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New evidence for the role of morphological markedness of gender agreement cues in monolingual and heritage-bilingual facilitative processing

Zuzanna Fuchs & Irina A. Sekerina*

Abstract. The presence of gender agreement markers prior to the noun speeds recognition of the noun in monolingual speakers of languages such as German, Spanish, Dutch and Polish, but this effect is still understudied for bilingual speakers. The present Visual World eye-tracking study investigated the real-time processing of gender agreement cues on adjectives and verbs to see if they facilitate recognition of the noun in both monolingual and heritage Russian speakers. Participants viewed visual displays in Ambiguous vs. Unambiguous conditions, crossed with MASC or FEM target nouns. Monolingual speakers looked more to the target in Unambiguous than Ambiguous conditions for both FEM (more salient cues) and MASC (null/less salient cues) targets. Heritage speakers (HSs) demonstrated facilitative use of the more salient FEM cues, in line with previous findings, but not MASC cues. We conclude that the morphological saliency of the agreement marker impacts HSs' ability to access the gender feature and integrate it into the process of spoken word recognition during language comprehension.

Keywords. grammatical gender; Russian; heritage language processing; eye-tracking

1. Introduction. Research on the processing of grammatical gender in languages that mark gender agreement has shown that the presence of such agreement marking prior to the noun itself can speed lexical access of the subsequent noun. When the comprehender encounters an agreement cue on a pre-nominal element, such as an article, adjective, or verb, they access the abstract gender feature on this cue and efficiently integrate it into the process of word recognition, leading to faster lexical retrieval. This has been robustly shown to be the case for monolingual speakers of languages such as Spanish (Lew-Williams & Fernald 2007, 2010), German (Hopp & Lemmerth 2016), Dutch (Brouwer et al. 2017), and Polish (Fuchs 2023). Investigations of facilitative processing in heritage speakers (HSs) have found that, despite broadly acknowledged differences in knowledge of grammatical gender in a heritage language (e.g., Polinsky 2006, 2008; for an overview see Polinsky 2018: §5.3.2), HSs can also use abstract gender agreement features to facilitate lexical retrieval in a target-like manner during real-time spoken language comprehension (Fuchs 2021, 2022).

However, existing work has not yet explored how the morphological markedness of the cue itself modulates listeners' facilitative processing. Properties of the languages in which facilitative processing has been investigated to-date have been such that cues to different grammatical genders in a single language typically occurred only once and were equally morphologically marked: e.g., in Spanish definite articles *el* vs. *la* (e.g., Lew-Williams & Fernald 2007), or in Polish, agreement on adjectives in the nominative case, in which agreement suffixes in each

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gender are realized as a single vowel (Fuchs 2022, 2023). Where asymmetries have been observed in the facilitative processing of a cue to a given gender, it has been hypothesized that these are the outcome of a lower reliability of a given cue, either due to it being phonologically unmarked (null) (Polinsky & Scontras 2020), phonetic similarity to other gender cues (Fuchs 2023), or distributional asymmetries, such as Dutch neuter articles preceding nouns of all genders in the diminutive (Loerts et al. 2013).

In this study, we address this gap in the literature by investigating the facilitative processing of grammatical gender in Russian. Adjectival agreement paradigms in Russian are such that agreement is fully morphologically marked for all three genders. However, in verbal agreement paradigms, only feminine and neuter are marked, whereas masculine is not. Flexible word order in Russian also allows multiple cues to gender to be available prior to the noun. We thus compare how facilitative processing proceeds when the cue to a grammatical category is more or less morphologically salient – or even, in the case of masculine agreement on verbs in Russian, phonologically null. This is a particularly compelling question for the investigation of facilitative processing in HSs, because, while it has been demonstrated that HSs generally do engage in facilitative processing, a different strand of the literature on HSs has generally acknowledged that HSs diverge from monolingual populations in their comprehension of less perceptually salient or silent linguistic material (Laleko & Polinsky 2017; Polinsky 2018). We first introduce the relevant properties of the Russian gender system and agreement paradigm (section 1.1) and what existing work on the processing of these systems has shown (section 1.2) before introducing the goals of the present study in further detail (section 1.3).

1.1. GENDER IN RUSSIAN. There is a vast linguistic literature on theoretical aspects (Corbett 1982, 1991: §3.1.1) of the category of gender in Russian that goes back 30 years. We refer the reader to these sources for an overview. In this section, we provide a necessarily brief description of gender and gender agreement in Russian essential for understanding the design of the present study (see also Polinsky 2008).

Russian has three genders – MASC, FEM, NEUT – which are marked on nouns, their modifiers (e.g., adjectives, pronouns, participles, numerals, quantifiers), and past tense verbs, but only in the singular, because gender distinctions are neutralized in the plural. Nouns are assigned gender lexically depending on the declension class. FEM nouns in Declension class I end in *-a/-ja* (e.g., *mašina* ‘car.FEM’) and MASC nouns in Declension class II end in a non-palatalized consonant *-C* (e.g., *avtobus* ‘bus.MASC’).¹ Nouns in plural (PL) most commonly end in *-i/-y* (*y* is an orthographic representation of the central mid vowel /i/) (e.g., *velosiped-y* ‘bicycle-PL’).

Modifiers agree with the head noun in gender and number (and also in case). Attributive adjectives in Russian typically precede the head noun. MASC adjectives end in *-yj/-ij* (e.g., *bystr-yj avtobus* ‘fast-MASC bus.MASC’), FEM adjectives end in *-aja/-jaja* (e.g., *bystr-aja mašina* ‘fast-FEM car.FEM’), and PL in *-ye/-ie* (e.g., *bystr-ye velosiped-y* ‘fast-PL bicycle-PL’). Verbal gender agreement is also very common and takes place between the sentential subject and the verb when it is in past tense, as illustrated in (1).

¹ There are nouns whose lexical gender assignment is idiosyncratic and not based on phonological characteristics. These include phonologically opaque FEM nouns from Declension class III (e.g., e.g., *ladon’* ‘palm.FEM’ vs. *olen’* ‘deer.MASC’), and hybrid (e.g., *vrač* ‘doctor.MASC/FEM’), and double-gender nouns (e.g., *sirota* ‘orphan.FEM/MASC’). NEUT nouns end in *-o/-e* (e.g., *oblako* ‘cloud.NEUT’). These are not discussed here as they were not included in the present study.

- (1) a. MASC Po doroge exal- \emptyset bystr-yj avtobus.
on road was.going-MASC fast-MASC bus.MASC
b. FEM Po doroge exal-a bystr-aja mašina.
on road was.going-FEM fast-FEM car.FEM
c. PL Po doroge exal-i bystr-ye velosiped-y.
on road were.going-PL fast-PL bicycles-PL
‘On the road, the fast car/bus/bicycles was/were going.’

A final nuance of gender agreement patterns in Russian has to do with lexical accent. Lexical stress can fall on any syllable, including adjectival or verbal agreement endings. When FEM adjectives and verbs are stressed on the stem, they leave the agreement suffix unstressed (*éxal-a* ‘went-FEM, Table 1), the unstressed ending *-a* is reduced to /ə/, making it ambiguous with the NEUT form (e.g., *éxal-o* ‘went- NEUT). That is, when unstressed, the FEM agreement suffix *-a* is opaque to gender. When the FEM adjective and verb agreement suffixes are stressed, the forms are unambiguous (*spal-á* ‘slept-FEM’, Table 1). PL *-y/-i* does not undergo vowel reduction.

			MASC		FEM		PL	
Verb, past tense								
ending stressed	<i>spát’</i>	‘to sleep’	<i>spál-\emptyset</i>	‘he slept’	<i>spal-á</i>	‘she slept’	<i>spál-i</i>	‘they slept’
ending unstressed	<i>éxat’</i>	‘to run’	<i>éxal-\emptyset</i>	‘he went’	<i>éxal-a</i>	‘she went’	<i>éxal-i</i>	‘they went’
Adjective								
ending stressed	<i>bol’s-</i>	‘big’	<i>bol’s-ój</i>		<i>bol’s-ája</i>		<i>bol’s-ýe</i>	
ending unstressed	<i>bystr-</i>	‘fast’	<i>býstr-yj</i>		<i>býstr-aja</i>		<i>býstr-yje</i>	

Table 1. Stress patterns in Russian gender agreement (stressed syllables marked by acute accent)

It is not surprising that this complex system of gender agreement in Russian causes production difficulties in HSs of Russian, although these difficulties are selective. Polinsky (2008) found that HSs were at ceiling for accuracy when they produced ending-stressed adjectives that had to agree with FEM/MASC nouns of Declension classes I and II in the citation form (e.g., *bol’s-ája mašina* ‘big-FEM car.FEM’). However, they were below chance with the stem-stressed NEUT nouns, instead assigning them to FEM (**zelén-ája bolóto* ‘green-FEM marsh.NEUT); it is notable that not all non-target-like gender assignment was to the (default) masculine gender. The HSs also assigned FEM nouns from Declension class III to MASC (**bol’s-ój postel’* ‘big-MASC bed.NEUT’). These errors were especially characteristic of low-proficiency HSs.

To sum up: gender agreement is marked both in the nominal domain on modifiers and in the verbal domain on past-tense verbs. Overt agreement markers on adjectives vary in syllable length, i.e., a /-Vj/ sequence for MASC vs. a /-VjV/ sequence for the other two genders. On verbs, MASC agreement is a phonologically null suffix ($-\emptyset$), but agreement for the other two genders is realized as a vowel. Thus, MASC agreement is different from FEM (as well as NEUT, not tested here) because it is less morphologically marked and less salient than the other agreement forms. Section 1.2 provides an overview of existing work on the processing of gender in monolingual and bilingual Russian, before section 1.3 introduces the key questions investigated in the present study through leveraging the properties of Russian gender agreement discussed here.

1.2. PROCESSING OF GENDER IN MONOLINGUAL AND BILINGUAL RUSSIAN. Gender agreement in Russian has been a topic of several experimental investigations of monolingual (Akhutina et al. 1999; Taraban & Kempe 1999) and bilingual L2 and heritage adults (Taraban & Kempe 1999; Polinsky 2006, 2008; Laleko 2019). In the priming paradigm, Akhutina and colleagues found

that monolingual Russian adults showed facilitation (i.e., faster reaction times in naming a noun after an adjectival modifier) in the matching gender condition, but only for FEM nouns. In a self-paced reading study, Taraban & Kempe (1999) measured reaction times on the subject noun and predicate verb that were preceded by an adjective. The facilitatory effect of gender agreement was evident only at the processing of the verb, but not the noun. L1-English–L2-Russian speakers in the same study did not differ in their patterns of RTs from the monolingual participants, but they were in general slower than monolinguals. No differences between MASC and FEM gender were reported in the study. Polinsky (2008) found that HSs produced non-target agreeing forms primarily for NEUT nouns and for FEM nouns ending in *-C'*. Laleko (2019) demonstrated that when L2 and heritage speakers of Russian judged grammatical acceptability of NPs with morphophonologically transparent nouns (Declension classes I and II), their accuracy of gender agreement between adjectives and nouns and between nouns and verbs was high and did not differ from the monolingual control group.

The present line of investigation focuses on real-time processing of gender agreement cues on adjectives and verbs when they precede a noun and specifically on whether these agreement markers help facilitate recognition of that noun in both monolingual and heritage Russian speakers. The facilitative effect of gender agreement during spoken-language comprehension is often studied using eye-tracking in the Visual World Paradigm (VWP) (Tanenhaus et al. 1995); we employ this methodology as well, with details presented in section 2. In this paradigm, participants view visual displays with two to four pictures of common objects whose names in the spoken instructions are preceded by a gender-marked element such as an article, adjective, or verb. In the version of the study implemented here, the target noun is preceded by two agreeing elements: a verb in the past tense and an adjective, as illustrated in Example (1) above. In the Ambiguous condition, there are two objects in the display of the same gender that matches the gender marking on the pre-nominal gender-marked modifier (e.g., a target *serebrist-yj samolet* ‘silver-MASC airplane.MASC’ vs. distractor *serebrist-yj šar* ‘silver-MASC balloon.MASC’); in the Unambiguous condition, there is only one target in the visual display that matches the gender of the gender-marked modifier in the spoken instructions. The facilitative effect of the gender agreement on the modifier here is manifest in a higher proportion of fixations to the Target in Unambiguous than Ambiguous conditions. This effect has been observed in several languages for monolingual and bilingual adult speakers (for German, Hopp & Lemmerth 2016; for Spanish, Grüter et al. 2012; Valdés Kroff et al. 2017; for Norwegian, Lundquist et al. 2016; for Polish, Fuchs 2023), as well as for heritage speakers (Fuchs 2021, 2022).

1.3. THE PRESENT STUDY. The present study leverages key properties of Russian grammar in order to investigate how facilitative processing is modulated by the morphological salience of the gender cue, and how facilitative processing proceeds when more than one gender agreement cue is available prior to the onset of the target noun. The asymmetries in the morphological realization of MASC versus FEM gender agreement allow us to observe whether a less salient morpheme, such as a phonologically null suffix, can serve as a cue, which has not been investigated previously in the literature on monolingual or bilingual populations.

Research Question 1: Do monolingual Russian speakers use both less salient shorter/null morphemes (MASC) and more salient morphemes (FEM) for facilitative processing during real-time spoken language comprehension?

Research Question 2: Do heritage Russian speakers use both less salient shorter/null morphemes (MASC) and more salient morphemes (FEM) for facilitative processing during real-time spoken language comprehension?

As discussed in section 1.1, FEM agreement morphology in Russian is more salient on both verbs and adjectives (two syllables); MASC gender agreement is null on verbs and less perceptually salient (one syllable) on adjectives than the FEM (or NEUT) gender (two syllables). If listeners are able to use gender cues on less salient/null morphemes as efficiently as gender cues on more salient morphemes to facilitate lexical retrieval, then we expect to observe effects of condition (Ambiguous vs. Unambiguous) following both MASC and FEM cues. If, however, listeners are unable to use less salient agreement morphemes for anticipatory processing, then we expect to see effects of condition following FEM but not MASC cues. Crucially, it may be that the two groups differ in this regard, given that HSs are often found to be non-target-like in their production and comprehension of null linguistic elements, known as *the silent problem* (Laleko & Polinsky 2017; Polinsky & Scontras 2020), and even of morphologically specified but less perceptually salient elements (for an overview, see Polinsky 2018: §5.1.1). If this extends to facilitative processing of agreement cues on less salient agreement morphemes, then we may expect to see effects following MASC cues for the control group but not the HSs.

We note also that an innovation in this study is the presence of two agreement cues prior to the target noun: one on the past-tense verb and one on the adjective. Previous research in German, Dutch, Spanish, Norwegian, and Polish on the effect of gender cues was conducted with just one cue preceding the noun, i.e., either the gender-marked article or adjective. Gender agreement encodes a relationship between two constituents that could be at a distance from each other (e.g., noun and verb), and such relationships may be difficult for HSs. That HSs are known to overmark some grammatical features, for example, double-marking the past tense forms (e.g., **dresseded*) (Polinsky & Scontras 2020) suggests that the double-marked agreement in our stimuli may raise the likelihood of observing facilitative processing in the heritage group if such facilitative processing does indeed occur, particularly in the MASC target conditions in which the agreement cues are less morphologically marked. While our stimuli do not include a condition with only one agreement cue for direct comparison that would allow us to draw firm conclusions regarding the role of double marking in facilitative processing, we explore the observed processing patterns and offer tentative insights to motivate future work in this domain in section 4.3.

2. Method. All materials, data, and code used for analysis are publicly available on the OSF repository for the study at <https://osf.io/2c36y/>.

2.1. MONOLINGUAL PARTICIPANTS. Traditional college-age undergraduate students ($N=25$, all women; mean age 20.0) from Moscow State Pedagogical University (Russia) participated in the experiment in exchange for \$3 (equivalent in rubles). All were native speakers of Russian, with working knowledge of one foreign language that they were learning at the university as part of their undergraduate curriculum.

2.2. HERITAGE BILINGUAL RUSSIAN-ENGLISH PARTICIPANTS. A similar group of traditional college-age undergraduate students ($N=35$, 10 men; mean age 18.9, range 18-24) from the College of Staten Island served as the experimental group. They self-identified as bilingual Russian-English HSs when signing up for the experiment advertised on the Sona (Human Subject Pool) management system. Prior to participating, each participant filled out a bilingual background questionnaire in English adapted from Fernández (2003).

All of the participants were born to Russian-speaking parents, so their exposure to Russian was from birth and has continued throughout their lives. Nine were born in the US; 26 arrived to the US before the age of 12 (the mean age of arrival 3.9 years, range 0-12), which was taken as the equivalent of first contact with English. The participants were asked to self-report language dominance by rating their proficiency in both languages on a five-point scale ranging from 1 = “very good” to 5 = “very poor”. The dominance score was calculated by subtracting a participant’s average rating for English from their average rating for Russian. Thus, a positive difference in scores indicate higher proficiency in Russian; a negative difference indicates higher proficiency in English. On average as a group, the HSs indicated higher proficiency for English in all four areas: oral comprehension ($M = -1.15$), speaking ($M = -1.3$), reading ($M = -2.3$), and writing ($M = -2.39$). Thus, the participants were typical HSs, with English being their dominant language, especially in literacy skills. Self-reported spoken language comprehension in Russian, nevertheless, was strong; this is important for our experiment as it tested processing during spoken language comprehension.

The study was carried out in accordance with the ethical principles of psychologists and code of conduct of the American Psychological Association and was approved by the Institutional Review Board of the College of Staten Island. All participants signed an informed consent form in accordance with the Declaration of Helsinki.

2.3. DESIGN AND MATERIALS. The study consisted of 30 experimental items and one practice item. Each item combined a set of four pictures (see Figure 1) paired with a spoken sentence (2a-c) that was created from the template LOCATIVE – VERB – ADJECTIVE – NOUN, discussed in further detail below. The spoken sentence instructed participants to identify the target item, which was MASC, FEM, or PL; the PL condition was a control condition. There were two instances of grammatical agreement in the sentence, as illustrated in (2): first, the verb predicate (e.g., *letel-∅/letel-a/letel-i* ‘was/were flying-MASC/FEM/PL’) that preceded the subject NP was always in the past-tense form and agreed in gender and number with the head noun of the subject; second, the adjective (e.g., *serebrist-yj/serebrist-aja/serebrist-ye* ‘silver-MASC/FEM/PL’) also agreed in gender and number with the head noun. The adjective was immediately adjacent to the noun, whereas the verb was separated from it by the adjective.

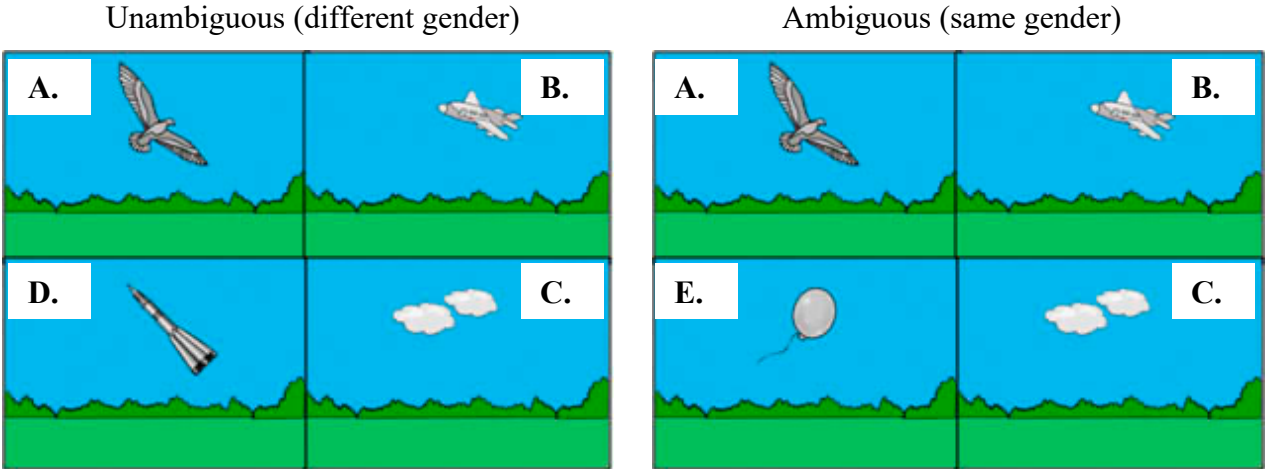


Figure 1. The MASC example of the two types of visual display used in the study. (A) FEM distractor 1, (B) MASC target, (C) PL distractor, (D) FEM distractor 2, (E) MASC competitor.

- (2)
- | | | | | |
|----|--|--------------------|----------------|------------------|
| a. | Po nebu | letel- \emptyset | serebrist-yj | samolet. |
| | in sky | was.flying-MASC.SG | silver-MASC.SG | airplane.MASC.SG |
| | 'A silver airplane was flying in the sky.' | | | |
| b. | Po nebu | letel-a | serebrist-aja | ptica. |
| | in sky | was.flying-FEM.SG | silver-FEM.SG | bird.FEM.SG |
| | 'A silver bird was flying in the sky.' | | | |
| c. | Po nebu | letel-i | serebrist-ye | oblak-a. |
| | in sky | were.flying-PL | silver-PL | cloud-PL |
| | 'Silver clouds were flying in the sky.' | | | |

The 30 spoken sentences illustrated in (2) were recorded individually and at normal speed by a female native speaker of Russian (the second author), using mono-mode sampling at 22,050 Hz. They all described an action event. To create a situation in which the agreeing words, i.e., verb and adjective, precede the noun that controls the grammatical agreement in gender and number, we used the locative inversion construction in Russian for which the most neutral word order of constituents in the sentence is PP.LOC-VERB-NP.NOM. This construction is very common in Russian and is, in fact, the default word order for discourse opening sentences, even with transitive verbs (Bailyn 2004, 2012).

The first constituent was a locative prepositional phrase (e.g., in the sky, on the street, under the tree, in the basket) followed by the verb and then by the subject NP in nominative case. The second constituent was the unambiguously gender-marked verb. There were 15 non-transitive verbs in the imperfective form of past tense listed here in the masculine form: *letel* 'flew', *šjol* 'walked', *bežal* 'ran', *guljal* 'strolled', *tanceval* 'danced', *visel* 'hung', *stojal* 'stood', *lez* 'climbed', *polzal* 'crawled', *plyl* 'swam', *igral* 'played', *exal* 'drove', *prygal* 'jumped', *spal* 'slept', and *ležal* 'lay'. The position of the stress, on the stem or on the ending, was not balanced, with only three of the verbs (e.g., *šl-á* 'walked-FEM', *plyl-á* 'swam-FEM', and *spal-á* 'slept-FEM')

being stressed on the FEM or PL ending.² Each verb was repeated twice, resulting in two unique sentences.

The third constituent was the subject of the sentence that contained a head noun modified by an adjective. Twenty-four of the 30 items contained the target noun in singular, either MASC or FEM, and were morphophonologically transparent for gender: FEM nouns from Declension class I ended in *-a* (e.g., *devočka* ‘girl.FEM’, *sobaka* ‘dog.FEM’, *perčatka* ‘glove.FEM’) and MASC nouns from Declension class II ended in a non-palatalized *-C* (e.g., *mal’čik* ‘boy.MASC’, *tigr* ‘tiger.MASC’, *samolet* ‘airplane.MASC’). The remaining six items contained the target noun in plural (e.g., *soldat-y* ‘soldiers-PL’, *varežk-i* ‘mittens-PL’). The lexico-semantic characteristics of the target nouns varied. They were of three semantic types: eight humans (e.g., boy, girl, sailor), 12 animals (e.g., dog, bear, tiger), and 10 inanimate objects (e.g., skirt, mitten, car).

The adjectives that had the critical agreement suffixes represented colors (e.g., silver, black, red, yellow), size (e.g., small, big), material (e.g., stone, wood), and state (wet, sad, dressed up). Just like with the verbs, the position of the stress was not controlled, with five adjectives (e.g., *molod-ój* ‘young-MASC’, *bol’s-ój* ‘big-MASC’, *golub-ój* ‘sky.blue-MASC’, *bos-ój* ‘barefoot-MASC’, *xud-ój* ‘thin-MASC’) being stressed on the ending. In the plural condition, grammatical gender agreement was neutralized on the adjective (and verb).

All pictures were color drawings of the event with animate and inanimate agents depicted against the backdrop, which was denoted by the locative prepositional phrase. Visual displays were divided into four quadrants, and each picture occupied one of the four quadrants. Pictures were animated (.tiff format) in which each agent was performing the action in an easily identifiable but not too busy way.

The visual displays (see Figure 1) were assembled in four different sets representing the five conditions of the experimental design, four of them in a 2 x 2 fashion, plus a control PL condition. The first factor was Gender of the target noun (the subject of the sentence), either MASC or FEM, that controlled the grammatical gender agreement features on the preceding verb and adjective. The second factor Condition reflected the pairing of the target noun with either a competitor noun in the other gender (Unambiguous; *serebrist-yj samolet* ‘silver-MASC plane.MASC’ vs. *serebrist-aja ptica* ‘silver-FEM bird.FEM’) or in the same gender (Ambiguous; *serebrist-yj samolet* ‘silver-MASC plane.MASC’ vs. *serebrist-yj šar* ‘silver-MASC balloon.MASC’). Thus, when a spoken sentence like in (2a) was paired with an Unambiguous MASC display (Figure 1, left panel), the target item (1A) differed in gender from the two FEM distractors (1B) and (1D), but when it was paired with an Ambiguous display (Figure 1, right panel), there were two pictures with a MASC noun (1A and 1E) and one with a FEM noun (1B). Analogously, the spoken sentence in (2b) for a FEM target noun (e.g., *serebrist-aja ptica* ‘silver-FEM bird.FEM’) was paired with either a distractor noun in MASC (e.g., *serebrist-yj samolet* ‘silver-MASC plane.MASC’) for the Unambiguous condition or with a FEM competitor noun (e.g., *serebrist-aja raketa* ‘silver-FEM rocket.FEM’) for the Ambiguous condition. For the control PL condition, a spoken sentence like in (2c) was paired with a visual display in either gender condition because a plural image (1C) was present in every visual display.

The resulting set of materials consisted of 30 items, with six items each in five experimental conditions (Ambiguous MASC, Unambiguous MASC, Ambiguous FEM, Unambiguous FEM,

² Per the discussion in section 1.1, this means that FEM adjectives and verbs whose endings were unstressed were in fact ambiguous between FEM and NEUT. Given that there were no NEUT items in the experimental materials, we do not believe this affected accuracy in the task. Still, given that HSs are known to have difficulty resolving ambiguity, this is useful to keep in mind in the interpretation of the results for FEM target nouns.

PL). There were no filler items due to the fact that the spoken sentences contained no special syntactic or morphological characteristics that could be detected by participants. Five versions of the experiment were created for the between-participants design, with experimental items rotated through the five conditions, in a Latin square design. Participants were randomly assigned to one of the five versions.

2.4. PROCEDURE. Participants were seated in front of a 17-inch HP laptop on which the visual displays were presented, with auditory sentences being simultaneously played through speakers. The task was to select the picture out of four in the visual display that matched the spoken sentence and to do so as quickly as possible by clicking on it with the mouse. The experiment was presented to the participants as a PowerPoint slideshow that combined four animated pictures and auditory sentences played through speakers. Each slide started with a simultaneous presentation of four animated pictures in the visual display, immediately followed by a happy face whose appearance was also animated through one of the PowerPoint entrance features, i.e., it would roll into the slide into the center and then twirl there for the duration of the attention-grabbing instruction, e.g., *Look at the happy face*. The moving happy face was meant to serve as a central fixation point forcing participants to fixate on it immediately prior to hearing the auditory prompt in (2) that was embedded in a carrying phrase: *Gde zdes'...* 'Where is here...'

The laptop that ran the PowerPoint slideshow was connected to a remote free-viewing eye-tracking system (ETL-500) from ISCAN, Inc. that recorded participants' eye movements. Eye movements were sampled at a rate of 30 times per second and were recorded on a digital SONY DSR-30 video tape-recorder. Prior to the experiment, participants underwent a short calibration procedure, and the experiment lasted 10 minutes.

2.5. PREDICTIONS. As presented in the Research Questions in section 1.3, the present study seeks to determine whether monolingual and heritage speakers of Russian exhibit facilitative processing of gender agreement morphemes, and whether this is modulated by the saliency of the agreement marker. Facilitative processing is typically observed when, following a gender cue, participants direct their gaze to the target item when the target item is the only one in the visual display matching the gender feature on the cue (here an Unambiguous condition) faster than when there is another item in the display that matches the gender feature on the cue (here the Ambiguous condition). Thus, within each experimental group, the results for trials with MASC target items and for trials with FEM target items will be interpreted with respect to the following predictions:

Prediction A: If participants can use gender agreement cues to facilitate lexical retrieval, then there should be more fixations to the target item over time in the Unambiguous condition trials than in the Ambiguous condition trials.

Prediction B: If participants cannot use gender agreement cues to facilitate lexical retrieval, then there should be no differences in the proportion of fixations to the target item over time in the Unambiguous condition trials and Ambiguous condition trials.

3. Analysis and results.

3.1. DATA TREATMENT AND ANALYSIS. Eye movements were extracted from videotape using a SONY DSR-30 videotape recorder with frame-by-frame control and synchronized video and audio. Data from four participants who arrived in the US between the ages of 13-14 was excluded from analysis. For each trial, six categories were coded: looks to the happy face, the target, the

competitor, the two remaining distractor pictures, and track loss. Track loss and looks elsewhere constituted a very small proportion of total looks and were removed from the eye-movement analyses. Data was prepared using the package *eyetrackingR* (Dink & Ferguson 2015) and analyzed using the package *clusterperm* (Barr 2022) in R version 4.2.1 (R Core Team 2021). To analyze the proportion of looks to the Target over time across conditions, a permutation-based cluster analysis was implemented to identify clusters of time bins in which there was a significant difference between conditions in the proportion of fixations to the Target (Ito & Knoeferle 2022; Maris & Oostenveld 2007). The onset of the critical region for fixations to the Target was the offset of the verb agreement marker (cf. Figure 2). Data were binned into time bins of 50 ms. Given the research questions, separate analyses were conducted for each group, and within each group, separate analyses were conducted based on the grammatical gender of the Target (MASC vs. FEM). In each analysis, generalized mixed effects models were fitted to the data in each time bin, predicting the empirical logit of the proportion of fixations to the Target in the given bin by Condition (Ambiguous vs. Unambiguous), with by-participant and by-item random intercepts; the data were permuted 1000 times.

3.2. ACCURACY. The sentences used in the study (see (2)) were simple and created with an eye to appropriateness for young children, who were also tested (but not reported here). Therefore, it was expected that accuracy in the sentence-picture selection task would be at ceiling. Indeed, accuracy on the task was high for both groups reported here: 99.4% for the control group and 94.19% for the heritage group.

3.3. PROPORTION OF FIXATIONS: MONOLINGUAL GROUP. The control group’s proportion of fixations to FEM Target in Ambiguous vs. Unambiguous trials is presented in Figure 2, top left panel. Visual inspection of the plot suggests that the proportion of fixations to the Target was higher in the Unambiguous than the Ambiguous trials. This is confirmed by the cluster-based permutation analyses, which identified two significant clusters for the effect of Condition. The first significant cluster was detected for the period of 650 ms to 800 ms following the verb (cluster mass statistic = 28.6, $p < 0.001$). The second significant cluster was detected for the period of 1500 ms to 1650 ms following the verb (cluster mass statistic = 17.6, $p = 0.016$). These and other results discussed in this section are presented in Table 2.

	Target gender		Cluster start time (ms)	Cluster end time (ms)	Cluster mass statistic	p
Control	FEM	cluster 1	650	800	28.6	< 0.001
		cluster 2	1500	1650	17.6	0.016
	MASC		250	400	19.0	0.008
Heritage	FEM		550	650	21.3	0.030
	MASC		-1000	-650	54.7	0.001

Table 2. Significant clusters identified by the cluster-based permutation analysis

The control group’s proportion of fixations to MASC Target in Ambiguous vs. Unambiguous trials is presented in Figure 2, bottom left panel. Visual inspection of the plot suggests that proportion of fixations to the Target was higher in Unambiguous than Ambiguous trials. Once again, this is confirmed by the cluster-based permutation analysis, which found a significant cluster for the effect of Condition for the period of 250 ms to 400 ms (cluster mass statistic = 19.0, $p = 0.008$).

3.4. PROPORTION OF FIXATIONS: HERITAGE GROUP. Visual inspection of the plot (Figure 2, top right panel) suggests that proportion of fixations to the FEM Target was higher in Unambiguous than Ambiguous trials. This is confirmed by the cluster-based permutation analysis, which identified a significant cluster starting at 550 ms and ending at 650 ms after the verb (cluster mass statistic = 21.3, $p = 0.03$).

The heritage group's proportion of fixations to the MASC Target in Ambiguous vs. Unambiguous trials is presented in Figure 2, bottom right panel. Visual inspection of the plot suggests that proportion of fixations to the Target did not differ between Ambiguous and Unambiguous conditions after the offset of the verb agreement marker. The cluster-based permutation analysis identified a significant cluster from -1000 ms to -650 ms (cluster mass statistic = 54.7, $p = 0.001$); however, because this cluster occurs before the region of interest (0 is set to index the offset of the verbal agreement marker), we take this effect to be spurious, as there was no gender information available to participants prior to the verb.

3.5. PROPORTION OF FIXATIONS: GROUP COMPARISON. We additionally compare facilitative processing between the two groups by directly comparing the proportion of fixations in Unambiguous condition trials between the monolingual and heritage groups. Visual inspection of Figure 3 suggests that overall the monolingual group fixated on target items in Unambiguous conditions (for both FEM and MASC target items) more than the heritage group did. This is confirmed by cluster-based permutation analyses performed on the data for FEM target items and on the data for MASC target items (Table 3).

Target gender		Cluster start time (ms)	Cluster end time (ms)	Cluster mass statistic	p
FEM	cluster 1	700	1650	325.8	0.001
	cluster 2	1750	2050	65.3	0.001
MASC		250	2450	745.7	0.001

Table 3. Significant clusters for the effect of group on proportion of fixation to target items in Unambiguous condition trials identified by the cluster-based permutation analysis

For proportions of fixations to FEM target items in Unambiguous trials, the analysis found two significant clusters for the effect of group: the first starts at 700 ms and ends at 1650 ms (cluster mass statistic = 325.8, $p = 0.001$), and the second starts at 1750 ms and ends at 2050 ms (cluster mass statistic = 65.3, $p = 0.001$). This indicates that FEM target items in the Unambiguous condition trials were fixated on more by the monolingual participants than by the heritage participants. The analysis for MASC target items also revealed a significant cluster for the effect of group from 250 ms to 2450 ms (cluster mass statistic = 745.7, $p = 0.001$). This indicates that MASC target items in Unambiguous condition trials were also fixated on more by the monolingual participants than by the heritage participants.

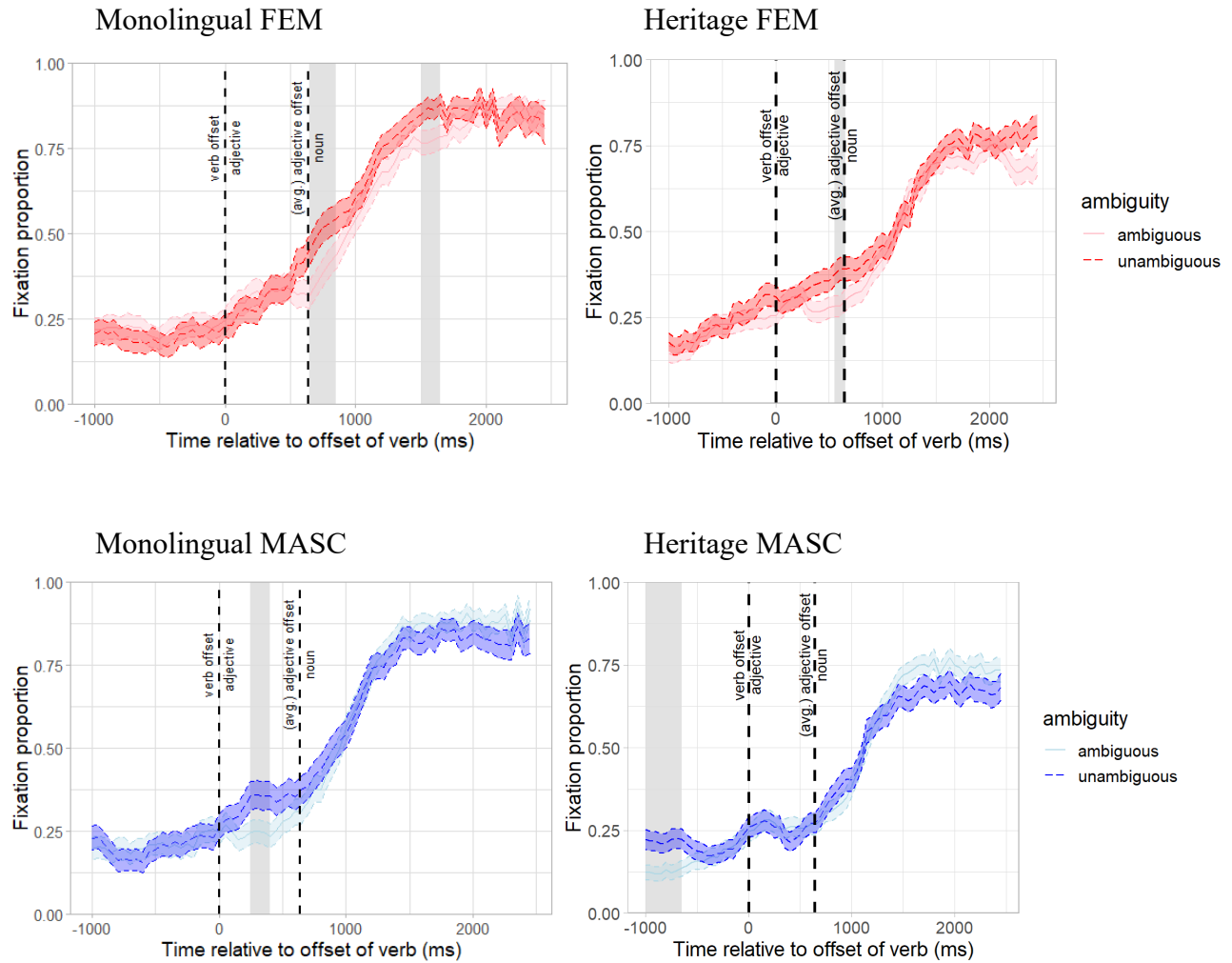


Figure 2. Proportion of fixations to the Target over the course of the trial for the control group for FEM targets (top left) and MASC targets (bottom left) and for the heritage group for FEM targets (top right) and MASC targets (bottom right). Significant clusters as identified by the cluster-based permutation analyses are shaded in gray.

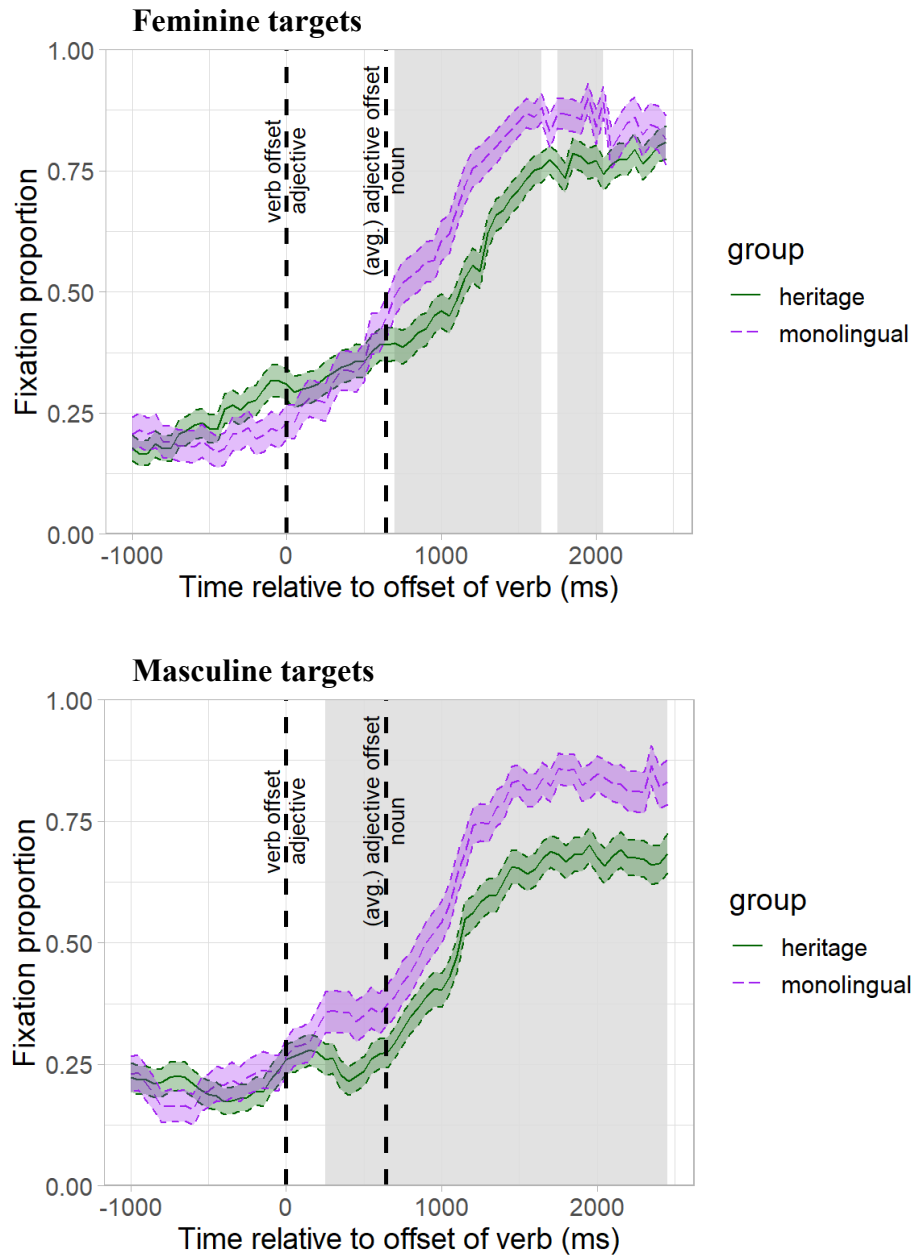


Figure 3. Proportion of fixations to the Target in the Unambiguous condition trials over the course of the trial compared between the heritage group and the monolingual group for the FEM targets (top) and MASC targets (bottom). Significant clusters as identified by the cluster-based permutation analyses are shaded in gray.

4. Discussion.

4.1 ANTICIPATORY PROCESSING AND SALIENCY OF AGREEMENT CUES FOR MONOLINGUAL GROUP. Asymmetries in the morphological saliency of agreement markers between MASC and FEM gender in Russian allow us to test how it affects facilitatory processing in monolingual speakers. Our first research question asked whether monolingual speakers can use gender to facilitate lexical retrieval of the noun when gender is marked on less/null vs. more salient agreement suffixes.

Results in section 3.3 showed that monolingual speakers of Russian looked more to the target in Unambiguous than Ambiguous conditions; these effects were observed both for FEM and MASC targets. Recall that FEM agreement marking is highly salient on both past-tense verbs (-*a*) and adjectives (-/V_jV/), whereas MASC agreement marking on verbs is a null suffix and on adjectives it is less salient (-/V_j/) than it is for FEM and NEUT. That effects of Condition were found for FEM targets is therefore unsurprising and consistent with previous literature on the anticipatory processing of gender agreement on fully morphologically specified elements, such as articles, as investigated for languages like Spanish, German, and Dutch (Lew-Williams & Fernald 2007, 2010; Hopp & Lemmerth 2016; Loerts et al. 2013; Lundquist et al. 2016) and adjectives, as investigated for German and Polish (Hopp & Lemmerth 2016; Fuchs 2022, 2023).

The findings for MASC targets are particularly notable though. The facilitative processing of morphologically less salient or even phonologically null agreement suffixes has, to our knowledge, not previously been investigated. Still, the control group in this study showed anticipatory processing of MASC agreement. In fact, the significant cluster identified by the analysis in section 3.3 occurs before the offset of the adjective, suggesting that this effect is immediate but short-lived: it was prompted by the null agreement suffix on the verb, but did not re-emerge after the adjective. This suggests that lower saliency of the agreement cue does not prohibit anticipatory processing of gender agreement for monolingual speakers of Russian and is sufficiently strong even with one cue. In other words, monolingual Russian speakers are able to access abstract gender features during real-time spoken language comprehension even when these features are hosted on less morphologically salient and null suffixes.

4.2 DIFFICULTY IN PROCESSING LESS SALIENT AGREEMENT CUES FOR HERITAGE GROUP. We asked the same research question for the heritage group tested in this study: do heritage Russian speakers use both less salient/null morphemes (MASC) and more salient morphemes (FEM) for facilitative processing during real-time spoken language comprehension? Results in section 3.4 found that there was an effect of Condition on the proportion of fixations to FEM targets, but not to MASC targets, which indicates that the heritage group exhibited facilitative processing of grammatical gender, at least for FEM. Given once again the morphological saliency of FEM gender agreement in Russian, these results are consistent with previous work on HSs' facilitative processing of gender in languages like Spanish (Fuchs 2021) and Polish (Fuchs 2022) when the cue to gender is fully morphologically specified. The comparison with the monolingual group in section 3.5 indicated, however, that the facilitative processing of the heritage group was reduced relative to the monolingual group, consistent with previous findings for heritage Spanish (Fuchs 2021), but not Polish (Fuchs 2022).

HSs' facilitative processing has not previously been investigated when the gender cue is not perceptually salient, and the lack of effect of Condition for MASC targets for the heritage group in our study suggests that the morphological markedness of the agreement marker does indeed impact HSs' ability to access the gender feature and integrate it into the process of word recognition during spoken-language comprehension. Recall also that the auditory stimuli in this study contained two cues to gender – a past-tense verb and an adjective – and there was still no effect of Condition in the region of interest for MASC target nouns. This contrasts with the control group who, as discussed in section 4.1, showed an effect of Condition for MASC targets.

In considering what exactly about the MASC gender cues may lead to the effect (or lack thereof) observed here, recall that the null morpheme on the past-tense verb is an unambiguous cue to MASC gender, as is the monosyllabic adjectival MASC agreement suffix, so HSs' inability to use these morphemes to facilitate lexical retrieval does not stem from a difficulty with

resolving ambiguity in the gender marking. Two other possibilities arise, as pointed out by an anonymous reviewer. The first has to do with the interplay between agreement marking and tense: in order to identify the null verbal agreement marker as a cue to MASC, participants must also integrate knowledge of tense agreement, i.e., to know that a null morpheme specifically in the past tense indicates MASC. We acknowledge that it is possible that HSs may have difficulty with processing the null morpheme due to this need to integrate tense information, but this does not capture the lack of effect for adjectival MASC agreement cues, which are not dependent on tense. The alternative is that HSs may not be sensitive to less salient agreement cues during real-time comprehension. This would predict that in a hypothetical context in which FEM agreement is null while MASC agreement is overt, HSs would exhibit facilitative processing for MASC targets but not FEM targets, but such an environment does not exist in Russian to our knowledge.

We take these findings to further contribute to the trend noticed elsewhere in the literature on heritage languages: HSs have non-target-like production and comprehension of null elements (Laleko & Polinsky 2017) or less perceptually salient elements (Polinsky 2018: §5.1.1). Moreover, studies of heritage language production suggest that HSs overproduce overt forms where null forms would be expected by a control speaker of the same language; this includes production of inflectional morphology. Polinsky & Scontras (2020) call this phenomenon *overmarking* and provide examples of overmarking in heritage English for irregular verbs (e.g., **wented*). In heritage Russian, HSs often add a MASC allomorph *-ov* for the genitive plural in FEM nouns that are marked with a null suffix (**tarelk-ov* instead of *tarelok-∅* ‘plates-GEN.PL’) (Polinsky 2018: 179).

The present results suggest that HSs’ non-target-like comprehension of null or less salient linguistic material may extend to real-time language processing of agreement marking. Whereas HSs have typically been found to have target-like facilitative processing of gender agreement – and indeed in the present study their processing of FEM agreement marking is target-like – when the relevant agreement marking is null or less salient, as for MASC agreement marking in Russian, facilitative processing is not observed for HSs.

4.3 FURTHER CONSIDERATIONS AND NEXT STEPS. There are a number of other aspects of the study and results that merit discussion. First, we note that our study was the first – to our knowledge – to have two gender cues prior to the noun, on different elements: a verb and an adjective. Flexible word order in Russian allowed the construction of such sentences presented even in isolation, i.e., without special context to render the non-default word order felicitous (cf. section 2.3). Of interest to us is how the presence of two gender cues prior to the noun affects facilitative processing. However, because we did not have a comparison condition with only one gender cue, our discussion remains exploratory at this stage. Results discussed in section 3 found two significant clusters for the effect of condition for FEM targets for the control group (as well as the heritage group) and only one for MASC targets. However, our ability to interpret these results with respect to the processing of double gender cues is limited given two considerations. The first is that the first significant cluster for FEM targets does not occur at such a time that we can say with confidence that it is prompted by integration of only information from verbal agreement. The second is that the cluster-based permutation analysis implemented for data analysis in this study is known to have reduced power to identify a second significant cluster (Ito & Knoeferle 2022), so the absence of a second significant cluster for the MASC target items should be interpreted with caution. Still, we suggest that the presence of two significant clusters for FEM target conditions is compelling motivation for further research into the processing of multiple agreement cues over the course of the clause.

We also note that we did not analyze how lexical stress affected the saliency of the gender cue. Recall from section 1.1 that the transparency of the FEM agreement marker is reduced for stem-stressed verbs and adjectives: when these elements are stem-stressed, the vowel in the FEM agreement marker is reduced. The outcome of this vowel reduction is that the agreement suffix becomes opaque to gender, as it then has the same form for FEM and NEUT agreement. Ending-stressed verbs and adjectives agreeing with FEM nouns are transparent for gender. Stimuli in our study included both stem-stressed and ending-stressed adjectives and verbs, and these were not equally distributed. Further investigation of the data contrasting FEM cues on stem-stressed vs. end-stressed elements may reveal that facilitative processing in Russian is further modulated by lexical stress for the control and/or heritage group. We leave this for future work.

Finally, we would like to address a possible alternative interpretation of the results. The asymmetry in how control vs. heritage participants were able to use MASC vs. FEM agreement marking to facilitate lexical retrieval could be couched in terms of the internal structuring of the gender feature in these two varieties of Russian. In other words, one might suggest that MASC and FEM are represented differently in the baseline Russian grammar than in the heritage Russian grammar. Indeed, there has been work on the restructuring of agreement features in heritage languages (e.g., Scontras et al. 2018), and work on gender in heritage Russian has shown HSs of Russian typically assign FEM agreement to NEUT nouns and MASC agreement to FEM nouns that end in *-C'* (e.g., Polinsky 2008). We consider such findings very compelling, and it is certainly plausible that the heritage gender system may undergo restructuring. Our results could be consistent with such an approach to gender in the baseline vs. heritage grammar. However, it is important to note that work on the facilitative processing of gender in languages for which the internal structuring of the gender feature has been much more thoroughly studied (e.g., Spanish) has not typically found asymmetries in the processing of agreement with different gender categories in control populations. Given this general lack of alignment between the internal structuring of gender and facilitative processing patterns in the VWP, we caution against using asymmetries in facilitative processing observed in the two experimental groups here as a diagnostic for the internal structuring of the gender feature in the baseline vs. heritage grammars of Russian.

5. Conclusion. It is well-established in the literature that gender agreement cues on modifiers and verbs that precede the noun in speech facilitate its recognition. However, questions remain open regarding how the facilitative processing of this agreement is modulated by the saliency of the agreement marker (more salient, less salient, null), the number of the cues available prior to the noun (one or more), and the sensitivity of different groups of participants (monolinguals, L2 learners, HSs). The present study on Russian makes two important contributions to the study of facilitative processing. First, we found that monolingual speakers take advantage of gender agreement cues on modifiers and verbs, regardless of their saliency or even when they are null. Second, heritage bilingual speakers are unable to do so in the case of less salient cues. These results suggest that we need to continue to investigate facilitative processing, especially in bilinguals, to arrive at a more nuanced view of effects of prediction in online language comprehension.

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