 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 noun phrase (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 crosslinguistic variation in attachment preferences. Native speakers (NS) of Russian, French, German and Italian prefer the syntactic modification in (3) and choose HA, or interpretation (2a) (Cuetos & Mitchell, 1988; Grillo & Costa, 2014; Hemforth et al., 1998; Sekerina, 1997; Zagar et al., 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).

Crosslinguistic 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 comprehenders' minds and defines 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 to which the parser develops sensitivity. 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*

The use of social bias and its effect on (non-)native processing is innovative. In their overview of the existing studies, Clahsen and Felser (2018) point out that some predictions of SHH have received little scholarly attention. The authors refer to the relative absence of studies investigating the different weight of semantic and/or pragmatic information on processing in non-native languages. Our study addresses this issue.

Some lexical–semantic information triggers social conventions established in society and influences sentence processing and sentence interpretation. This is what we call 'social bias.' To be more specific, we assume that 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 HA and the one in (6)—LA.

(5) Maria called the <u>grandfather</u> of the boy that was wearing a tie.
Who was wearing a tie?
The grandfather *(more likely choice)*

(6) Maria called the son of the <u>woman</u> 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. The SSH claims that '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 are implementing purely structural parsing.

Alternatively, the FT/FA/FP approach advocated by Dekydtspotter et al. (2006, 2008) claims that L1 and L2 processing implement the same routines, i.e., mental structure building. To be more specific, in both L1 and L2, the parser builds the linguistic structure in (3), which favors HA (2a) in Russian. In English, structure (4) ensures LA (2b) for both L1 and L2 speakers.

Dekydtspotter and 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 to our experiment. RC resolution is predicted to have a language-specific pattern, HA in Russian and LA in English, in all experimental groups; and social conventions may not overrule a certain structural preference typical for a given language. In other words, social conventions are not expected to influence L2 speakers in any special way.

## *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 crosslinguistic 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 favors LA of the RC. Dekydtspotter et 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 et 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 determiner phrase (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 RCs 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 linguistic prompts. We would like to highlight the fact that RC-length influences RC resolution in both French and English (Dekydtspotter et al., 2008). Therefore, the length of a constituent, the RC, can be viewed as a universal parsing cue that prompts a certain parsing decision. If this assumption is correct, native and non-native speakers, even at lower proficiency levels, would attach longer RCs higher in the tree while short RCs will return to LA preference.

The described effect should be observed in both English and Russian, in either L1 or L2. If, on the other hand, native and non-native speakers demonstrate different sensitivity to the lengths of the RC, we will have attested different processing behavior in native and non-native languages and will have to seek potential explanations within the framework of the SSH.

The last alternative for RC resolution and the effect of the RC-length is that neither L1 nor L2 speakers are sensitive to it. In particular, the participants may demonstrate HA preference in Russian and LA preference in English, irrespectively of the length of the RC. This will mean that the participants are sensitive to the default prosody of either English or Russian and parse the RC accordingly. These findings will go in line with the assumptions of the IPH. However, the length of the RC will not be viewed as a universal processing cue that shapes RC resolution across languages.

## *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 verbs) 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 and Schneider (2000), among others. These scholars claimed that a generated projection shaped the whole sentence parse, 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). This model describes sentence parsing in the following way. 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.

To make predictions for the participants' processing behavior, we extend the assumptions of the Race model. First, the model claims optionality in structural analysis, i.e. the parser can choose from several possible predictions. In our case, a different number of structural predictions can be anticipated after a perception or a non-perception matrix verb. Second, only one parsing hypothesis is selected and only one structure is built at a time. In our experiment, the preferred parsing hypothesis after a perception verb is the eventive complement described below (cf. Pozniak et al., 2019). Third, the preferred structure must be supported by multiple sources of linguistic information. We check this claim only partially. To be more specific, we use a perception verb as the matrix predicate and test the participant's sensitivity to its selectional properties. We understand the type of the matrix verb as a syntactic prompt that favors a certain type of parsing behavior (see Christianson, 2016 for an alternative approach).

The effect of a perception verb on RC resolution was studied by Grillo and Costa (2014) in Romance languages. 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 an 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 upcoming sentence. Grillo and Costa (2014) claim that an eventive complement is easier for the parser than 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 upcoming 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 toward the RC mid-sentence. The latter translates into increased processing difficulty at certain segments.

Processing patterns in Russian and English are going to be different. To start with, Russian is an HA language, 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 govori-la
*Maria-NOM saw-PAST.fem.sg that mother-NOM boy-GEN talk-PAST.fem.sg*
pro kosmetik-u]
*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. However, checking all possible effects of a perception verb is beyond the goals of the current study. We are assuming that a processing effect caused by a perception verb occurs early in the sentence in Russian. Therefore, we compare the reading time (RT) at the complementizer and at the embedded verb, the regions where English and Russian differ. In doing so, we 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 is 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 . . . talking about cosmetics].
b. Maria **saw** [$_{DP}$ the mother of the boy [$_{RC}$ that was talking about cosmetics]].

When the parser has processed the head DP *[the mother of the boy]*, it still anticipates a verbal element *talking* to follow. Therefore, a processing conflict occurs only when the complementizer *that* 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 adjustment increases the processing load at the following area, 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 in English only. In Russian, the erroneous anticipation of the eventive complement is ruled out earlier. Therefore, a perception verb is not expected to cause any processing difficulty at this segment. We treat a perception verb as a syntactic prompt that favors HA. If the FT/FA/FP is right, both native and non-native speakers will be sensitive to the selectional properties of this verb. The sensitivity will mainly show in English where the default preference for LA needs to be overridden by the effect of a perception verb (see Grillo et al., 2015 for examples). The SSH predicts a different weight of linguistic information in native and non-native languages. Therefore, L2 speakers may not be sensitive to the structural prompt of the matrix verb and rely more on social conventions.

## Research questions

The general predictions will be tested by the following set of research questions (RQ).

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

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

We anticipate that RQ 1 would receive the answer—no—L1 and L2 processing are fundamentally similar. This conclusion will be possible, if RQ 1.1, RQ 1.2 and RQ 1.3 do not receive any statistically significant difference between L2ers and native speakers in how much their processing relies on social conventions (RQ 1.1), or the length of the RC (RQ 1.2) or the structural prompt triggered by a perception verb (RQ 1.3).

RQ 1 (as well as RQ 2) considers the participants' answers to the comprehension questions to be a proxy of their preferred type of RC resolution. It also relies on the processing data which checks whether any of the three main factors make sentence parsing more difficult. A perception verb is expected to influence sentence parsing in English more than in Russian. Therefore, an increase in processing load mid-sentence in English, be it the L1 or the L2 of the participants, will become evidence for similar sensitivity to the processing effects of a perception verb.

The study also aims at providing a detailed description of how the human sentence processor works. RQ 2 focuses on the amount of effect each factors has on RC resolution. Bearing in mind that there is a crosslinguistic variation in RC resolution between English and Russian, RQ 2.1 and RQ 2.2 check whether social bias, or RC length, or the structural effect of a perception verb override the default preference for HA in Russian or for LA in English.

RQ 2 relies on processing data too. The three main factors create either congruent or incongruent processing conditions in each of the target languages. For example, social bias favoring LA creates an incongruent processing condition in a HA language—Russian. At the same time, the longer RCs favoring HA create an incongruent processing condition in the LA language—English. Therefore, incongruent processing conditions should influence the participants and their effect will show in prolonged response time.

## Experiment

### *Stimuli*

The experiment had a two-by-three-by-three design in each language, English and Russian. The stimuli manipulated the type of 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(s) indicating the most likely doer of an activity. The selection criterion was 85% preference and above. For example, if 85% of the respondents selected a combination like *play with a kitten—a child, a boy, a girl*, the activity was classified as associated with a child doer and used in the biased condition. Alternatively, if an activity like *participate in a social project* returned a mixed preference—*a boy, a girl, a woman, a professional*—in 85% of the answers, it was classified as neutral from the perspective of social conventions.

**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 |
| | Maria **videla** *vnučku ženščiny* kotoray igrala s kotenkom | Maria **videla** *babušku devochki* kotoray igrala s kotenkom | Maria **videla** *sestru sosedki* kotoraya učastvovuet v sotsialnom proekte |
| | Maria saw-Past granddaughter-ACC woman-GEN that-FEM play-PAST FEM with kitten-INS | Maria saw-Past grandmother-ACC girl-GEN that-FEM play-PAST FEM with kitten-INS | Maria saw-Past sister-ACC neighbor-GEN that-FEM participate-PAST FEM in social-ADJ project-PR |
| | *Maria saw the sister of the neighbor that participated in a social project* | *Maria saw the granddaughter of the woman that played with a kitten* | *Maria saw the grandmother of the girl that played with a kitten* |
| 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. |
| | Politsia **arestovala** *vnučku ženščiny* kotoray igrala s kotenkom | Politsia **arestovala** *babušku devochki* kotoray igrala s kotenkom | Politsia **arestovala** *sestru sosedki* kotoraya učastvuet v sotsialnom proekte |
| | Police arrested-Past granddaughter-ACC woman-GEN that-FEM play-PAST FEM with kitten-INS | Police arrested-Past grandmother-ACC girl-GEN that-FEM play-PAST FEM with kitten-INS | Police arrested-Past sister-ACC neighbor-GEN that-FEM participate-PAST FEM in social-ADJ project-PR |
| | *Police arrested the sister of the neighbor that participated in a social project* | *Police arrested the granddaughter of the woman that played with a kitten* | *Police arrested the grandmother of the girl that played with a kitten* |

The survey was given to 20 people in each country, the USA and Russia. The respondents were of similar age and social status to the participants of the study, 27–42 years old. They were either college students or young professionals with BA or MA degrees. None of the respondents of the survey took part in the subsequent experiment.

The social bias factor had three levels: Favoring HA, Favoring LA and Neutral. The matrix verb (verb type) factor had two levels—a perception vs. a non-perception verb. An example of experimental sentences manipulating verb type and social bias is given in Table 1.

Notice that Russian requires a grammatical gender agreement between the head nouns and the complementizer. For this reason, English and Russian examples in the biased conditions can vary in the use of a social convention in a given sentence. To create the experimental targets, the English examples in Table 1 were initially changed from *the mother of the boy* to *the mother of the girl* to observe the grammatical gender in Russian. However, the survey did not return the required 85% for a biased condition, i.e. the activity of *talking about cosmetics* was not collectively assigned to *the mother* making it impossible to use direct translations. Instead, a condition that observed the grammatical gender in Russian and was selected as biased in 85% of the cases was picked. The number of conventionally biased and neutral cases was balanced across the full stimulus set between the target languages.

**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 | | |
| | Maria videla | vnučku ženščiny | kotoraya igrala | s kotenkom | | |
| | Maria saw-Past | granddaughter-ACC woman-GEN | that-FEM play-PAST FEM | with kitten-INS | | |
| Medium | Maria **saw** | the grandson of the man | that was playing | football | in the yard. | |
| | Maria videla | vnuka mužčiny | kotoryj igral | v futbol | vo dvore. | |
| | Maria saw-Past | grandson-ACC man-GEN | that-MASC play-PAST MASC | in football-ACC | in yard-PR | |
| Long | Maria **saw** | the grandson of the man | that was buying | flowers | on the corner | of the street. |
| | Maria videla | vnuka mužčiny | kotoryj pokupal | tsvety | na uglu | ulitsy. |
| | Maria saw-Past | grandson-ACC man-GEN | that-MASC buy-PAST MASC | flowers-ACC | on corner-PR | street-GEN |

The second 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. The Russian and English examples are equivalent, except for the example in the short condition. It uses the sentence from Table 2; a possible mismatch between the stimuli is explained above. Table 2 demonstrates how the condition for RC-length was created. The total number of items was balanced so that RC of each length, short, medium and long, would occur in every condition for social bias.

A full list of experimental items included 40 target sentences (10 quadruples) and 40 distractors. The 40 target items were split into halves by the factor verb type, and divided by 1/3 for the 3-level factors social bias and RC-length. There were 12 sentences *Favoring HA*, 12 sentences *Favoring LA* and 16 *Neutral* sentences in the condition social bias. The RC-length factor had 16 long, 16 medium and eight short sentences. Variability in the number of items in each factor occurred due to the difficulty of balancing between the two 3-level factors in two typologically different languages. The different number of experimental items per condition were taken into consideration in the statistical analysis.

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, which reduced their fatigue and lack of concentration. Both the target sentences and the distractors were followed by comprehension questions which offered two answer choices. The distractors had only one grammatically possible answer to the comprehension question, for example, *Bill knows the neighbor whose daughter played with a kitten in the yard. Who played with the kitten? (a) the daughter (b) the neighbor*. The distractors were an additional measure double-checking that the participants stayed focused throughout the entire experiment. The order of the target sentences and distractors was randomized by Linger so that every participant saw a unique sequence of items.

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

| 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% (30–60%) | 37% (30–60%) | 45% (30–60%) | 45% (30–60%) |
| 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 (32–44) | 29 (27–39) | 21 (21–24) | 21 (21–24) | 29 (24–32) | 29 (24–32) |

## *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 at a time on the screen and make their parsing decisions at the time of processing. The way the sentence has been parsed is reflected in a comprehension question that follows the target sentence. Since the participants cannot reread the target sentences to reconsider their parsing decisions, a self-paced reading experiment reflects their initial parsing preferences, thus, closely imitating real-life processing.

In the study, 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. Participants were not paid for the study and volunteered their time and effort.

## *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 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 participants is given in Table 3. All bilingual participants completed a language proficiency measure in their L2.

**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 | ER-E | RE-E | ER-R | RE-R | NR |
| HA choice | 29% | 35% | 57% | 50% | 79% | 69% |

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 was adult L2 learners with no exposure to the target language in childhood. Heritage speakers of Russian, who are the majority of L2-Russian learners in colleges in the USA, were not included in the study. After splitting the ER participants into two, we ended up with 14 people in group ER-R to be tested in their L2 Russian and 7 people in the semi-control group ER-E to be tested in their native language—English. Equal numbers of Russian participants were also recruited.

## *Data analysis*

The data were analyzed with R version 3.6.3. Sentence processing is investigated through 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, language of testing (language) and native language of the participants (NL) were independent variables.

A generalized linear mixed model was used to analyze the reading time (RT) at the complementizer (RT_comp), the embedded verb (RT_emb) and the response time. The complementizer was included in the analysis because there is a popular assumption that native speakers demonstrate processing effects earlier that L2ers (Dekydtspotter et al., 2006)] For the verb type effect, the complementizer is the first constituent which signals that parsing should be adjusted to the restrictive RC in English. We are particularly interested in the language-specific RT effects in the L1s and L2s of the participants.

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 measured against the effect of language, social bias, RC length and NL factors. A possible processing effect of social bias and RC-Length was additionally checked in the analysis of the response time, or the time taken to answer a comprehension question.

The statistical analysis observes the following significance code from 0 to 1: *'0 '***'0.001 '**' 0.01 '*'0.05 '.'0.1 ' '1'*. The data in the results section are 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 the processing load 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 five levels of comparison. 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 vs. RE-R+NR, shaded in Table 4.

Table 2 demonstrates that there are two significant contrasts in the participants' preference for RC resolution, group_factor2 and group_factor4. These contrasts divide the entire population of participants into three subcategories, two groups in each. The first subcategory is groups NE+ERE, the second one is groups REE+ERR, and the third one is groups RER+NR. As we can see, all the participants whose native language is English are different from the participants whose native language is Russian, and both subgroups are different from the L2 speakers, tested in their respective L2s. This difference by group, in fact, shows that RC resolution preferences depend on the language of testing. In particular, those who are tested in their L1 Russian, monolingual and bilingual, demonstrate the Russian-like HA preference. Those who are tested in their L1 English, either the only language (NE) or the first language (ER-E) do not like HA. Instead, they stick to the English-like LA preference in RC resolution. The participants tested in their L2s are in between their native preference and their target-like performance. In particular, ER-R prefer HA in their L2 Russian in 50% of the cases on average, about 20% more than the monolingual English controls. Group RE-E have lower preference for HA than what is demonstrated in their native language—Russian—57% vs. 69%, as demonstrated by the NR group. Both groups show preferences in the middle between the monolingual controls, that is, 50% HA is preferred in L2 Russian and 57% of HA is preferred in L2 English.

*Effect of a perception verb.* There is a significant effect of verb type on RC resolution. In the full data analysis, a perception verb changes RC resolution by 5% (Table 5). For illustrative purposes, Table 5 also demonstrates the effect of verb type, but split by group. Even though the interaction verb type*group does not reach statistical significance, these data shed light on the effect of the matrix verb on RC resolution; the latter is statistically significant. The data provide a clearer picture of how a perception verb in the matrix clause favors HA of the RC.

In the descriptive statistics presented in Table 5, shading separates the participants tested in English from the participants tested in Russian. It is noticeable that the respondents tested in English show higher sensitivity to the effect of a perception verb, that is, a perception verb favors HA by 6–11% when the participants process English. In Russian, the change toward HA is 1–4%. It is important to appreciate that this division joins together English monolinguals, bilinguals tested in their L1-English and bilinguals tested in their L2-English; likewise, in Russian. Such groupings pool together participants on the basis of language of testing, be it their L1 or L2. In this light, L2ers demonstrate strong, native-like sensitivity to the effect of a perception verb in their L2 English and lighter sensitivity in Russian, which again represents native-like behavior.

**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 % | | Non-perception verb % | |
| NE | 32 | | 25 | |
| ERE | 40 | | 29 | |
| REE | 60 | | 54 | |
| ERR | 52 | | 49 | |
| RER | 80 | | 76 | |
| NR | 69 | | 68 | |

*Effect of social bias and the length of the RC.* Both RC-length and social bias are 3-level factors. The five levels of comparison in the group factor are described above. For RC-length, routine 1 compares *Long vs. Medium + Short*; routine 2 is *Long + Medium vs. Short*. For social bias, level 1 of comparison means *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 shows significant simple effects of the factors RC-length and social bias. There is a significant interaction RC-length*social bias. The effect of RC-length shows that long RCs facilitate HA resolution, whereas medium and short RCs are more likely to result in LA. The absence of the interaction group*RC-length suggests that the factor RC-length influences all groups of participants in the same way. In other words, a long RC favors HA across languages and in both native and non-native speakers.

An overall effect of social bias on RC resolution implies that non-structural information is considered in sentence processing. However, the absence of group*social bias interaction points to a homogenous effect of social bias in native and non-native languages. Lexical semantic information

**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 |

triggers social conventions which are equally accessible for monolingual speakers and language learners in each of their languages.

The RC-length*social bias interaction leads to a few interesting observations. First, let us compare the conditions where social bias prompts RC resolution, that is, the conditions *Favoring HA* and *Favoring LA*. Having established that long RCs favor HA across languages, we see that RC-length overrides the effect of social bias. Long RCs are attached high in the condition *Favoring LA*. Meanwhile, the non-structural prompt takes the upper hand in short RC: They are attached high despite of the predicted effect that short RCs tend to attach low. Importantly, in the *Neutral* condition, short RCs are also attached high. The analysis of RC-length*social bias demonstrates mixed results. There are effects of both structural and non-structural information in sentence processing in both native and non-native language. However, none of the main factors exhaustively defines RC resolution.

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

**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 |

Table 7 shows the effect of language on RC resolution, that is, it demonstrates 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 verb type factor.

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

As can be gathered from Table7, the language factor supports the well-established assumption that English is an LA-language and Russian is an HA-language. Besides, there is no interaction with the group factor, which means that RC resolution has a language-specific preference for both native and non-native speakers. The language*RC-length interaction shows that in Russian the language effect overrules the potential of short RCs to be attached lower in the tree. Likewise, Russian is almost insensitive to the social bias condition *Favoring LA*. HA preference remains

**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* | | | | |
| Fixed effects | Estimate | Std. error | t value | Pr(>\|z\|) |
| (Intercept) | 0.52591 | 0.02790 | 18.853 | <2e−16 *** |
| NL_factor | 0.25671 | 0.05354 | 4.795 | 1.09e−05 *** |
| Social_factor1:NL_factor | 0.08150 | 0.03755 | 2.170 | 0.0301 * |

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 |

slightly above 50% in Russian in this condition. English shows a similar pattern within the range of LA preference.

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

*Effect of native language.* 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). The NL factor comes out significant as a simple effect and in the interaction NL*social bias (Table 8). There are no significant interactions NL*RC-length, NL*verb type or NL*group.

Table 8 shows that NL has an influence on RC resolution, which may seem contradictory to the language effect reported in Table 7. It is important to mention that two-thirds of the population in each subgroup 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 (Table 4).

If the results of the language effect (Table 7) and the effect of NL (Table 8) are considered together, it can be seen that L2ers show a preference for RC resolution that is already statistically different from their L1 but not yet quite like their L2. This situation results in two significant simple effects: Language (of testing) and NL. An effect of social bias interacts with NL, but within the range of a language-specific preference for RC resolution.

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

model.biling = lmer(RT_Rel ~ VerbType_factor*Gender_factor*Language_factor*NL_factor + (1 | Participant) + (1 | Item) + (1 | Rel_Let), data = data_all, REML = FALSE)

Random effects

| Groups | Name | Variance | Std. dev. |
|---|---|---|---|
| Participant | (Intercept) | 83058 | 288.20 |
| Item | (Intercept) | 329 | 18.14 |
| Comp_Let | (Intercept) | 0 | 0.00 |
| Residual | | 280835 | 529.94 |

*Number of obs: 2440, groups: Participant, 61; Item, 40; Comp_Let, 2*

| Fixed effects | Estimate | Std. error | df | t value | Pr(>\|z\|) |
|---|---|---|---|---|---|
| (Intercept) | 764.882 | 38.712 | 62.015 | 19.758 | <2e–16 *** |
| Language_factor1 | 222.511 | 77.219 | 62.125 | 2.882 | 0.00543 ** |

model.biling = lmer(RT_V2 ~ VerbType_factor*Gender_factor*Language_factor*NL_factor + (1 | Participant) + (1 | Item) + (1 | V2_Let), data = data_all, REML = FALSE)

Random effects

| Groups | Name | Variance | Std. dev. |
|---|---|---|---|
| Participant | (Intercept) | 155764 | 394.7 |
| Item | (Intercept) | 14021 | 118.4 |
| V2_Let | (Intercept) | 34150 | 184.8 |
| Residual | | 444492 | 666.7 |

*Number of obs: 2440, groups: Participant, 61; Item, 40; V2_Let, 7*

| Fixed effects | Estimate | Std. error | df | t value | Pr(>\|z\|) |
|---|---|---|---|---|---|
| (Intercept) | 840.856 | 91.896 | 16.303 | 9.150 | 7.96e–08 *** |
| Language_factor | –264.141 | 112.969 | 80.935 | –2.338 | 0.0218* |
| Social_factor | –123.127 | 59.223 | 98.400 | –2.079 | 0.0402* |

RT complementizer: language effect

| | English | Russian |
|---|---|---|
| Reading time, ms | 655 | 877 |

RT embedded verb: language effect

| | English | Russian |
|---|---|---|
| Reading time, ms | 900 | 680 |

Social Bias effect: RT embedded verb, ms

| | |
|---|---|
| Favoring HA | 765 |
| Favoring LA | 922 |
| Neutral | 830 |

### *Reading and response time*

This section measures the processing effect of the verb type, social bias and RC-length. The effects of the verb type and social bias are measured through the increased RT at the complementizer and at the embedded verb.[1] Table 9 summarizes the statistically significant effects and interactions on the RT at the complementizer and the embedded verb. The results of the RT analysis are provided in Table 9.

Table 9 demonstrates that RTs are influenced by simple effects only: a language effect and an effect of social bias. The anticipated effect of a perception verb on the RT mid-sentence was not attested. However, the effect of a perception verb is indirectly supported by the fast RT in the condition *Favoring HA* and by the language effect at the embedded verb. First, if parsing decisions to favor HA are made at the level of the matrix verb, the subsequent information supporting the HA analysis creates congruent processing conditions. Therefore, a sentence where HA is favored has faster RT at the embedded verb. Second, there is an anticipated slowdown in the RT at the embedded verb in English, where the complementizer signals a change of structure toward the RC.

Third, the complementizer itself is read faster in English than in Russian. The complementizer was included in the analysis to establish possible differences between native and non-native processing. Dekydtspotter et al. (2006) argued that native speakers demonstrate processing effects earlier than L2ers. Our analysis did not reveal such differences. The complementizer was read faster by all participants tested in English, be it their L1 or L2. Therefore, faster RT in English can be explained by the length of the word itself. The complementizer has four characters in English, and seven in Russian. We would like to mention that the number of letters was constant across all experimental conditions in a given language, besides the analysis checked for possible random effects of the factor number of letters (Comp_Let). The embedded verbs had the equivalent number of characters in English and Russian, meanwhile, they were read slower in English. The latter allows us to conclude that a slowdown of the RT at the embedded verb in English can only mean a processing difficulty at this segment.

As pointed out by one of our reviewers, social bias resolves the ambiguity toward the final segments of the sentence. Therefore, the final stages of sentence processing should be checked for this effect. Bearing in mind that our target sentences vary in length, we check the response time, or the time taken by the participants to answer a comprehension question for significant effect of any of the factors used in the analysis. The results are provided in Table 10.

There is only one significant effect on response time—the effect of social bias—but even this effect is marginally significant. The data in Table 10 indicate that the condition *Favoring HA* is the easiest at the final stage of linguistic decision making. These results go in line with the data on social bias and language effect on the RT at the embedded verb (Table 9). They indirectly support the claim that the non-structural condition *Favoring HA* is congruent with the parsing decision triggered by a perception verb in the matrix clause. This congruence makes sentences prompting HA of the RC easier for processing.

## Discussion

The study reported in this paper investigates the processing of ambiguous RCs by native speakers and L2 learners. Our scholarly investigation is organized around two main research questions: (1) whether processing in L2 is different from processing in L1; and (2) whether non-structural information influences sentence parsing. We use a perception verb in the matrix clause to test whether native and non-native speakers are sensitive to the selectional properties of the matrix verb and adjust their sentence parsing accordingly. The second experimental condition checks whether the

**Table 10.** Response time.

model.biling = lmer(RespTime ~ VerbType_factor*Social_factor*RC_Length_factor*Language_factor*NL_factor + (1 | Participant) + (1 | V2_Let) + (1 | Item), data = data_all, REML = FALSE)

Random effects

| Groups | Name | Variance | Std. dev. |
|---|---|---|---|
| Participant | (Intercept) | 155764 | 394.7 |
| Item | (Intercept) | 14021 | 118.4 |
| Residual | | 444492 | 666.7 |

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

| Fixed effects | Estimate | Std. error | df | *t* value | Pr(>\|z\|) |
|---|---|---|---|---|---|
| (Intercept) | 3356.433 | 175.951 | 15.199 | 19.076 | 4.97e−12*** |
| Social_factor | 241.408 | 135.763 | 43.537 | 1.778 | 0.0824 |

| Social Bias effect: response time, ms | |
|---|---|
| Favoring HA | 3257 |
| Favoring LA | 3426 |
| Neutral | 3508 |

placement of prosodic pauses in relation to the length of the RC influences its attachment resolution. Third, we use lexical information that triggers social bias in RC interpretation and check whether it has a different effect in native and non-native languages.

The results of the experiment demonstrate no differences between processing behavior in native and non-native languages. There is no factor that influences L2ers but has no effect on the participants tested in their L1s, and vice versa. For example, social conventions were expected to have a stronger effect on non-native than on native speakers in RC resolution (RQ 1.1). 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. These results are even more remarkable when we consider the intermediate proficiency of the L2 speakers. Processing L1–L2 similarities such as the ones we established here confirm the FT/FA/FP position and argue against the SSH hypothesis which predicts stronger influence of non-structural information in non-native languages than in native ones.

A further piece of evidence for L1–L2 processing similarity comes from the analysis of the length of the RC (RQ 1.2). The general assumption that RC-length entails a certain prosodic structure of the sentence and defines RC resolution is supported by our results. This effect is 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 are less clear for short RCs, which were expected to favor LA. However, short RCs attach high when social bias prompts HA, as well as in the *Neutral* social bias. The latter is unexpected.

The inconsistency in the effects in interaction RC-length and social bias require further investigation. However, they definitely speak in favor of the processing models which argue for simultaneous access to structural and non-structural information in human sentence processing (see van Gompel et al., 2000 for an overview). In the field of non-native processing, the SSH (Clahsen & Felser, 2018) claims that the non-native parser is more sensitive to non-structural information than the native-language parser. The stronger sensitivity of the non-native parser to non-structural information is not supported by our results.

The only analysis where the contrast 'native–non-native' came out as significant was RC resolution by group (Table 4). L2ers in both Russian and English showed intermediate preference in RC resolution, i.e. their percentile score for HA of the RC was between the HA attested in Russian and the LA shown in English. Similar results were obtained in early studies by the proponents of SSH (Clahsen & Felser, 2006; Felser et al., 2003; 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 L2 of the speakers. However, the deeper analysis conducted in this article provides evidence that these results may have a more complex explanation.

Adding two language-related factors, the effect of the language (of testing) and the effect of NL, our study demonstrates that L2ers preference for RC resolution has become different from their native language but has not yet achieved a target-like performance in L2. We explain these results by our participants' intermediate level of L2 proficiency. This assumption can be easily checked with advanced L2 speakers of English and Russian, who are expected to behave target-like in their L2.

It is important to note that neither of the findings summarized above demonstrates that any of the attested effects overrides the language-specific preference in RC resolution, i.e. all the effects shaping RC resolution work within the scope of the general preference for LA in English and for HA in Russian. The effect of a perception verb has not become an exception (RQ 1.3). It has a homogenous effect on all the participants and favors HA. However, the effect of a perception verb is just a tendency to favor HA of the RC under its influence. It is not a decisive factor that annuls the default preference for LA in English. Interestingly, both native and non-native speakers of English are more sensitive to the effect of a perception verb than the mirror-image groups in Russian. The latter brings another strong argument in favor of processing similarities in native and non-native languages.

The second research question examines the different effect each factor has on sentence processing. This question checks whether the RC-length or social bias overrides the effect of a perception verb (RQs 2.1 and 2.2). Our results demonstrate that both prosody and social bias are taken into account in sentence processing, and there is no difference in how native and non-native speakers use prosodic information, or social conventions, or react to the selection properties of the matrix verb. We also conclude that none of these factors is decisive for RC resolution.

Analysis of the reading and response time provides a slightly different picture. Our results demonstrate that the structural information triggered by a perception verb has a stronger effect on sentence processing than RC-length or social bias. Despite the fact that there is no direct effect of a perception verb on RT mid-sentence, the language effect shows that the embedded verb is read more slowly in English than in Russian. Our linguistic analysis demonstrates that the eventive complement triggered by a perception verb should cause an increase in processing load in different places in English and Russian. The expectation of slow processing in English was at the embedded verb, exactly where our participants, both L1 and L2 speakers, slowed down their reading time in English.

The processing effect of the matrix verb receives additional support in the analysis of social bias. At the embedded verb, the condition which biased HA demonstrated faster RTs than the condition *Favoring LA* or the *Neutral* condition. Bearing in mind that a *Neutral* condition should be the easiest for processing (see Tanenhaus et al., 1995; van Gompel et al., 2000 for an overview), we argue that the preference for HA ensured by the effect of a perception verb becomes a congruent processing condition when the socio-conventional information in the RC also favors HA. The same effect of social bias is observed at the end of the sentence. The response time is faster when social bias favors HA. Therefore, we conclude that structural information guides sentence processing in both native and non-native languages.

Our findings clearly demonstrate that native speakers and L2ers incorporate the information from different sources in online sentence processing. However, the reading and response time point to the fact that non-linguistic factors facilitate sentence processing only when they are congruent with the effects of structural parsing. We would like to highlight the homogenous sensitivity to the effect of a perception verb and to the manipulated RC-length in both English and Russian. We propose that both RC-length and the effect of a perception verb are universal processing cues that deserve further investigation.

## Conclusions

The study investigated processing patterns for RC resolution in native and non-native languages and attested no difference between monolingual and non-native processing. Our findings establish that native and non-native speakers are sensitive to the selectional properties of the matrix verb and begin their sentence processing with a structural prediction. Both native and non-native speakers respond to non-structural information. However, its effects do not overrule the effects of a structural prompt.

The study demonstrates that there are processing universals that shape sentence parsing across languages. Both RC length and the effect of a perception verb appear to be such universal cues. The relatively early parsing success of our intermediate-proficiency learners is thus easily explained. At the same time, having universal processing prompts does not guarantee identical sentence processing across languages. Our participants deal with the processing costs of a perception verb in English and Russian in different ways.

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### Note

1. The factor RC-length is not relevant for the analysis of the processing load mid-sentence.

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