The Role of Grammatical Gender in Predictive Processing in Russian

ReMA Thesis

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Abstract

Previous studies have shown that adult and child native speakers can use grammatical gender cues, in particular articles, to predict upcoming nouns in online sentence interpretation (e.g. Lew-Williams & Fernald, 2010; Brouwer et al., 2017). This type of research mostly focused on Roman and West-Germanic languages. In this study we looked at gender-marked adjectives in Russian. The aim was to examine whether adult and child native speakers of Russian of varying ages can use grammatically marked adjectives to predict the upcoming noun during sentence comprehension.

In a looking-while-listening paradigm, 31 adult participants and 49 2-to-7 year old children heard simple questions (e.g. *Где красивый зеленый стульчик?* 'Where is the pretty$_{masc}$ green$_{masc}$ chair$_{masc}$?') and saw two pictures on the screen. One picture was the target (e.g. chair$_{masc}$) and the other the distractor of either the same (e.g. ball$_{masc}$) or different gender (e.g. hat$_{fem}$). Importantly, only when the target and distractor had the different gender the gender-marked adjective was informative. All questions had the same structure with two gender-marked adjectives followed by a noun. We hypothesised that participants would look more and faster at the target picture in the different-gender than the same-gender condition. More specifically, we examined whether they could use gender-marking anticipatorily (i.e. before the onset of the noun) or facilitatively (i.e. after the onset of the noun). We predicted that children's anticipation ability would increase with age.

Using mixed-effects logistic regression analyses, our results revealed that native Russian adults and children anticipated the upcoming noun before its onset. Moreover, the anticipation effect was stronger for the adult group than for the child group.

Subsequent analyses on the child data suggested that age is involved in anticipation ability in children, but it seems not to be the only (defining) predictor. The results of our study extend and improve existing theoretical knowledge regarding the role of grammatical gender in online sentence processing.

Introduction

Roughly half of the languages spoken today have grammatical gender. Grammatical gender is a type of noun class, in which the nouns of a language are semantically divided into categories such as male versus female. Frequently, grammatical gender is marked not only on the noun itself but also on other aspects of the language, including definite and demonstrative articles, relative pronouns, verbs and adjectives. In Russian, for example, adjectives associated with nouns are marked for gender agreement. The aim of the current study is to examine whether Russian-speaking children and adults are able to use these grammatically marked adjectives to anticipate the upcoming noun during sentence comprehension.

Although grammatical gender might seem costly in terms of learning and processing, previous work using online techniques has shown that it can facilitate speech processing. These studies have demonstrated that adults are faster to respond to nouns preceded by informative cues to grammatical gender than to nouns without such cues. This pattern has been replicated in many languages such as French (Grosjean, Dommergues, Cornu, Guillelmon, & Besson, 1994; Dahan, Swingley, Tanenhaus, & Magnuson, 2000), German (Friederici & Jacobson, 1999), Spanish (Lew-Williams & Fernald, 2010; Wicha, Moreno, & Kutas, 2004) and Dutch (Brouwer, Sprenger, & Unsworth, 2017).

Besides adults, children have also been tested to investigate whether gender-marking facilitates their speech processing. Lew-Williams & Fernald (2007) examined grammatical gender processing in Spanish learning toddlers (2- to 3-year-old children) as well as an adult control group on a looking-while-listening paradigm. Participants were

presented with pairs of pictures that either had the same gender (e.g. *la pelota*, 'the$_{fem}$ ball$_{fem}$', *la galleta*, 'the$_{fem}$ cookie$_{fem}$') or different gender (e.g. *la pelota* 'the$_{fem}$ ball$_{fem}$', *el zapato*, 'the$_{masc}$ shoe$_{masc}$'). Immediately after presentation of the visual stimuli, the participants heard simple sentences that contained one of the two objects on the screen (i.e. target). It was found that Spanish adults were faster to look at the target picture on trials where pictures had different gender, because in this case they could get information from the article, than on the trials with same gender, where they could not make use of the gender of the article. This indicates that child native speakers of Spanish use grammatical gender to facilitate their sentence comprehension.

Following Lew-Williams and Fernald's (2007) experimental set-up, Brouwer et al. (2017) tested 4- to 7-year-old Dutch-speaking children and an adult control group. They used a visual-world eye-tracking paradigm (Cooper, 1974; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995) to assess whether their participants could use gender-marking to not only recognize a noun faster but also to predict it. In order to do this, they added an adjective in between the gender-marked article and the noun (e.g. *Waar is de groene lamp?* 'Where is the green lamp?'; see also Loerts, Wieling, & Schmid (2013); Melançon & Shi (2015)). This inclusion of an adjective extended the period during which gender effects could be found and allowed them to differentiate between effects of grammatical knowledge and knowledge of co-occurrence probabilities between the article and the noun (Dahan et al., 2000). It also aided in teasing apart facilitation from prediction effects. A facilitation effect entails that participants recognize the noun faster on different than same gender trials, as measured from the onset of the noun. An anticipatory effect, however, means that participants are able to predict which noun is coming up on the basis

of the article (only). To measure this effect, eye movements on different and same gender trials are compared *before* the noun itself is uttered. Their results demonstrated that children who were successful in producing correct gender-marked articles were able to anticipate (i.e. predict) the gender of the upcoming noun in an eye-tracking task, however, children who were not successful at producing correct articles only showed a facilitation effect. The current study will look at both types of effects.

So far, the research on the role of grammatical gender in sentence processing mostly focused on so-called WEIRD languages (Western, Educated, Industrialized, Rich, and Democratic societies; Henrich, Heine, & Norenzayan (2010). To our knowledge, the only paper that conducted this type of research in a non-WEIRD language is a recent study by Covey, Gabriele, & Fiorentino (2018). They examined the effect of grammatical gender cues on sentence processing in native speakers and second language learners of Hindi. Nevertheless, they failed to find an appropriate native Hindi group, so no conclusive results can be drawn based on this study. More research is thus needed to examine whether grammatical gender is used universally during sentence processing. Furthermore, the vast majority of previous research looked at the role of gender-marked articles in sentence processing. In this study we will focus on gender-marked *adjectives*.

The Russian language has a grammatical gender system with three possible genders: masculine, feminine and neuter. However, Russian does not have articles like Spanish or Dutch do. In Russian, all adjectives must be marked for gender that corresponds with the noun, meaning that adjectives have several possible endings depending on the gender of the following noun (e.g. *бел<u>ое</u> облак<u>о</u>* ‘white$_{neut}$ cloud$_{neut}$’, *бел<u>ая</u> машин<u>а</u>* ‘white$_{fem}$ car$_{fem}$’, and *бел<u>ый</u> снег<u>Ø</u>* ‘white$_{masc}$ snow$_{masc}$’; see Table 1). Furthermore, there are

different endings depending on the case of the presented noun. In the current study we will restrict the number of possible endings only to nominative case because nouns in other cases are usually presented in more complex sentences. Very young children might experience difficulties processing complex sentences. In addition, plural endings will not be used in this study as they carry no information about the gender of the following plural noun. Furthermore, we also look at the group of younger children, who are still in the process of acquiring noun morphology related to grammatical gender (Gvozdev, 2007).

Table 1: *Possible endings of the adjectives in singular, nominative case in Russian*

Gender	Ending
Masculine	-ой, -ый, -ий
Feminine	-ая, -яя
Neuter	-ое, -ее

Up till now, there is only one study that looked at the role of grammatical gender in predictive processing in Russian. Akhutina, Kurgansky, Polinsky, & Bates (1999) tested Russian-speaking adults using the cued-shadowing procedure. In a cued-shadowing procedure, participants are asked to repeat a second word in a word pair primed by the cue that contains the first word (the adjective ending in this case). It was found that "Russian listeners can exploit gender agreement cues "on-line", helping them to predict the identity of an upcoming word" (p. 695). However, it is questionable whether the cued-shadowing procedure truly measures sentence processing online.

The present study

The aim of the current study is to examine whether native Russian-speaking children and adults use grammatically marked adjectives to anticipate the upcoming noun during sentence comprehension. More specifically, we test **age range children** in order to investigate the development of this prediction skill. We use a visual-world paradigm as this type of a task is suitable for younger children. Sentences are constructed with two adjectives that precede the noun, such that we could distinguish between facilitation and anticipation effects. In line with previous research (Lew-Williams & Fernald, 2007; Brouwer et al., 2017), we expected, on the one hand, that Russian-speaking adults and older children use the adjective to predict the gender of an upcoming noun in online sentence interpretation. On the other hand, we predicted that younger children do not show an anticipation effect. They might, however, show the facilitation effect.

Methods

Participants

Participants were adult L1 speakers of Russian (N = 34, M_{AGE}= 22;10 years, SD_{AGE} = 6;2 years, range = 19 to 48 years) and child L1 speakers of Russian (N = 50) of varying ages (M_{AGE} = 4;9 years, SD_{AGE} = 1;2 years, range = 2;0 to 7;0 years). For the children this age range was chosen because previous research has shown that by the age of four Russian speaking children finished the acquisition of noun morphology that is directly associated with gender classification (Gvozdev, 2007). Thus, we had children who completely acquired gender system and children that did not acquire it to the full extent yet.

The experiment was conducted in Riga, Latvia. For adult participants the experiment was set up at the University of Latvia, Faculty of Humanities. Children were tested at the Riga pre-school educational institution number 259. Written consent was provided by the supervisors of these educational institutions. Adult participants and parents of the child participants had to give written consent, indicating that they took voluntarily part in the experiment and could stop at any moment if they wished to do so. For this study we received ethical approval from Ethics Assessment Committee of the Faculty of Arts and the Faculty of Philosophy, Theology and Religious Studies, Radboud University.

Stimuli

Similar stimuli were used as in Lew-Williams & Fernald (2007) and Brouwer et al. (2017). The same experimental set up was used for both adults and children to make the results comparable to each other. Therefore, the experiment was made suitable for young children.

Auditory stimuli

For the auditory stimuli, simple questions were recorded in Russian by a female native speaker in a child-directed pace:

(1) Где красивый зеленый стульчик?
'Where is the pretty$_{masc}$ green$_{masc}$ chair$_{masc}$?

All the audio stimuli were constructed in a similar manner with two adjectives followed by the noun. We decided to use two adjectives to add more time between the first gender cue (i.e. the ending of the first adjective) and the noun. Adding a second adjective allows us to see the possible anticipation effects of grammatical gender on sentence processing before a noun is revealed.

The first adjective in a sentence was the word *хороший* 'nice' for animate objects and *красивый* 'pretty' for inanimate objects. The second adjective in a sentence was always a colour adjective (*красный* 'red', *синий* 'blue', *желтый* 'yellow' or *зеленый* 'green'). For target nouns eight diminutive nouns were used because diminutive nouns are common in child-directed speech in Russian. In addition, previous research on first language acquisition in Russian has shown that diminutives play an important role in novel word acquisition in Russian children (Kempe, Brooks, Mironova, & Fedorova, 2003). Nouns were four animate objects (*мишка* 'bear$_{masc.dim}$', *ежик* 'hedgehog$_{masc.dim}$', *птичка* 'bird$_{fem.dim}$', *собачка* 'dog$_{fem.dim}$') and four inanimate objects (*книжка* 'book$_{fem.dim}$', *шапочка* 'hat$_{fem.dim}$', *мячик* 'ball$_{masc.dim}$', *стульчик* 'chair$_{masc.dim}$'). Within each

animation-category two nouns were feminine and two were masculine. We decided not to use neuter gender nouns because the neutral gender is mostly used for abstract nouns like *счастье* 'happiness' or *слово* 'word' and are (1) probably not acquired yet by toddlers and (2) hard to find a graphical representation for. Apart from diminutive suffixes, all nouns in this experiment were phonologically dissimilar, so there could be no effects of phonological competition between the target noun and the distractor.

A total amount of 32 target sentences were used in this experiment, out of which 16 sentences consisted of masculine adjective-adjective-noun combinations and 16 sentences consisted of feminine adjective-adjective-noun combinations.

After sentences were recorded, we used Praat (Boersma & Weenink, 2005) and Audacity© to adjust sound recordings to align the onsets and durations of the critical words across the experimental stimuli. The following durations were set for all experimental items: adjective 1 – 720 ms, adjective 2 – 590 ms and noun – 780 ms. From the beginning of the sentence adjective 1 onset was set at 480 ms, adjective 2 onset at 1200 ms and noun onset at 1780 ms.

Eight filler sentences were recorded. Filler sentences were words of encouragement, such as *У тебя отлично получается!* 'You are doing great!', *Молодец!* 'Well done!' and *Умничка!* 'Smart girl/boy!' to maintain children's attention. In addition, a short, royalty-free bell sound was found on the internet for fixation item.

Visual stimuli

The visual stimuli were cartoon pictures of the same nouns as spoken in the audio stimuli (see Fig. 1). Two different visual representations were found for each noun. The pictures were shown in pairs, one being the target picture (the label of the noun as uttered in the audio stimuli) and another the distractor. Both pictures were presented in the same colour, i.e. the colour adjective that was labelled in the audio stimuli. Pairs could be either same-gender nouns or different-gender nouns.

Eight pictures were chosen as the filler items. They were colourful cartoon pictures depicting animals, children and kindergarten activities. For the fixation screen a picture of a smiley face was used. All pictures were presented on a grey background.

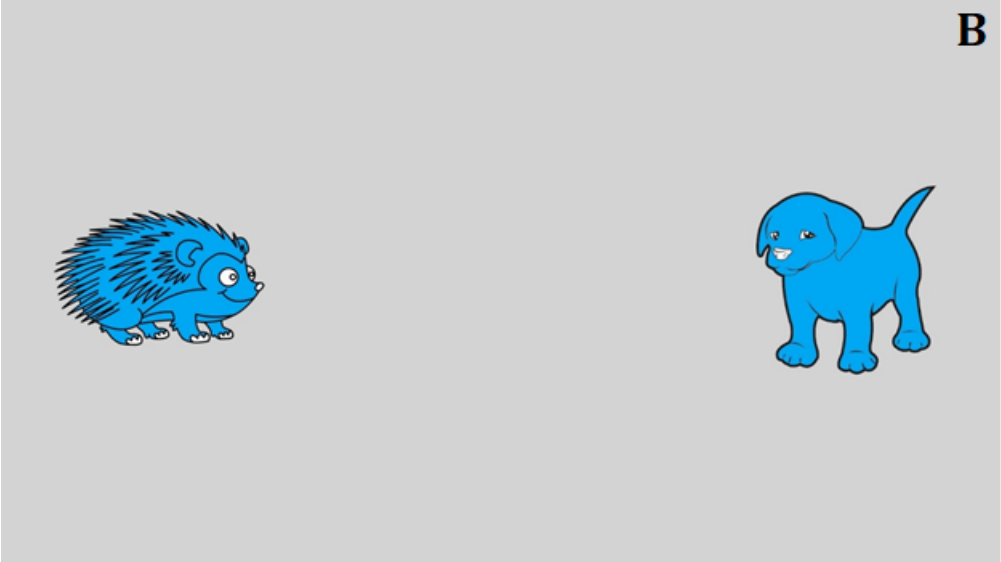


Fig. 1. (A) An example of a same-gender trial (*стульчик* 'chair$_{masc}$', *мячик* 'ball$_{masc}$'. This is the visual stimuli is presented with the following audio stimuli: *Где красивый зеленый стульчик?* ('Where is the pretty$_{masc}$ green$_{masc}$ chair$_{masc}$?'); and (B) An example of a different-gender trial (*ёжик* 'hedgehog$_{masc}$', *собачка* 'dog$_{fem}$'). This visual stimulus is presented with the following audio stimuli: *Где хороший синий ёжик?* ('Where is the nice$_{masc}$ blue$_{masc}$ hedgehog$_{masc}$?').

Materials

The task was created using auditory and visual stimuli described above. There was total of 40 trials: 32 experimental trials and 8 filler items. Four lists were created to counterbalance the colour, the side of the target picture and the picture of the noun. Side was counterbalanced within and between lists (target picture left or right) and colour adjective was counterbalanced between lists (animate target picture was yellow or blue; inanimate target picture was red or green). A list consisted of eight blocks of trials. Each block had one filler item at the beginning of the block, followed by four experimental trials.

Each individual trial had the following structure: a fixation picture (smiley face) appeared on the screen simultaneously with a fixation sound (bell sound). The fixation screen lasted for 2000 ms followed by a visual stimuli pair that remained on the screen for 4000 ms. Auditory stimuli were presented 1000 ms after the visual stimuli pair appeared and lasted for approximately 2560 ms (+/- 50 ms). Filler items were colourful pictures presented together with words of encouragement.

A questionnaire for adult participants included questions about participants' sex, age, education, linguistic proficiency in Russian, Latvian and English and parental education. The parents of the children had to fill in a questionnaire about their child's age, sex and linguistic situation at home (mono- or bilingual).

Procedure

Participants were tested individually in a quiet room at the educational facility they attended. Children were tested in a kindergarten bedroom and adults were tested in an empty lecture room at the university. Participants were seated in front of a computer monitor while their eyes were recorded using high-resolution video camera. The camera recorded the video with frequency of 50 frames per second. To make the eye movement recordings easily interpretable we opted for using a large TV monitor (LG, 78cm diagonal, 1920x1080 Full HD) for presenting stimuli. That way participants had to make larger and more noticeable eye movements to look at presented stimuli.

Participants were instructed to only look at the computer screen. Visual stimuli were shown on the screen and audio stimuli were played through speakers. Participants heard

the audio stimuli and had to look at the monitor. Each participant was presented with one out of four possible lists.

The experiment lasted approximately 5 minutes for all the age groups. This time limit was chosen to make sure that all groups are tested under the same conditions and toddlers would not get bored and lose attention. After the experimental task, adult participants filled out a questionnaire. Children's parents and teachers filled questionnaires about children in their private time, either before or after the experimental session. At the end of the experiment child participants were rewarded with stickers.

Data processing

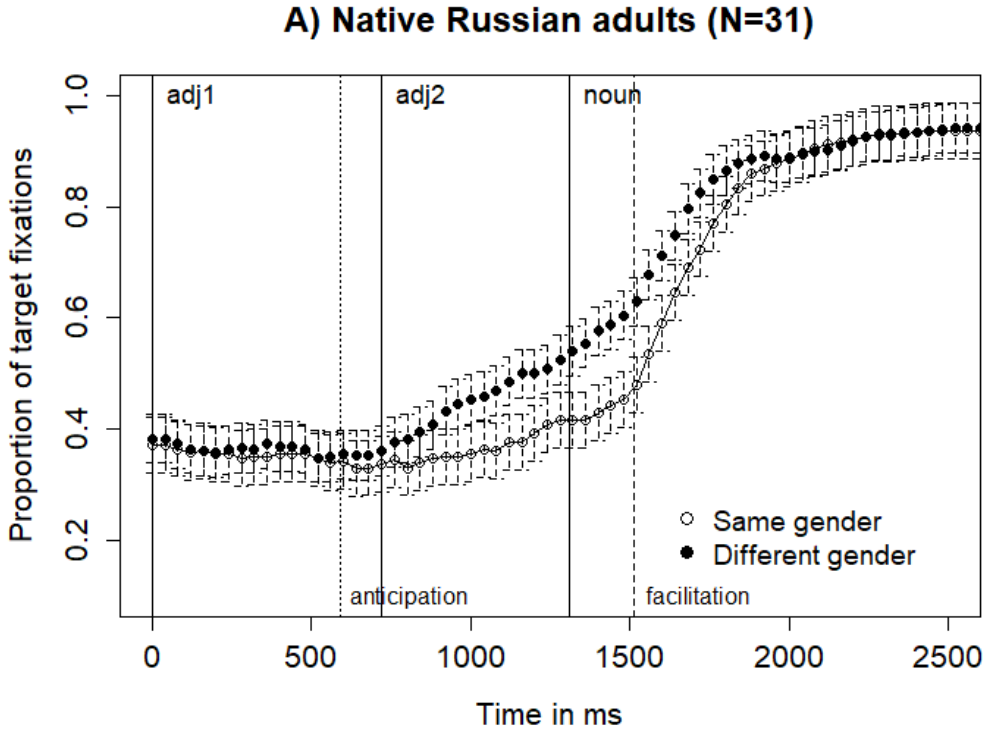
The video recordings of participants were coded for gaze location using ELAN (Wittenburg, Brugman, Russel, Klassmann, & Sloetjes, 2006) software by a research assistant who had no knowledge of the Russian language and who was unaware of the purpose of this study. The research assistant examined video recordings frame by frame (40 ms each) and determined whether participants were looking at the left side of the screen, the right side of the screen, in the centre or away. And after this, the looks were categorised as target (if participant looked at the target) versus distractor (when participant looked at the distractor) looks in R (R Development Core Team, 2008).

Results

Fig. 2 shows the proportions of fixation to targets over time for adults (Fig. 2A) and children (Fig. 2B). The time course is presented from the onset of the first adjective until the end of the noun. In our analysis, we focused on the time frame starting from 200 ms

after the onset of the last syllable of the first adjective until the offset of the noun, as the latency to plan and execute a saccade has been estimated to be around 200 ms (Matin, Shao, & Boff, 1993).

To investigate the role of grammatical gender in sentence processing in Russian we conducted several generalised mixed-effects logistic regression analyses (glmer; Jaeger, 2008) in R using the *lme4* package (Bates, Mächler, Bolker, & Walker, 2015). The dependent variable was categorical with target fixations coded as 1 and distractor fixations as 0. In each model, Trial type (different vs. same) was entered as a categorical fixed effect and Time (40 ms bins) as a continuous fixed effect. Trial type was coded as a numeric contrast, that is, Different as -0.5 and Same as +0.5 (Barr, 2008). Time was centered and rescaled. In addition, Participants and Items were entered as random effects.



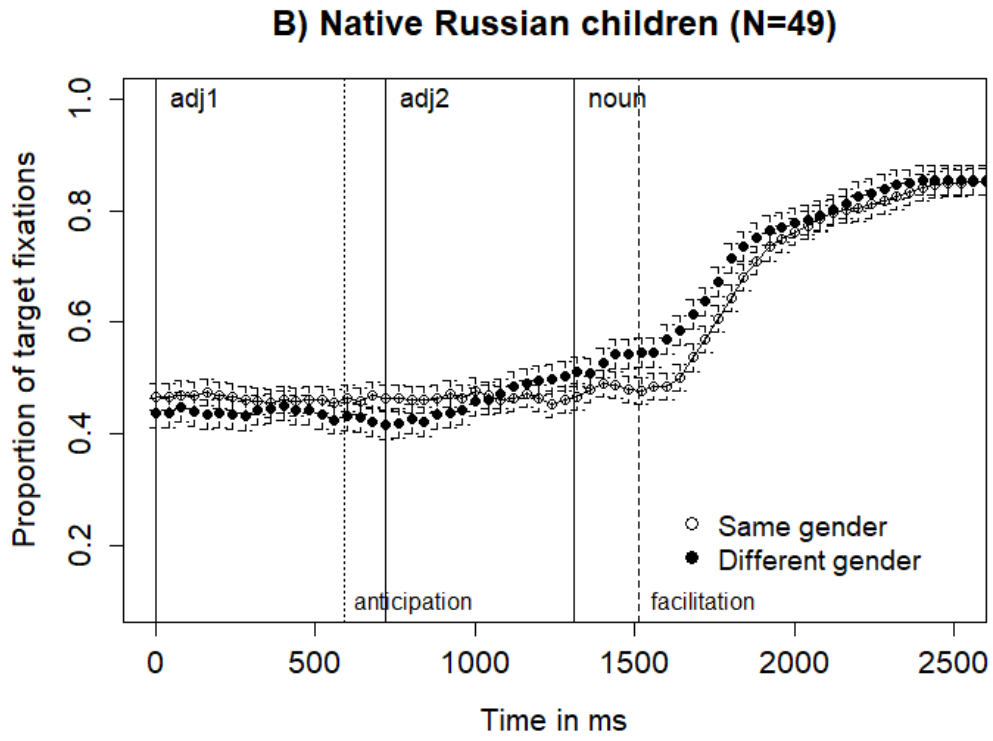


Fig. 2. Target fixation proportions over time for same vs. different gender trials for (A) adult and (B) child native speakers of Russian. The start of the anticipation window is marked by the dotted line and the start of the facilitation window by the striped line.

The analyses were conducted on two time windows (cf. Brouwer et al., 2017). To analyse anticipation effects, a time frame was chosen starting from 200 ms from the offset of the last syllable of the first adjective until 200 ms after the onset of the noun. For facilitation effects we looked at the time frame starting from 200 ms after the onset of the noun until the offset of the noun.

Adults

The aim of the first analysis was to investigate the ability of adult speakers to anticipate the gender of the upcoming noun. Table 2 provides the results of the first analysis, which revealed a significant effect of Trial type, a significant effect of Time and a significant interaction between Trial type and Time. Figure 3 shows a plot for the interaction between Trial type and Time. The slope of the different gender trials is steeper than the slope of the same gender trials suggesting that adult speakers of Russian anticipate the upcoming noun on the basis of an adjective.

Table 2. Anticipation ability in adults: Results of the glmer model.

	Estimate	SE	z-value	p-value
Intercept	0.401	0.106	3.768	< .001
Trial type	-0.363	0.037	-9.745	< .001
Time	0.342	0.023	14.845	< .001
Trial type : Time	-0.249	0.032	-7.812	< .001

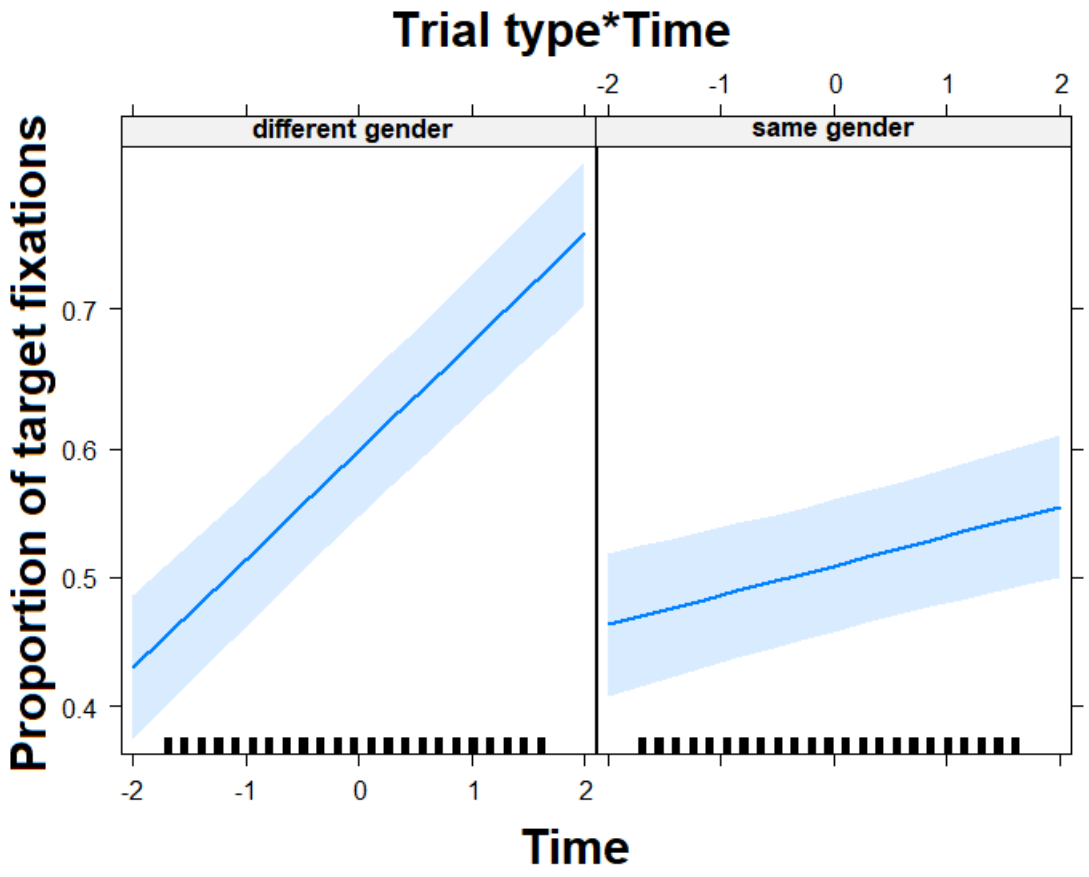


Fig. 3. Plot for the interaction between Trial type and Time. It shows the proportion of target fixations over time for same vs. different gender trials for adults in the anticipation window. Note that smaller x-axis values indicate earlier in time.

Children

The second analysis looked at the anticipation ability in children. Besides Trial type, we also included Age (in months) as a continuous fixed factor to the model. This factor was centered and rescaled. The third analysis revealed a significant effect of Time, a significant interaction between Trial type and Time and a marginally significant interaction of Trial type, Time and Age (see Table 3). The plot for the interaction between Trial type and Time (Fig. 4) shows that, although children start lower on the intercept for

different gender trials than for same gender trials, they rapidly start using gender information to look at the target. Figure 5 shows the plot for the marginal three-way interaction between Trial type, Time and Age (p=.054). The difference in slopes between same and different gender trials seems to increase with age, although there is much individual variation, especially in the younger children. These data reveal that children show an anticipation effect, which tends to increase with age. These findings will be further discussed in the Discussion section.

Table 3. Anticipation ability in children: Results of the glmer model.

	Estimate	SE	z-value	p-value
Intercept	0.017	0.084	0.202	0.84
Trial type	0.024	0.028	0.856	0.391
Time	0.147	0.017	8.768	< .001
Age	0.024	0.054	0.444	0.657
Trial type : Time	-0.134	0.024	-5.657	< .001
Trial type : Age	0.038	0.024	1.552	0.121
Time : Age	0.03	0.017	1.703	0.089
Trial type : Time : Age	-0.047	0.024	-1.927	0.054

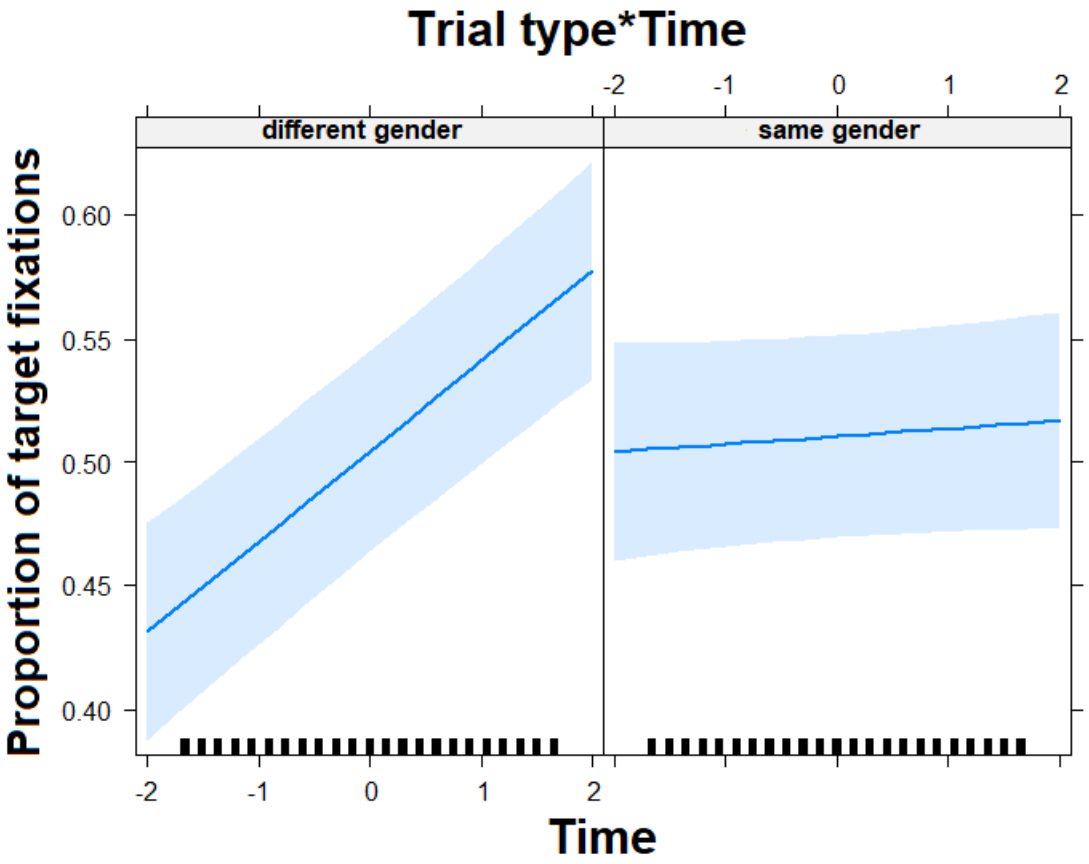


Fig. 4. Plot for the interaction between Trial type and Time. It shows the proportion of target fixations over time for same vs. different gender trials for children in the anticipation window. Note that smaller x-axis values indicate earlier in time.

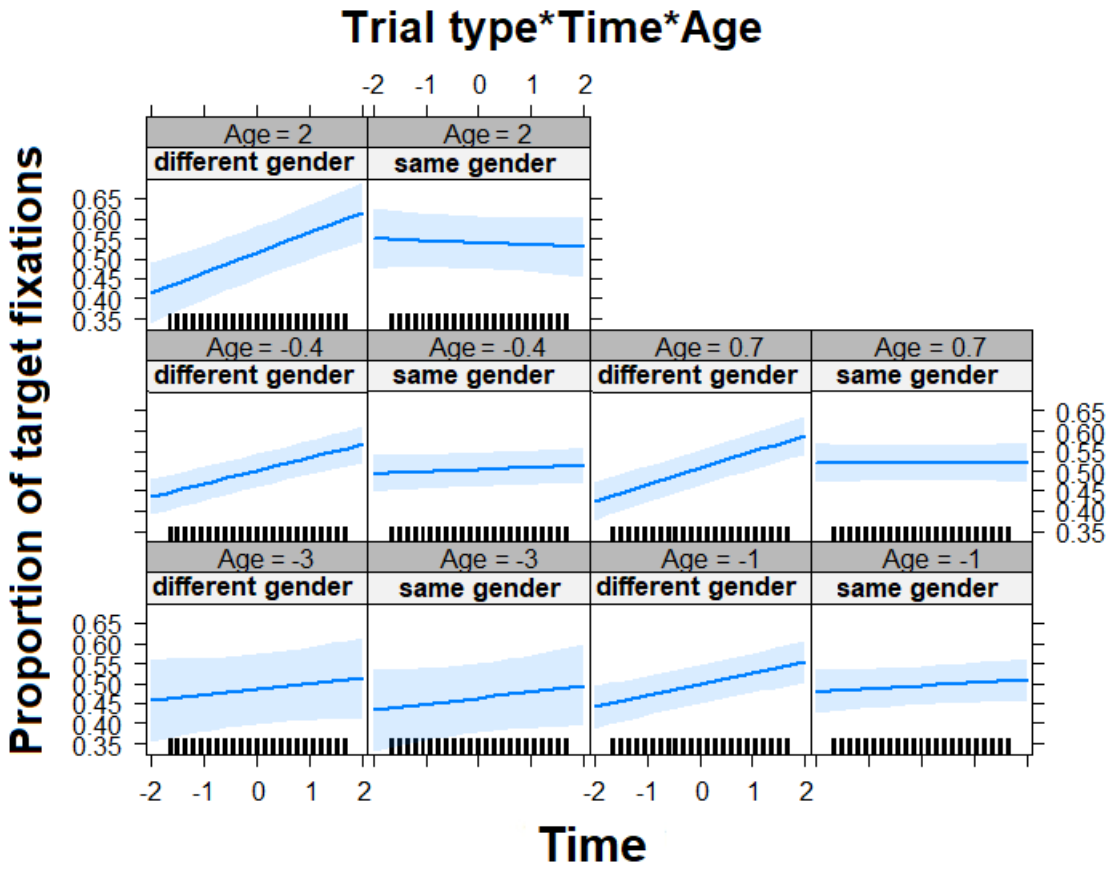


Fig. 5. Plot for the three-way interaction between Trial type, Time and Age. It shows the proportion of target fixations over time for same vs. different gender trials for the children with different ages in the anticipation window. Note that the youngest children (Age = -3) are on the bottom left of the plot and the oldest children (Age= 2) are on the top left of the graph. Note also that smaller x-axis values indicate earlier in time.

Adults vs. Children

In our final analysis we compared the eye gaze behaviour of the children with the adults to examine the differences in predicting behaviour between those two groups. A new predictor called Group (adults vs. children) was therefore added. It was coded as a numeric contrast (adults as -0.5 and children as +0.5).

The results for the anticipation window are shown in Table 4. The analysis revealed a significant effect of Time, Trial type, and Group. It also showed a significant two-way interaction between Trial type and Time, Trial type and Group, and Time and Group. Finally, the analysis revealed a significant three-way interaction between Trial type, Time and Group. Figure 6 shows the plot for this significant three-way interaction. The slope of adults for different gender trials is much steeper than the slope of children, indicating that the anticipation effect is stronger in adult speakers of Russian than in child speakers.

Table 4. Anticipation ability in adults vs. children: Results of the glmer model.

	Estimate	SE	z-value	p-value
Intercept	0.408	0.088	4.640	< .001
Trial type	-0.378	0.034	-11.187	< .001
Time	0.337	0.023	14.773	< .001
Group	-0.409	0.09	-4.553	< .001
Trial type : Time	-0.247	0.032	-7.801	< .001
Trial type : Group	0.413	0.039	10.465	< .001
Time : Group	-0.189	0.028	-6.693	< .001
Trial type : Time : Group	0.112	0.039	2.832	0.004

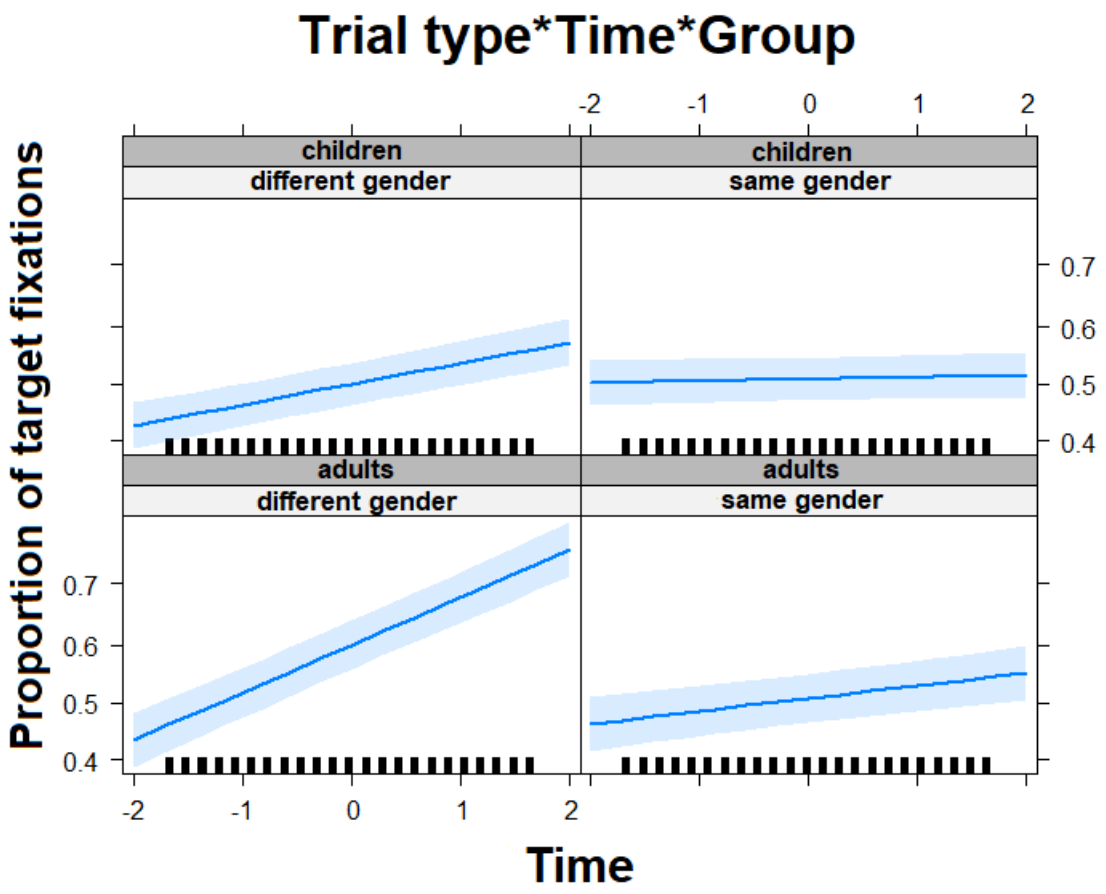


Fig. 6. Plot for the three-way interaction between Trial type, Time and Group. It shows the proportion of target fixations over time for same vs. different gender trials for children and adults in the anticipation window. Note that smaller x-axis values indicate earlier in time.

Note that we also planned to conduct analyses in the facilitation window for both adults and children. However, this appeared to be redundant as we already found an anticipation effect in both groups. It would also be hard to interpret a facilitation effect as it may have been due to an aftermath of the anticipation effect. Therefore, we do not include this analysis here, but it can be found in the Appendix.

Discussion

The present study aimed to investigate whether Russian speaking adults and children use grammatical gender to predict upcoming nouns. More specifically, we looked at the role of age in grammatical gender processing in children. Unlike previously investigated languages such as French (Grosjean et al., 1994; Dahan et al., 2000), German (Friederici & Jacobson, 1999), Spanish (Lew-Williams & Fernald, 2010; Wicha et al., 2004) and Dutch (Brouwer et al., 2017), Russian does not have articles to provide its speakers with gender information, but it has gender-marked *adjectives* (e.g. *бел<u>ое</u> облак<u>о</u>* 'white$_{neut}$ cloud$_{neut}$', *бел<u>ая</u> машин<u>а</u>* 'white$_{fem}$ car$_{fem}$', and *бел<u>ый</u> снег <u>Ø</u>* 'white$_{masc}$ snow$_{masc}$'). This study is the first one to look at the effect of gender-marked adjectives on online sentence comprehension in a non-WEIRD language (Henrich et al., 2010).

To investigate this, we tested native Russian adults and children on a preferential looking paradigm (Golinkoff, Ma, Song, & Hirsh-Pasek, 2013). Participants were presented with pairs of pictures displayed on a computer screen while hearing simple Russian sentences (e.g. *Где красивый зеленый стульчик?* 'Where is the pretty$_{masc}$ green$_{masc}$ chair$_{masc}$?'). Those sentences contained one of the displayed pictures (i.e. the target, chair) and a distractor (e.g. ball). Each target noun was preceded by two gender-marked articles. Two types of trials were presented: same-gender trials, in which both pictures were of the same grammatical gender (e.g. chair$_{masc}$, ball$_{masc)}$ and different-gender trials, in which the pictures were of different gender (e.g. chair$_{masc}$, hat$_{fem}$). Importantly, in different-gender trials, listeners received an informative gender upon hearing the first adjective, allowing them to narrow down possible lexical candidates.

We hypothesized that Russian-speaking adults and children can predict an upcoming noun based on grammatical gender cue when it is potentially informative (i.e. in different-gender trials). We expected that the ability to predict in children will be dependent on age: the older they are, the better they are at prediction. Following Brouwer et al. (2017), we investigated this by looking at whether they could use the gender of the adjective anticipatorily (i.e. before hearing the onset of the noun) and/or facilitatively (i.e. from noun onset). There were two main findings. First, as predicted, we demonstrated that adult native speakers of Russian looked faster and more on the target in different-gender trials. This means they are able to use grammatical gender information to anticipate the upcoming noun. This finding is in line with previous research on the role of grammatical gender in predictive sentence processing (e.g. Grosjean et al., 1994; Friederici & Jacobson, 1999; Brouwer et al., 2017). This result also extends the previous research as we found that, next to articles, *adjectives* can be used as a grammatical gender cue.

Secondly, in line with our predictions, we found that native Russian children use gender-marked adjectives to anticipate the gender of the upcoming noun in online sentence interpretation. This is in line with Lew-Williams & Fernald (2007) and Brouwer et al. (2017), who found similar results for native Spanish and Dutch children, respectively. Furthermore, Brouwer et al. (2017) found that this effect was dependent on the ability of children to correctly produce gender-marked articles. In the current study, we also looked at the development of prediction ability in children. In line with Gvozdev's (2007) findings, we proposed that age may be associated with the ability of Russian children to predict the gender of an upcoming noun. However, we only found a marginally significant effect of age. It thus seems that the strength of the anticipation effect is not

(only) associated with age, suggesting that individual differences in linguistic skills such as children's vocabulary size might affect anticipation (see also Borovsky, Elman, & Fernald (2012) and Mani & Huettig (2012) for the effects of (productive) vocabulary size on the semantic prediction skill in children). We come back to the marginal effect of age later in this section.

Finally, we compared the strength of the anticipation effect in the adult and child groups. Just like adults, children process sentences in an anticipatory manner, orienting on the target picture before it is named in different-gender trials. We found that the anticipation effect is stronger for adults than for children. This is in line with previous research (Lew-Williams and Fernald, 2007; Brouwer et al., 2017) that found that adults were faster at using grammatical gender information than children. It is not surprising, as children are still in the process of first language acquisition and are not able to use prediction to the full extent (Trueswell, Sekerina, Hill, & Logrip, 1999).

There are several possible explanations for why we only found a marginally significant effect of age. First, Russian children might be less familiar with an experimental session than WEIRD-language children. In Latvia, where the current study was conducted, the field of experimental psycholinguistics is not as developed as in the western world. None of the participants (both children and adults) ever participated in an experiment before. As inexperienced participants, children in our study might have paid less attention to the stimuli and more attention to the novelty of the situation (e.g. being recorded, being in front of the large screen, having to hear repetitive sentence structures).

Secondly, we included a broad age range of children (2 – 7 year-olds) to be able to examine age as a continuous factor. Although the total group size was relatively large, the number of participants in each age category was perhaps too small to show a strong effect of age (power issue).

Thirdly, some other factors might be more closely associated with gender prediction in Russian speaking children than age. As we mentioned before, Brouwer et al. (2017) found that children who scored higher on article production task were the ones who were more successful in prediction. Gvozdev (2007), as well as personal experience working with Russian speaking children, suggested that by the age of 4 children consistently produce correct gender-marked adjectives. Therefore, we can speculate that correct gender production ability may not be sufficient for developing linguistic prediction skills. This discrepancy with the prior work might be due to the fact that the previous research exclusively looked at gender-marking on articles. Lew-Williams and Fernald (2007) suggested that Spanish children may acquire articles together with nouns they belong to, making it easier to associate certain articles with a respective noun. This is, however, less the case with adjectives which more often vary from sentence to sentence.

Fourthly, adjectives are semantically "heavy", they do not just convey information about the gender of the noun (like articles do) but also indicate the characteristics of the noun (e.g. colour, shape, etc.) that listeners have to pay attention to. Working memory is mediating linguistic prediction (Huettig & Janse, 2016). If working memory is occupied with semantic information, it is possible that prediction ability decreases. It is worth to note that Brouwer et al. (2017) used sentences, in which a gender-marked article was followed by a non-gender-marked adjective, so subjects also had additional working

memory costs. However, there are three main points that make our experiment more cognitively demanding than that by Brouwer et al. (2017): in the current paper we used two adjectives, requiring participants to process more semantic information before hearing the target noun; in Russian, gender cue is embedded in an adjective, so speakers need to extract that information, unlike in Dutch, where the article itself is a gender cue; in Dutch articles precede adjectives, therefore, the gender information is fed into the working memory before semantic information, possibly allowing gender information to persist longer in the working memory.

In conclusion, the current study found, in line with previous research, that Russian speaking adults and children use grammatical gender cues to anticipate gender of the upcoming noun. Both groups were able to process sentences in an anticipatory manner, before the noun itself was revealed, although adults' prediction ability was larger than children. Our findings suggest that age is involved in anticipation ability in children, but it seems not to be the only (defining) predictor. Future research should explore which linguistic and cognitive factors contribute to anticipation ability in Russian-speaking children.

References

Akhutina, T., Kurgansky, A., Polinsky, M., & Bates, E. (1999). Processing of grammatical gender in a three-gender system: Experimental evidence from Russian. *Journal of Psycholinguistic Research*, *28*(6), 695–713.

Barr, D. J. (2008). Analyzing 'visual world' eyetracking data using multilevel logistic regression. *Journal of Memory and Language*, *59*(4), 457–474.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*(1). https://doi.org/10.18637/jss.v067.i01

Boersma, P., & Weenink, D. (2005). Praat: Doing phonetics by computer [Computer program]. Version 6.1, retrieved 13 July 2019 from http://www.praat.org/

Borovsky, A., Elman, J. L., & Fernald, A. (2012). Knowing a lot for one's age: Vocabulary skill and not age is associated with anticipatory incremental sentence interpretation in children and adults. *Journal of Experimental Child Psychology*, *112*(4), 417–436.

Brouwer, S., Sprenger, S., & Unsworth, S. (2017). Processing grammatical gender in Dutch: Evidence from eye movements. *Journal of Experimental Child Psychology*, *159*, 50–65.

Cooper, R. M. (1974). The control of eye fixation by the meaning of spoken language: A new methodology for the real-time investigation of speech perception, memory, and language processing. *Cognitive Psychology*, *6*, 84-107.

Covey, L., Gabriele, A., & Fiorentino, R. (2018). Can learners use morphosyntactic cues to facilitate processing? Evidence from a study of gender agreement in Hindi. *Language Acquisition*, *25*(3), 327–337.

Dahan, D., Swingley, D., Tanenhaus, M. K., & Magnuson, J. S. (2000). Linguistic gender and spoken-word recognition in French. *Journal of Memory and Language*, *42*(4), 465–480.

Friederici, A. D., & Jacobson, T. (1999). Processing grammatical gender during language comprehension. *Journal of Psycholinguistic Research*, *28*(5), 467–484.

Golinkoff, R. M., Ma, W., Song, L., & Hirsh-Pasek, K. (2013). Twenty-five years using the intermodal preferential looking paradigm to study language acquisition: What have we learned? *Perspectives on Psychological Science*, *8*(3), 316–339.

Grosjean, F., Dommergues, J.-Y., Cornu, E., Guillelmon, D., & Besson, C. (1994). The gender-marking effect in spoken word recognition. *Perception & Psychophysics*, *56*(5), 590–598.

Gvozdev, A. N. (2007). *Voprosih izucheniya detskoyj rechi [Problems of child speech study]*. Moscow: Detstvo-Press.

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences*, *33*(2–3), 61–83.

Huettig, F., & Janse, E. (2016). Individual differences in working memory and processing speed predict anticipatory spoken language processing in the visual world. *Language, Cognition and Neuroscience*, *31*(1), 80–93.

Jaeger, T. F. (2008). Categorical data analysis: Away from ANOVAs (transformation or not) and towards logit mixed models. *Journal of Memory and Language*, *59*(4), 434–446.

Kempe, V., Brooks, P. J., Mironova, N., & Fedorova, O. (2003). Diminutivization supports gender acquisition in Russian children. *Journal of Child Language*, *30*(2), 471–485.

Lew-Williams, C., & Fernald, A. (2007). Young children learning Spanish make rapid use of grammatical gender in spoken word recognition. *Psychological Science*, *18*(3), 193–198.

Lew-Williams, C., & Fernald, A. (2010). Real-time processing of gender-marked articles by native and non-native Spanish speakers. *Journal of Memory and Language*, *63*(4), 447–464.

Loerts, H., Wieling, M., & Schmid, M. S. (2013). Neuter is not common in Dutch: Eye movements reveal asymmetrical gender processing. *Journal of Psycholinguistic Research*, *42*(6), 551–570.

Mani, N., & Huettig, F. (2012). Prediction during language processing is a piece of cake — but only for skilled producers. *Journal of Experimental Psychology: Human Perception and Performance*, *38*(4), 843.

Matin, E., Shao, K. C., & Boff, K. R. (1993). Saccadic overhead: Information-processing time with and without saccades. *Perception & Psychophysics*, *53*(4), 372–380.

Melançon, A., & Shi, R. (2015). Representations of abstract grammatical feature agreement in young children. *Journal of Child Language*, *42*(6), 1379–1393.

R Development Core Team (2008). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

Tanenhaus, M. K., Spivey-Knowlton, M. J., Eberhard, K. M., & Sedivy, J. C. (1995). Integration of visual and linguistic information in spoken language comprehension. *Science*, *268*(5217), 1632–1634.

Trueswell, J. C., Sekerina, I., Hill, N. M., & Logrip, M. L. (1999). The kindergarten-path effect: Studying on-line sentence processing in young children. *Cognition*, *73*(2), 89–134.

Wicha, N. Y., Moreno, E. M., & Kutas, M. (2004). Anticipating words and their gender: An event-related brain potential study of semantic integration, gender expectancy, and gender agreement in Spanish sentence reading. *Journal of Cognitive Neuroscience*, *16*(7), 1272–1288.

Wittenburg, P., Brugman, H., Russel, A., Klassmann, A., & Sloetjes, H. (2006). ELAN: A professional framework for multimodality research. *5th International Conference on Language Resources and Evaluation (LREC 2006)*, 1556–1559.

Appendix

Facilitation analysis

In addition to anticipation window we also looked at the facilitation in adults and children. The results for the analysis in the facilitation window for adult group are shown in Table 5. We find a significant effect of Trial type, a significant effect of Time and a significant interaction between Trial type and Time. However, this interaction does not mean that adult speakers facilitate the processing of the upcoming noun. The plot (Fig. 7) for the interaction between Trial type and Time suggests that the significant interaction is due to the fact the intercept is higher in different gender trials than in the same gender trials. Because adult speakers always end up fixating at the target in both types of trials, this leads to the slope being steeper in the same gender trials. The difference in intercept and steepness for same vs. different gender trials leads to a significant interaction between Trial type and Time.

Furthermore, we conducted analysis in the facilitation window for child group. Table 6 outlines the results of the analysis, which demonstrated a significant effect of Trial type, a significant effect Time, a significant effect of Age, a significant interaction between Trial type and Time, a significant interaction between Trial type and Age and a significant interaction between Time and Age. Figure 8 shows a plot for an interaction between Time and Age. We can conclude that irrespective of Trial type older children are better at performing this type of task. Figure 9 shows a plot for the two-way interaction between Trial type and Age, irrespective of Time. In this case, we see a clear facilitation effect when we collapse the data over time, especially in older children. Figure 10 shows a plot for a significant interaction between Trial type and Time. The slope for the different gender

trials has higher intercept than the slope for the same gender trials, this means that irrespective of age, children fixate at the target faster when adjective is informative. However, we find no significant interaction between Trial type, Time and Age. Similarly to adult group, this might be due to the fact that we already observed a prediction effect during the anticipation window. So, the facilitation window only provides us with an aftermath of an effect.

Finally, we compared child and adult groups. The analysis revealed a significant effect of Trial type, a significant effect of Time, a significant effect of Group, a significant two-way interaction between Trial type and Time, a significant two-way interaction between Time and Group and a significant three-way interaction between Trial type, Time and Group. Figure 11 shows a plot for the three-way interaction between Trial type, Time and Group. Those results suggest that children and adults differ in their looking behaviour in the aftermath of the anticipation effect.

Table 5. Facilitation ability in adults: Results of the glmer model.

	Estimate	SE	z-value	p-value
Intercept	3.626	0.382	9.485	< .001
Trial type	-0.955	0.257	-3.718	< .001
Time	0.542	0.034	16.136	< .001
Trial type : Time	0.345	0.046	7.531	< .001

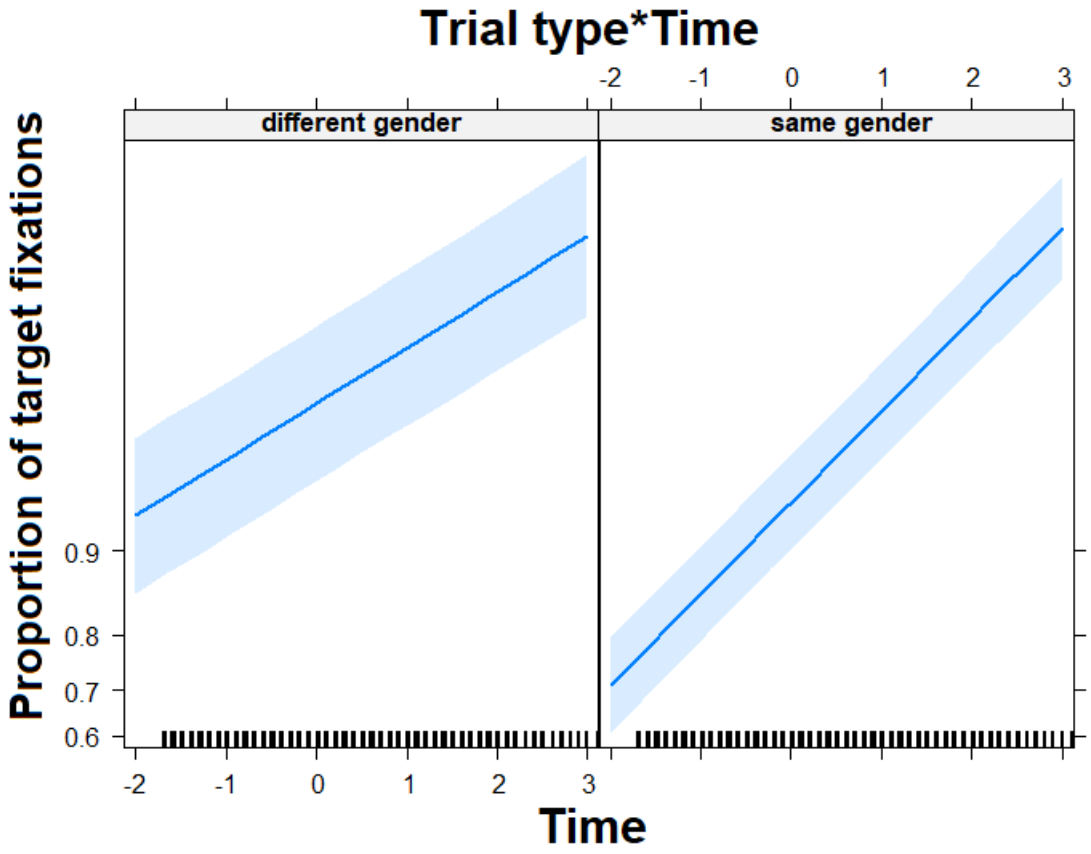


Fig. 7. Plot for the interaction between Trial type and Time. It shows the proportion of target fixations over time for same vs. different gender trials for adults in the facilitation window. Note that smaller x-axis values indicate earlier in time.

Table 6. Facilitation ability in children: Results of the glmer model.

	Estimate	SE	z-value	p-value
Intercept	1.258	0.107	11.725	< .001
Trial type	-0.229	0.037	-6.204	< .001
Time	0.569	0.023	25.060	< .001
Age	0.302	0.076	3.995	< .001

Trial type : Time	0.106	0.032	3.349	< .001
Trial type : Age	-0.124	0.032	-3.912	< .001
Time : Age	0.07	0.023	3.032	0.002
Trial type : Time : Age	-0.044	0.031	-1.384	0.166

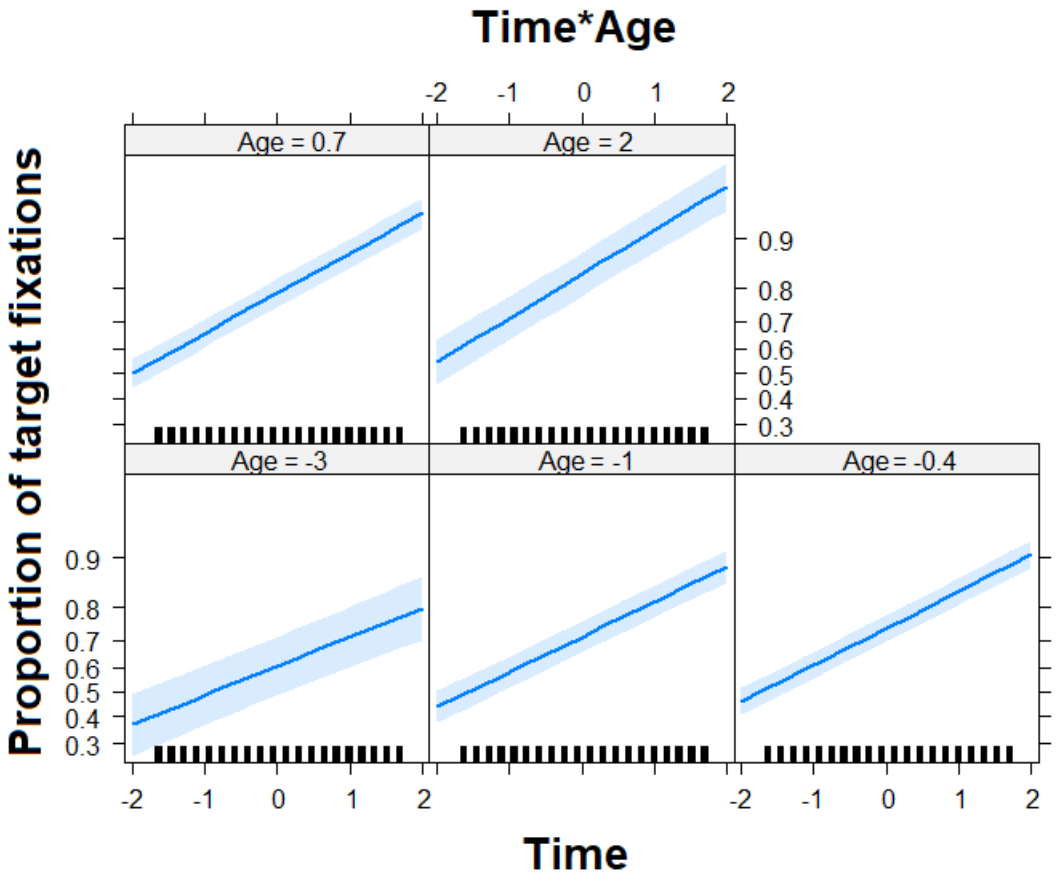


Fig. 8. Plot for the interaction between Time and Age. It shows the proportion of target fixations over time for the age range of children in the facilitation window. Note that the youngest children (Age = -3) are on the bottom left of the plot and the oldest children (Age= 2) are on the top left of the graph. Note also that smaller x-axis values indicate earlier in time.

Fig. 9. Plot for the interaction between Trial type and Age. It shows the proportion of target fixations over childrens' age for same vs. different gender trials in the facilitation window. Note that smaller x-axis values indicate younger children.

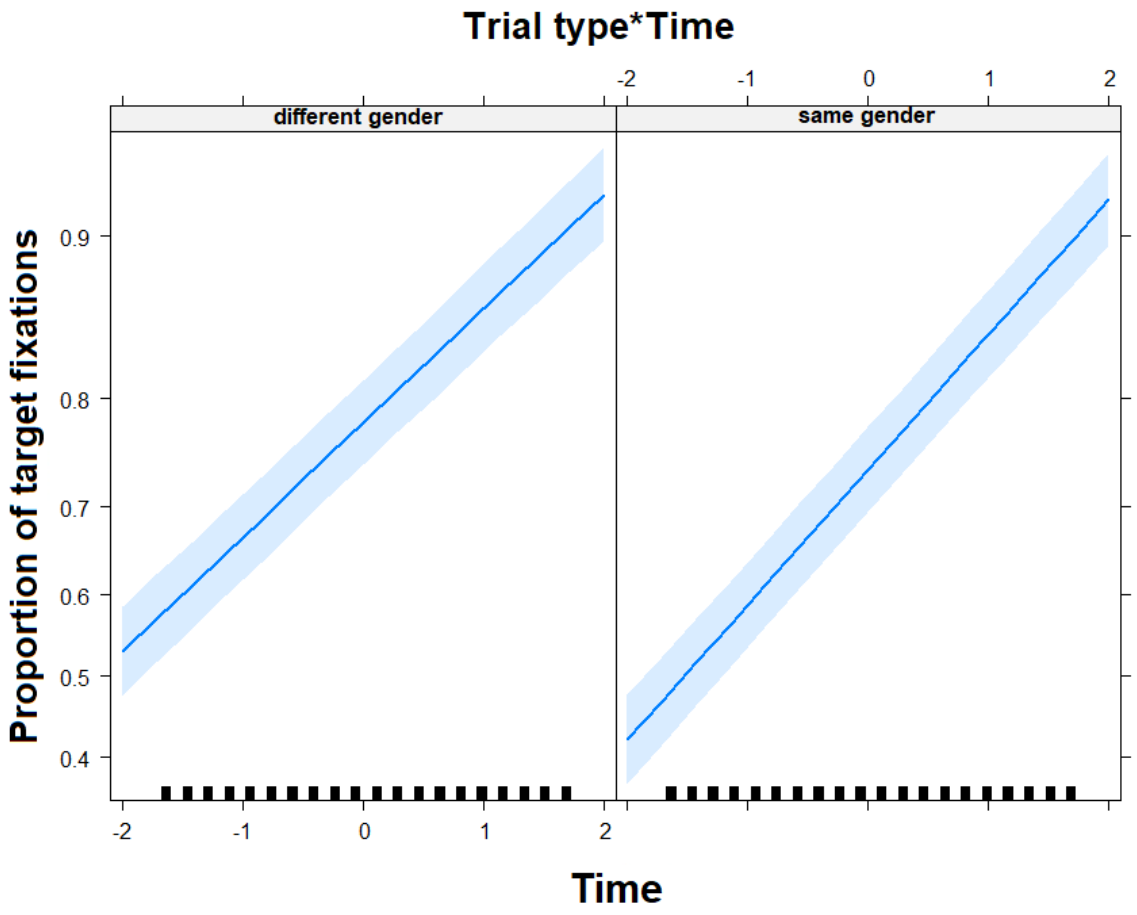


Fig. 10. Plot for the interaction between Trial type and Time. It shows the proportion of target fixations over time for same vs. different gender trials for children in the facilitation window. Note that smaller x-axis values indicate earlier in time.

Table 7. Facilitation ability in adults vs. children: Results of the glmer model.

	Estimate	SE	z-value	p-value
Intercept	2.469	0.16	15.405	< .001
Trial type	-0.284	0.052	-5.456	< .001
Time	0.421	0.035	11.885	< .001
Group	-1.181	0.181	-6.533	< .001

Trial type : Time	0.442	0.049	8.951	< .001
Trial type : Group	0.054	0.058	0.928	0.353
Time : Group	0.135	0.042	3.221	0.001
Trial type : Time : Group	-0.325	0.058	-5.563	< .001

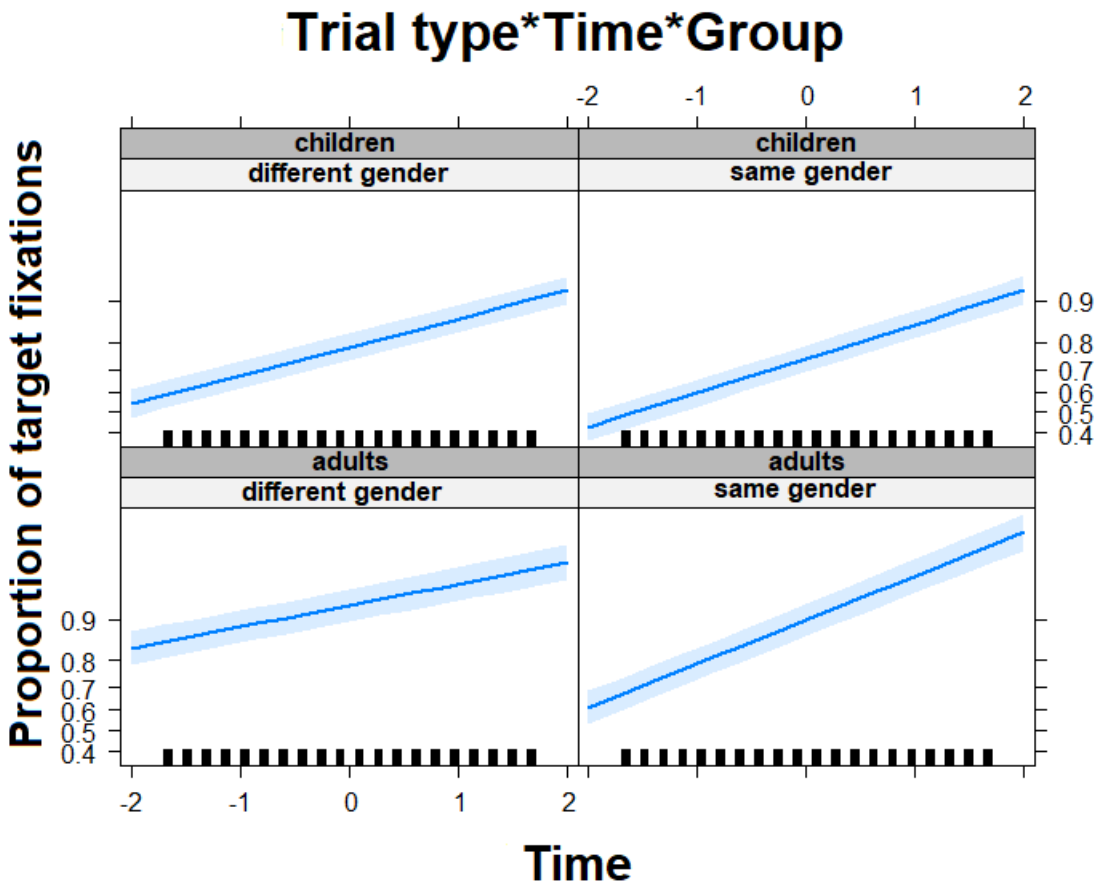


Fig. 11. Plot for the three-way interaction between Trial type, Time and Group. It shows the proportion of target fixations over time for same vs. different gender trials for children and adults in the facilitation window. Note that smaller x-axis values indicate earlier in time.