Každyj den’ turist *otdoxnul na pljaže. An event-related potentials study on the processing of aspectual violation in Russian iterative sentences

Каждый день турист *отдохнул на пляже. Исследование вызванных потенциалов при обработке неограниченно-кратных предложений с видовыми нарушениями в русском языке

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Abstract The treatment of verbal aspect in Russian grammar and its interaction with lexical semantics are controversial matters. We address these issues from a psycholinguistic perspective. We conducted an EEG study with 14 native Russian speakers processing 160 sentences in the unrestrictedly iterative meaning; the sentences were either correct or contained semantic, morpho-syntactic, or aspectual violations (e.g., Každyj večer otec *zasnulpfv na divane. ‘Every evening the father *fell asleep on the sofa’). Processing the aspectual violation resulted in a P600, which is typical for processing morpho-syntactic violations and usually is interpreted as an index of difficulties in syntactic (re-)analysis, while an N400, which is typical for processing lexico-semantic violations, could not be observed. Our results show that Russian speakers must make more effort to analyze aspectually incorrect sentences compared with aspectually correct sentences. Processing aspectual violations in Russian clearly resembles processing of morpho-syntactic violations. This is in line with the interpretation of aspect as a typical grammatical category.

Аннотация Вопросы о статусе вида в русской грамматике, а также о его взаимодействии с лексической семантикой глагола до сих пор являются предметом дискуссий. В предлагаемой статье мы рассматриваем их с точки зрения психолингвистики. В нашем электроэнцефалографическом исследовании приняли участие 14 носителей русского языка, которым были предложены 160 предложений с неограниченно-кратным

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значением. При этом предложения либо не содержали никаких нарушений, либо включали в себя семантическое, морфосинтаксическое или видовое отклонение от нормы (напр., Каждый вечер отец *заснул на диване). При обработке видовых нарушений проявился компонент P600, который обычно встречается при обработке нарушений в области морфосинтаксиса и рассматривается как показатель сложности при синтаксической (ре-)интерпретации, в то время как N400, типичный для обработки нарушений лексико-семантических ожиданий, не был обнаружен. Наши результаты показывают, что носителям русского языка требуется больше усилий при интерпретации предложений с видовыми нарушениями, чем при интерпретации предложений без видовых нарушений. Обработка видовых нарушений в русском языке имеет очевидное сходство с обработкой морфосинтаксических нарушений и, таким образом, соответствует интерпретации глагольного вида как грамматической категории.

1 Introduction

Verbal aspect is arguably one of the most debated issues in Slavic, and especially Russian, linguistics. However, currently, little is known about its psycholinguistic nature. Possible questions range from the relationship between aspectual partners in the mental lexicon to the contribution of aspect to, and its interaction with, sentence and textual levels. Importantly, insights into the psycholinguistics of aspect are not only relevant for Slavic linguistics. Aspect is a grammatical category that is widespread throughout the world’s languages (Comrie 1976, pp. 123–128), but so far, its psycholinguistic correlates have predominantly been studied in relation to English. Admittedly, this is not a unique feature of research on aspect; rather, it is true for psycholinguistic research overall. Although it is far from easy to adapt experimental designs for languages that are structurally different from English (Clasmeier, Anstatt, and Gattnar 2016, pp. 8–9), this step is indispensable. English aspect is not representative of aspect in general, as the grammatical category can appear with widely different forms and functions. Accordingly, it is crucial to study its psycholinguistic representation and processing in each language individually.

In the present paper, we address this need with respect to Russian. Our investigation is inspired by an EEG-study on English aspect processing by Flecken, Walbert, and Dijkstra (2015), who exemplified how the event-related potential (ERP) technique can shed light on the processing of aspectual mismatches in comparison with morpho-syntactic and semantic violations. We have taken over the method and general design of this study, applying them to Russian as an aspect language of another type: Can we observe differences in the processing of Russian sentences with aspectual violation compared with correct sentences and sentences with semantic and other morpho-syntactic violations? Furthermore, because of the structural (formal and functional) differences between the two aspectual systems, we expected to observe quite different ERP patterns in terms of Russian aspectual violations to those found by Flecken et al. (2015) for English.

In Sect. 1.1, we roughly outline the grammatical category of Russian aspect and give an overview of what psycholinguists have found out about its mental representation and processing up to now. Since our study extensively draws on Flecken et al.’s (2015) study on English, we discuss this study at some length in Sect. 1.2, along with other studies on aspect processing using the ERP technique. In the last part of the introduction (Sect. 1.3), we compare aspect in English and Russian and formulate our research questions and hypotheses. Then, we present the materials and methods used in our investigation, as well as the results, and discuss them against the background of psycholinguistic research on aspect cross-linguistically, as well as from the perspective of theoretical Russian linguistics.
1.1 Russian verbal aspect

Russian aspect consists of the opposition between two verbal forms, the imperfective (ipf) and perfective (pf), which form aspectual pairs and are referred to as aspectual partners. The treatment of verbal aspect in Russian grammar is a controversially debated issue to this day. If we differentiate between inflectional, derivational, and classificatory grammatical categories (Lehmann 2013, p. 234ff), aspect could be assigned to each of them, depending on concrete approach. Thus, following Isačenko (1968, p. 350), aspect is inflectional because neither of the two members of an aspectual pair has a complete verbal paradigm. Others argue to treat Russian verbal aspect as a classificatory category (Avilova 1976, p. 41; Švedova 1980, p. 584). According to this approach, aspectual value (pf / ipf) is an inherent classifying property of a verb, and thus, the members of an aspectual pair are perceived to be independent verbs, not forms of the same verb. Last, aspect can be interpreted as a derivational category (Lehmann 1999, 2010, 2013) since in the majority of aspectual pairs, in one of the members, the aspectual function is provided by the verbal stem (e.g., the perfective zakry(t’) ‘to close’), while in the other member, it is provided by the derivational affix (suffix or prefix; in the example, the suffix -va-: zakryvat’). Of course, each of the mentioned approaches (and those beyond them) are accompanied by further differences in the conception of the aspectual distinction. At a theoretical level, all of them are plausible in their own way, and their differences are not least the result of different ideas about grammatical relationships in general. Another crucial question concerns the meaning or function of the perfective and imperfective aspect, and its interaction with and contribution to sentence meaning. For example, there is a long-standing debate on whether some invariant meaning can be assigned to imperfective and perfective aspect, and if so, which (e.g., “achievement vs. non-achievement of the internal limit of an action”, Maslov 1985, p. 30). Traditionally, different functions are attributed to each aspectual form, which are sometimes divided into primary/canonical and secondary/non-canonical functions. Although the concrete division into the functions and their definition may differ between authors, there is some consensus on the canonical functions of each aspect (see Sect. 1.3.1).

From a psycholinguistic perspective, one may ask how the different aspectual theories fit the ‘reality’ of language processing as provided by data from a range of different experiments. The psycholinguistic investigation of Russian verbal aspect is still in its early stages, but studies related to this issue shed some light on specific elements.1

Roussakova et al. (2002) dealt with the question of whether the members of an aspectual pair are stored and processed as separate lexemes or as forms of the same lexeme in the mental lexicon of native Russian speakers. They conducted a speech production experiment and asked their subjects (children of various ages and adults) to produce the past tense form of a verb given in the present tense (e.g., stimulus rešaet ‘he/she/it decides’ > expected reaction rešal ‘decided’). In this way, the authors tested 10 different aspectual pairs and then analyzed ‘mistakes’ (i.e., when subjects used the opposite aspectual form of the stimulus verb in their answers). As the probability of mistakes differed heavily between the tested items, the researchers concluded that the “degree of intimacy in the mental representations of the members of aspectual pairs differs considerably” (Roussakova et al. 2002, p. 308); thus, some

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1 Although not directly relevant for our own study, we would like to mention the eye-tracking experiments by Christiane von Stutterheim, Barbara Mertins, and others, who investigated the influence of aspect on event conceptualization in different languages, and thus, the relationship between aspect as a linguistic feature and the general cognitive process of thinking (v. Stutterheim et al. 2012, pp. 833–867). Note also that we only concentrate on studies with adult participants here. Russian verbal aspect during language acquisition is a rather well-established field of research but is not of direct relevance for our investigation.
pairs may be stored as one lexeme, but certainly not all of them. Interestingly, the smallest children showed the highest probability of correct answers, which implied that the mental representations of the members of an aspectual pair are acquired separately, only to then be combined during the development of language competence.

Anstatt and Clasmeier (2012) also asked the question whether the members of an aspectual pair are stored as forms of the same lexeme in the mental lexicon; they investigated this issue using the subjective frequency measurement technique. The researchers asked native Russian speakers to rate the frequency of appearance of 48 perfective and imperfective infinitives in everyday life on a 7-point scale. Interestingly, the subjective frequencies of the two members of an aspectual pair were rated very similarly, even when the two members differed widely concerning their corpus frequency. For example, the imperfective besedovat’ and perfective pobesedovat’ ‘to chat’ clearly differ in their corpus frequency (33.8 vs. 7.7 instances per million (ipm)), but in the subjective frequency test, both were rated to appear similarly often (median 5.91 and 5.61). The authors interpreted these results as psycholinguistic evidence for the interpretation of aspectual partners as forms of the same lexeme.

Unlike Roussakova et al. (2002), Makavčik (2004) dealt with aspectual semantics. She performed a series of three experiments with a sample of adult native Russian speakers. They were asked to sort single verbs and name the criterion they applied, describe the semantic difference between two sentences differing only in the aspectual form of the predicate, and finally, produce verbs of a particular semantic category (e.g., processes, repeating actions, etc.). Makavčik found that the aspectual semantics identified by native Russian speakers resembled the academic descriptions of the perfective and imperfective functions to a great extent. Although the author does not mention it, this result may have been influenced by the instructions in Russian language classes at school.

While Makavčik (2004) dealt with aspectual semantics in general, Gattnar (2013) focused on one particular syntactic context, that is, the description of restrictedly repeated actions. In principle, Russian allows for both aspectual forms in these contexts; however, in combination with (determined/undetermined) quantifying adverbials preceding or following the predicate, the perfective or imperfective verb is more typical. Gattnar conducted a reaction time experiment with native Russian speakers and confronted them with sentences describing restrictedly repeated actions. Each sentence appeared twice, at first with a gap at the predicate’s position, the second time together with the predicate in both aspectual variants. Participants had to choose the ‘better’ variant as quickly as possible. As Gattnar (2013) expected, in sentences with an undetermined quantifying adverbial (neskol’ko raz ‘a few times’), the imperfective aspect was chosen more often than the perfective was, while for determined quantifying adverbials (dva raza, tri raza ‘two/three times’), the opposite was the case. Moreover, if the adverbial followed the predicate, perfective verbs were chosen more often, while preceding adverbials seemed to be correlated to the imperfective aspect.

Clasmeier (2015) psycholinguistically investigated the formal and functional sides of Russian aspectual relationships. She conducted two experiments with native Russian speakers. In the first experiment on aspectual forms, she confronted the subjects with a series of isolated Russian verbs and pseudo-verbs (e.g., *podzuryvat’) and asked them to classify the (pseudo-) verbs with regard to their aspectual function (pf/ipf) and name the aspectual partner (to the verbs) or build a plausible one (for the pseudo-verbs). Most of the participants’ pseudo-partner proposals were formally plausible and matched the expectations formulated based on a corpus analysis. Moreover, prefixation, which is not accepted by all theoreticians as a method of deriving aspectual partners, was frequently applied in pseudo-partner formation. In the second experiment, Clasmeier (2015) gave her subjects 10 pairs of word forms written on cards and asked them to describe the difference of meaning between the word forms.
either two forms of the same verb with the same aspectual value (e.g., *otkryl* – *otкроет* ‘he opened’ – ‘he will open’) or two words with the same root (e.g., *otkryl* – *otкрытка* ‘he opened’ – ‘postcard’) or two verb forms that differed in their aspectual value (*otkryval* – *otкрыт* ‘he opened’). Moreover, participants were asked to indicate the significance they attributed to the difference in meaning by placing the cards in a greater or smaller distance to each other. Thus, Clasmeier (2015) found that Russian speakers used different semantic components to characterize the aspectual relationship, but they most commonly mentioned aspectual and temporal differences or neglected to see any difference in meaning. This was consistent with the finding that aspectual meaning difference, as indicated by the distance between cards, did not appear to be highly significant to the participants. Interestingly, this could be observed not only for uncontroversial aspectual pairs like the telic *otкрыть* / *открыт* ‘to open’, but also for controversially debated aspectual relationships like the atelic *плакать* / *поплакать* ‘to cry’ / ‘to cry for some time’ and *плакать* / *заплакать* ‘to cry’ / ‘to start to cry’.

To summarize, the discussed psycholinguistic studies on verbal aspect in Russian have focused on the mental representation of aspectual pairs and aspectual functions, as well as factors influencing the aspectual choice in production. To our knowledge, Bott and Gattnar (2015) performed the only study on processing Russian aspect in comprehension, especially the grammatical category’s contribution to sentence processing in comparison with the absence of such a category in another language. They focused on the time course of aspectual interpretation in Russian as an aspect language compared to German as a non-aspect language. They tested sentences with achievement verbs followed or preceded by an aspectually fitting or mismatching adverbial (e.g., the Russian sentence with mismatching adverbial: *Знаменитая и опытная боксерша выиграла турнир целых три часа и зрители радовались* ‘The famous and experienced boxer won the championship whole three hours and the attendance was happy’) in two experiments involving eye tracking during reading. As expected, they found differences between the two languages. While Russian readers noticed the mismatch immediately when it occurred, that is, depending on word order in the verb or at the adverbial phrase, German readers only showed mismatch effects after processing the complete predication with all its arguments.

### 1.2 EEG experiments on aspect

In this section, we briefly comment on studies on aspect in languages other than Russian using the ERP technique. Ferretti, Kutas, and McRae (2007) studied the effect of different aspectual forms in sentence processing, and more precisely, in processing locative phrases combined with past progressive (*was snorkeling*) and non-progressive past perfect (*had snorkeled*) English verb phrases. The location denoted by the locative phrase was either typical (*in the ocean*) or less typical (*in the pond*) for the event denoted by the verb. They focused on the N400 effect, a negative peak in the ERP around 400 ms after stimulus onset that reflects difficulties in processing lexico-semantic information (Kutas and Hillyard 1980; see Kutas and Federmeier 2000 for an overview). The N400 component was smallest for typical locations with progressive verbs and largest for atypical locations with progressive verbs, and there was no difference between typical and atypical locations when the verb was in the non-progressive past perfect. This indicates that information about typical circumstances of events was more activated, and thus, more accessible when the event was presented as ongoing. As the authors argued, this is in line with the interpretation that the progressive presents the event ‘from within’ (Leech et al. 2009, p. 121; see Sect. 1.3.1), making its circumstances more available.

Błaszczak and colleagues (Błaszczak, Jabłońska, and Klimek-Jankowska 2014; Błaszczak and Klimek-Jankowska 2016) studied the processing of aspect in Polish converbs. In Polish
(like in Russian), converbs can be built both with imperfective and perfective verbs, but they differ in two respects. First, they differ at the formal level, since imperfective and perfective verbs take different suffixes; second, they diverge in terms of taxis as imperfective converbs denote an event taking place simultaneously with the event expressed in the main clause, whereas perfective converbs denote a previous event. Consequently, imperfective converbs mostly combine with imperfective verbs in the main clause, while perfective ones combine with perfective verbs. The authors looked at two kinds of mismatches: Firstly, cases in which imperfective verbs were combined with the suffix used for perfective verbs and vice versa; and, secondly, cases in which converbs were created correctly from a formal point of view, but combined with the contrary aspectual form in the main clause. It must be said that the combination of a converb and finite verb that differ in aspect is unusual but not completely ungrammatical in Polish. The authors compared these with control sentences with the morphologically correct converb and aspectually corresponding verbs in the main clause. They found some statistical trends at certain post hoc selected electrodes but no statistically robust effects for aspectually diverging converbs.

As mentioned above, Flecken et al.’s (2015) study is of particular importance for our work. These authors investigated whether the processing of English sentences with aspectual mismatch resembles or is different to the processing of sentences with morpho-syntactic and semantic violations. While semantic violations elicit an N400 component (see above), morpho-syntactic violations, especially errors in grammatical agreement, result in a P600 (i.e., a late positivity in the EEG signal), and in most studies, in an earlier Left Anterior Negativity (LAN). The LAN effect is interpreted as reflecting difficulties in processing non-expected morphological information of the processed word, while the P600 reflects difficulties in syntactic integration of the processed information into the sentence structure (Osterhout and Mobley 1995; Kaan et al. 2000; Friederici 2002; Molinaro, Barber, and Carreiras 2011). Flecken et al. (2015) tested 30 native English speakers by measuring their ERPs while they fulfilled a reading task on a computer screen. Participants read questions providing a temporal context that was progressive or habitual (e.g. *What is Sophie doing in the pool right now?* or *What does Sophie do in the pool every Monday?*). Each question was followed by one of four different answer types, which were as follows: a) a correct sentence matching the expectations elicited by the temporal context of the question (*Right now, Sophie is swimming in the pool*) (control); b) a sentence boasting aspectual mismatch (*Right now, Sophie *swims in the pool*); c) a sentence in which a morpho-syntactic violation occurs (*Right now, Sophie *are swimming in the pool*); and d) a sentence in which a semantic violation occurs (*Right now, Sophie is *cooking in the pool*). In the second part of the experiment, participants rated the grammaticality of the sentences from the control condition, aspectual mismatch and the morpho-syntactic violation conditions on a 5-point scale.

Apart from the typical ERP components for semantic and morpho-syntactic violations (N400 and P600, respectively), Flecken et al. (2015) had the following expectations regarding the aspectual mismatch condition: If aspectual mismatch primarily resembles a semantic anomaly, an N400 component should be observed. If the aspectual mismatch is more akin to morpho-syntactic violations, particularly violations of agreement, a P600 component should appear. Finally, in line with studies on grammatical agreement processing, a LAN may be obtained. The latter pattern (i.e., LAN and P600) has also been found in studies on mismatches between a temporal adverbial and verb tense (Steinhauer and Ullman 2002; Baggio 2008).

As expected, Flecken et al. (2015) found typical N400 effects for semantical violations, hinting at higher lexical processing costs, and P600 effects for morpho-syntactic violations,
suggesting processes of syntactic reanalysis and repair. Interestingly, processing aspectual mismatch exhibited a specific pattern, namely, an early short (shorter than the N400 for semantic violations) and central negativity (250–350 ms) without a P600.

The early negativity may resemble “the early and almost automatic detection of a violation of the expected verb form […], an early stage of processing which, arguably, is not sensitive to overt grammaticality judgements” (Flecken et al. 2015, p. 12). Following this rationale, the early negativity effect would not be an effect of aspectual mismatch per se, but rather, reflect a reaction to an unexpected graphemic word form, especially since in the Right now sentences, the expected progressive involved the highly specific form of the copula is (is swimming). However, while this provides an explanation for the progressive sentences, it cannot account for the habitual sentences, in which no such expectation of a specific word form is involved. Interestingly, the habitual and progressive variants did not differ from each other in general, nor did this distinction interact with the factor ‘Condition’ (Flecken et al. 2015, p. 6). However, if the early negativity effect in the progressive aspectual mismatch sentences was caused by the unexpected word form (missing is), one would expect the habitual sentences to show another ERP pattern in this time window.

The absence of a P600 component indicates that “participants did not need to reintegrate the unexpected aspect marker with the context” (Flecken et al. 2015, p. 12). This interpretation is consistent with the results from the grammaticality judgment task. On average, the aspect mismatch sentences were not overtly judged as ungrammatical (mean = 3.73, standard deviation [SD] = 0.89, in comparison with 1.59, SD = 0.63 for morpho-syntactic violation sentences and 4.90, SD = 0.13 for correct sentences). Nevertheless, the lack of a P600 was unexpected for the authors, so they offer two different possible reasons for it. First, the participants temporarily resided in the Netherlands; thus, their frequent exposure to non-native English language use may have influenced their behavior. Second, Flecken et al. (2015, p. 12) mentioned a possible language-internal reason for the lack of a P600: “[I]n specific contexts of language use, the ongoing—habitual distinction regarding the English progressive is not adhered to strictly (e.g., in sports coverage, Right now, Robben passes the ball and he scores).” This is an interesting hypothesis; indeed, the apparently absent need for structural reanalysis may result from the nature of the English aspectual category and expansion of progressive forms into non-progressive contexts (see Sect. 1.3.1). We will come back to this in the discussion of our results.

Incorporating this idea, we adopted the design developed by Flecken et al. (2015) and set up a similar experiment for Russian—a Slavonic language that principally resembles English in having a grammatical verbal aspect but fundamentally differs from it regarding the structural and semantic features of the aspectual category. In Sect. 1.3, we consider the aspectual systems in English and Russian in more detail.

1.3 The present study

1.3.1 Verbal aspect in English and Russian

In terms of the classification suggested by Comrie (1976, p. 25), English and Russian represent different types of aspectual oppositions. While English aspect is based on the opposition progressive versus non-progressive, the Russian aspectual category belongs to the perfective versus imperfective type, as is the case for all Slavonic languages. Among the world’s languages, the perfective/imperfective distinction appears more frequently (in over 40%) than the progressive/non-progressive distinction (Mair 2012, p. 807). Moreover, among
languages with the latter distinction, the degree of grammaticalization varies considerably: “Languages such as English, in which the category is by and large obligatory with a few exceptions, are in the minority” (Mair 2012, p. 823).

In English, the progressive is used for the representation “of a situation from within, paying attention to its duration in time and to its ongoing or dynamic character” (Leech et al. 2009, p. 119). Morphologically, progressive aspect is expressed by the analytical construction of the copula be and the main verb in the -ing form. Thus, it is opposed to the simple form, which is used in any non-progressive function. As the dynamic character is a crucial feature of progressive situations, the English be + V-ing construction is normally ruled out for stative verbs (*I am understanding Polish). However, it may be used with relational stative verbs, such as live (I’m living on the other side of town; example from Mair 2012, p. 806), but in these cases, the use of the progressive implicates that the state is continuous but temporary. Furthermore, progressive aspect is incompatible with verbs denoting an achievement in the sense of Vendler (1957), for example, *She is noticing a drunk on the street (Mair 2012, p. 814).

Leech et al. (2009) found evidence that indicates a significant increase in the category’s use in the late twentieth century. Interestingly, inherent changes in the language system, especially syntactic or semantic factors, seem to account for only a small part of the expansion. Mair (2012, p. 822) argued: “[I]t is the pragmatic and stylistic overtones of the progressive—informality, emotional coloring, and so on—which seem to be the driving forces behind the observed increases in the discourse frequency of the form.”

As stated above, Russian grammar makes a perfective/imperfective distinction instead of a progressive/non-progressive one. Unlike in English, there is no specific inflectional form for this category; rather, (almost) each Russian verb can be assigned either to the group of perfective or to the group of imperfective verbs. Usually, two verbs from each group form an aspectual relationship, for example, the perfective pridumat’ and the imperfective pridumyvat’, both meaning ‘(to) come up with something, (to) invent’. Morphologically, the imperfective verb in the example is derived from the perfective one via suffixation (-yva-). Except from suffixation (-a- and -va- also function as imperfective suffixes), aspectual partners can be derived from their simplex via prefixation (e.g., varit’/syarit’ ‘(to) boil’; a lot of different prefixes are used for this purpose), and in a few cases, suppletion (i.e., the use of two different verbal stems lovit’/pojmat’ ‘(to) catch’). Nowadays, there is a comparatively broad consensus regarding the formal side of Russian aspectual relationships, although there are some differing views, such as the radically form-oriented approach proposed by Isačenko (1968) and others. In contrast, aspectual semantics is a matter of ongoing debate. Depending on the theoretical concept of the aspectual distinction, Russian grammatical aspect may be regarded as limited to pairs formed via suffixation only (Isačenko 1968), limited to telic verbs (e.g., Švedova 1980; Maslov 1985, 2004; Padučeva 1996) or applicable to almost all verbs apart from states (Čertkova 1996; Breu 2000, 2005; Lehmann 1999, 2010).

Coming back to the comparison with English, it is important to mention the particular meanings perfective and imperfective verbs can provide in Russian. Canonically, perfective verbs express the concrete-factual meaning, as in the perfective form rešila in (1):³

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² An exception must be made for verbs like izolirovat’ ‘(to) isolate (so.)’ or kaznit’ ‘(to) execute (so.)’, which can be used in both contexts requiring perfective and imperfective verbs, and therefore, they are interpreted either as ‘bi-aspectual’ (traditional view, e.g., Švedova 1980) or ‘without aspectual category’ (German aspektlos, e.g., Koschmieder 1934, p. 11).

³ Examples (1)–(5) are drawn from the Russian National Corpus (RNC; www.ruscorpora.ru).
Imperfective verbs, in contrast, can express a range of different canonical meanings. Often, they carry concretes-processual meaning, resembling the English progressive, as otkryvali in (2):

(2) [....] kogda otkryvali šampanskoe, probka rvanula tak, čto obilo kartinu Grigor’eva [....].

‘When we were opening the champagne, the cork popped so heavily that the picture of Grigor’ev was poured over [....].’ (S. Spivakova. Ne vse. 2002)

Imperfective verbs also denote a general-factual meaning, as rešali in (3), which presents events without any definite temporal specification:

(3) Semušin vsě znaet. Voprosy oplaty s vami uže rešali?

‘Semušin knows everything. Has the salary issue already been discussed with you?’ (Ju. I. Vizbor. Al’ternativa veršiny Ključ. 1981)

They also may express states, as in (4):

(4) Tol’ko nado pri etom každyj raz, dobavljat’, [sic!] to čto˙eto ne sootvetstvuet osnovnomu zakonu našej strany—Konstitucii RF.

‘But one has to add each time that this does not comply with the basic law of our country—the Constitution of the Russian Federation.’ (kollektivnyj. Forum: 12 časov v den’? Ne mogu soglasit’sja s M. Proxorovym. 2010–2011)

Finally, imperfective verbs can express an unrestrictedly iterative (or habitual) meaning for repeated actions, as in (5):

(5) [....] i každyj den’ k semi utra, kak na dežurstvo, vyxodil ja na ulicu Seny, [....]

‘[....] and every day around seven o’clock in the morning I went out on Sena Street, as if I was on guard duty [....].’ (Recepty nacional’nyx kuxon’: Francija. 2000–2005)

In specific contexts, both perfective and imperfective verbs can carry a range of further particular meanings (e.g., the summative meaning of the perfective aspect). Although there are a few special contexts that allow for both aspectual forms with identical or similar meanings (e.g., the restricted-iterative or restricted-durative meaning; Maslov 2004; Scheljakin and Schlegel 1970, pp. 136–153), it is traditionally assumed that the perfective and imperfective meanings are clearly distinct from one another.4 Choosing the ‘wrong’ aspectual partner would either make the sentence ungrammatical or cause a considerable change in the interpretation of meaning. Of special importance for our study is the fact that unrestricted iterative contexts are one of the contexts in which a perfective form cannot trigger a different interpretation, but renders the sentence ungrammatical.

4However, in an empirical study, Švedova (1984) already hinted at contexts in which both perfective and imperfective forms are possible. More recently, the claim of a very clear-cut divide between perfective and imperfective meanings has been challenged in a study by Janda, Endresen, and Reynolds (2019). The authors applied data from experiments with over 500 native Russian speakers and found that the distinction between contexts which allow for only one aspect (‘categorical contexts’) and contexts in which both aspectual partners are accepted (‘overlapping contexts’) is not discrete but scalar.
In contrast to English, when the term ‘progressive’ is applied to Russian grammatical aspect, it is best accounted for as one of the canonical syntactic functions, that is, the concrete-processual function, which is expressed by imperfective verbs (e.g., *ona sejčas plavaet* /*she is swimming right now*). However, imperfective verbs can carry a lot more meanings than the progressive ones can. In particular, one of these other meanings of the Russian imperfective is the iterative/habitual meaning, which corresponds to one function of the non-progressive aspect in English. The other main function of the English non-progressive corresponds to the concrete-factual meaning of the Russian perfective aspect. Still, this is only the general picture. The functional correspondences between the Russian perfective/imperfective opposition and the English progressive/non-progressive (indefinite) distinction are complex; see Fig. 1, adapted from Maslov (1985, p. 34).

In general, while in Russian the perfective has a narrower spectrum of meanings than the imperfective does, in English, the progressive is the semantically more specialized form. Following Maslov (1985, p. 33), the non-progressive “has such a wide spectrum that it is quite justifiable to call it the ‘general aspect.’” The line separating the progressive from the non-progressive (indefinite) in English does not coincide with that dividing the concrete-processual and the unrestrictedly iterative meaning because there is no sharp boundary here. As discussed in Sect. 1.2 and pointed out by Flecken et al. (2015, p. 12), in some contexts, the indefinite form may be used for the expression of an ongoing situation, and the other way around, the progressive is “encroaching upon the territory of iterativity” (Maslov 1985, p. 36).

To summarize, Russian and English are both languages with a grammatical aspect, but they vary considerably regarding both the formal expression and semantic features of the aspectual subcategories. While Russian aspect is synthetic (more precisely, derivational; i.e., stems or aspectual affixes, respectively, carry the perfective or imperfective meaning), the English progressive is expressed analytically. The particular aspectual meanings are spread over the two members of the respective opposition differently, with English allowing more overlap and having less clear boundaries than Russian does. Considering both the aforementioned similarities and differences, the investigation of grammatical aspect processing in Russian continues the work of Flecken et al. (2015) and provides an opportunity for cross-linguistic comparison and interpretation.
1.3.2 Research question and hypotheses

To our knowledge, the present study is the first to investigate brain processing of Russian grammatical aspect violations in direct comparison to violations in other areas of verbal grammar and in semantics. Therefore, our first research question is directed to the differentiation of these three violation types, supplemented by correct sentences functioning as a baseline. Can we observe differences in the processing of Russian sentences with aspectual violation in comparison with correct sentences and sentences with semantic and other morpho-syntactic violations? If a specific ERP pattern for aspectual violation sentences can be observed, we are interested in a comparison with Flecken et al.’s (2015) results. Does the observed ERP pattern resemble the pattern observed by Flecken et al. (2015) for English, or does it differ from their results, and if so, how?

Analogously to Flecken et al. (2015), we compared the processing regarding sentences with and without aspectual violation (Každyj četverg torgovec napivalsja\textsuperscript{pfl} /*napilsja\textsuperscript{pfl} v pivnoj. ‘Every Thursday the merchant got drunk in the pub’), sentences with semantic violations (Každyj četverg torgovec zagoral v pivnoj. ‘Every Thursday the merchant sunned himself in the pub’), and sentences with a violation in number agreement (Každyj četverg torgovec *napivalis’\textsuperscript{pl} v pivnoj. ‘Every Thursday the merchant got drunk in the pub’). All sentences described an unrestrictedly iterative situation (every day, every morning, etc.), requiring the imperfective aspect form. Unlike Flecken et al. (2015), we could not make use of Russian sentences with concrete-processual meaning (Right now...) because they do not fit the requirements of our experiment. Due to the complex interactions of grammatical aspect with different contextual factors, it is hardly possible to construct sentences that are unambiguously correct or incorrect depending on the aspectual form.

As the design of our study basically resembles the Flecken et al. (2015) investigation, we expect the processing of Russian sentences with aspectual violation reflected by the ERP pattern to differ from the processing of correct sentences and sentences with semantic and morpho-syntactic violations. However, due to the different character of aspect formation in Russian (no concrete graphemic form like the English is is involved), we did not expect to observe an ERP component resembling the early negativity noticed by Flecken et al. (2015), nor do we expect to find an N400 because aspect mismatch in Russian, like English, does not cause any change in lexical meaning (at least for uncontroversial aspect pairs like those used in our study). Finally, as the boundary between the Russian perfective and imperfective (at least in the unrestrictedly iterative meaning) is more clear-cut than that between the English progressive and non-progressive, unlike Flecken et al. (2015), we expect to observe a P600 component that would indicate higher processing costs in integrating the aspectual information into the sentence context.

2 Materials and methods

2.1 Participants

Nineteen native speakers of Russian participated in the experiment. Two of them were excluded immediately (one because of a high number of artifacts; one described herself as left handed). To keep the sample more homogenous, we decided to exclude three other participants who were under 13 years old when they immigrated to Germany. In the final sample, 14 people remained—10 females and 4 males aged between 23 and 35 (mean age: 26.9, SD:
Although all of them had at least some knowledge of German, they had completed the L1 acquisition in a Russian-speaking environment. They were born in a Russian-speaking country and had lived there for between 17 to 25 years (mean: 21.4, SD: 2.6). They had been living in Germany for between less than 1 to 17 years (mean: 5.4, SD: 4.5). All of them were right-handed and had normal or corrected-to-normal vision and no known neurological disorders. Participants were paid for participating in the experiment.

### 2.2 Materials

The materials for the reading task consisted of 160 experimental question–answer pairs, complemented by 80 comprehension question filler trials. Thus, each participant performed a total of 240 trials. These trials were put together in the following way: Based on 40 locative adverbials, we built four experimental conditions (see Table 1). Each location was combined with two different verbs: for the control, the morpho-syntactic violation and the aspectual violation conditions with a verb denoting an action typical for the location; for the semantic violation condition with a verb denoting an action untypical for the location. Note that the variation was always within the same 40 experimental verbs; thus, each verb appeared in the experiment twice—one with a typical and once with an atypical location (e.g., *tormožit’ na svetofore* ‘(to) brake at the traffic light’ vs. *tormožit’ v kazino* ‘(to) brake in the casino’). All the verb–location pairs were pretested on 18 native Russian speakers living in Germany in a typicality rating task. None of these participants took part in the main experiment. Participants of the pretest rated 43 typical and 43 atypical verb–location pairs on a scale from 1 (very atypical combination) to 5 (very typical combination) in a paper-and-pencil test. The mean rating for typical verb–location pairs was 4.6 (SD = 0.4), while for atypical pairs, it was 1.9 (SD = 0.6). For the main experiment (reading task), we took only those items that were rated on average at least 1 point higher in the combination with the typical than with the atypical location.

For the experiment, each verb–location pair was embedded in a question–answer pair of the structure illustrated in Table 1. In the critical sentence, they formed the predicate and an adverbial of place and were supplemented by a temporal adverbial explicitly marking the unrestrictedly iterative context (e.g., *každyj den’* ‘every day’) and a subject (appellative noun or proper name). The critical sentence was preceded by a question that further contained the interrogative pronoun *čto* ‘what’ and instead of the critical verb, a form of *delat’* ‘(to) do’.

Predicates had to be telic intransitive verbs. The criterion of intransitivity resulted from the chosen experimental design insofar as transitive verbs would have required a direct object, which in turn, would have strongly affected interpretation of the aspectual form (Anstatt 2003). Moreover, for the purpose of comparison with Flecken et al. (2015) it was necessary to construct the Russian sentences of our experiment so that they would be as similar to the English ones as possible. For telicity, there is a difference between our study and the Flecken et al. (2015) design as the latter did not restrict their material to telic verbs only. However, as shown in Sect. 1.3.1, Russian grammatical aspect interacts heavily with the lexical category of telicity, and consequently, telic and atelic verbs exhibit different aspectual behavior. For our study, we aimed to ensure that the material was as homogenous as possible, and thus, restricted it to telic verbs only.\(^6\)

\(^5\)We are aware that the number of participants remaining in the final sample is rather low. However, in terms of our data and results, we have no reason to assume that an increased number would change results significantly.

\(^6\)Note that the situation is rather complex: The majority of Russian verbs is polysemous, and sometimes the different meanings do not belong to the same telic or atelic classes, e.g., *prjat’* ‘(to) hide’. Thus, wider context
Table 1 Examples of sentences in each condition (critical verb phrase used for ERP time locking is italicized)

| Example of preceding question | Example of critical sentence | Condition |
|-------------------------------|-----------------------------|-----------|
| Čto delal torgovec v pivnoj   | Každyj četverg torgovec napivalsja_\text{pf} v pivnoj. | Control  |
| každyj četverg?              | ‘Every Thursday the merchant got drunk in the pub.’ |          |
| ‘What did the merchant do in | Každyj četverg torgovec zagoral v pivnoj. | Semantic violation |
| the pub every Thursday?’     | ‘Every Thursday the merchant sunned himself in the pub.’ |          |
| Každyj četverg torgovec      | Každyj četverg torgovec napivalis'_\text{pl} v pivnoj. | Morpho-syntactic violation |
| napivalis' _\text{pl} v       | ‘Every Thursday the merchant got drunk in the pub.’ |          |
| pivnoj.                       | Každyj četverg torgovec napilsja_\text{pf} v pivnoj. | Aspectual violation |
| ‘Every Thursday the merchant | ‘Every Thursday the merchant got drunk in the pub.’ |          |
| got drunk in the pub.’       |                                            |          |

In 31 of our 40 aspectual pairs, the imperfective partner was derived via suffixation (e.g., napit’sja > napivat’sja ‘to get drunk’), 8 pairs consisted of a simplex and a perfective partner derived via prefixation (e.g., vrat’ > sovrat’ ‘(to) lie’), and 1 pair had a suppletive formal relationship (rasxodit’sja > razojtis’ ‘(to) separate’). The mean length of predicates was measured by their number of graphemes. Imperfective verb forms (as used in the control) were slightly and marginally significantly longer (mean: 9.95, SD: 2.35) than perfective verb forms were (mean: 9.43, SD: 2.07; paired \( t \)-test, \( p = 0.053 \)). However, this difference is not considered to be one that interferes with the results because we expect higher processing costs for the aspectual violation condition, which always contains the perfective forms. If we observe higher processing costs for the aspectual violation condition compared with the control condition with the longer imperfective verbs, this effect will occur despite the shorter length of the perfective forms.

As gathered from the frequency dictionary of the Russian National Corpus (Ljaševskaja and Šarov 2009), frequency strongly differed between aspectual pairs, ranging from very frequent pairs like sobirat’sja (192.6 ipm)/ sobrat’sja (94.5 ipm) ‘(to) meet, get together’ to ones that only occur seldomly like otxlaždat’sja (1.0 ipm)/ oxtladit’sja (0.5 ipm) ‘(to) cool oneself down’. Moreover, in some pairs, one aspect form is much more frequent than the other, for example, vyigrat’ (52.3 ipm) versus vyigryvat’ ‘(to) win’ (13.9 ipm). The need to incorporate infrequent and heterogeneous aspectual pairs arose from the multiple other requirements of our experimental design (see footnote 6). The mean frequency is 27.21 (SD: 38.9) for imperfective verbs and 25.35 (SD: 32.4) for perfective ones. A paired \( t \)-test (\( p = 0.80 \)) showed that perfective and imperfective verbs do not significantly differ from each other.

As Table 1 illustrates, there were four answer types (conditions), which were as follows: sentences without any violation (control condition); sentences containing a predicate in the
plural instead of the singular or the other way around, and thus, a violation in number agreement (morpho-syntactic violation condition); sentences containing the perfective instead of the imperfective aspect form (aspectual violation condition); and sentences containing an atypical verb-location combination (semantic violation condition). Finally, as it was advisable for participants to encounter each verb stem in each of the four conditions without repetition, four variants of each answer sentence were constructed by varying the subject of the sentence. In addition, 80 filler question–answer pairs were distributed in a pseudorandom order. Their structure resembled the experimental items; however, we made use of atelic verbs here. The fillers were followed by a simple comprehension question (U druzej Lina rabotala každuju subbotu? ‘Did Lina work at her friends’ place every Saturday?’), which had to be answered by button press (yes/no). Half the comprehension questions required a positive and the other half a negative answer. Comprehension questions referred—appropriately or inappropriately—to different types of information presented in the immediately previous filler question–answer pair. 25% of these questions referred to the temporal adverbial, 25% to the subject, 25% to the predicate, and 25% to the adverbial of space of the preceding sentence. The purpose of these comprehension questions was to ensure that participants paid attention throughout the whole experiment and did not particularly focus on the predicates.

We created four lists with 160 stimulus sentences each plus 80 fillers in which the sentences were pseudo-randomized. The lists were counterbalanced. Across all lists, the 640 stimulus sentences (the combinations of context sentence and target verb) appeared only once. The lists differed in the combination of context sentence and target verb. Each context sentence appeared in each list, and each target appeared in each list. The order of items in two lists was opposite to the order in the other two lists.

2.3 Procedure

After filling out a questionnaire regarding handedness, factors that could influence the EEG, and their language biography, participants were told that they would be reading Russian question–answer pairs and would occasionally have to answer additional questions related to the content of the answers. The experiment took place in a sound-attenuating chamber. During the experiment, participants sat in a comfortable chair while the experiment was presented on a computer screen. The experimental procedure was programmed in Eprime 2.0 (Psychology Software Tools, Pittsburgh, PA). Initially, 10 question–answer pairs were presented as a practice set. The experimental procedure was like that of Flecken et al. (2015): Before each question–sentence pair, a fixation cross appeared on the computer screen for 2,000 ms. After another 350 ms, the question appeared for 4,000 ms, followed by a fixation cross for 1,350 ms. The answer was presented in chunks. The temporal phrase was presented for 500 ms and the following single-word chunks for 350 ms. Between each chunk, there was an interstimulus interval of 350 ms. After each filler sentence, participants had to answer a comprehension question by pressing a key. The next trial started automatically after 1,500 ms. The experiment was divided into five blocks of 48 sentences, each with a self-timed break in between. After the experiment, participants were asked to complete a grammaticality judgment task. In this task, participants rated the grammaticality of the sentences of the control condition and of the aspectual and morpho-syntactic mismatch conditions in another list than the one used in the EEG-experiment on a scale from 1 to 5.

2.4 Data preprocessing and analyses

The EEG signal was recorded with 27 Ag/AgCl-electrodes attached to an elastic cap (Easy-cap, Munich, Germany: www.easycap.de) at the following sites: F7/8, F3/4, Fz, FC5/6,
FC1/2, FCz, T7/8, C3/4, Cz, CP5/6, CP1/2, P7/8, P3/4, Pz, O1/2, and Oz. Eye movements were controlled by recording the vertical electro-oculogram (VEOG) and horizontal electro-oculogram (HEOG). The EEG was recorded using the BrainAmp amplifier system (Brain Products, Gilching, Germany), amplified within a bandpass of 0.01–150 Hz using a time constant of 10 s (0.016 Hz) and digitized with a sampling rate of 500 Hz.

Signals were referenced online to the left mastoid. Offline, the data were re-referenced to the average of the left and right mastoids. Electrode impedances were kept below 5 kΩ. A bandpass filter of 0.3–20 Hz was applied offline. Trials were rejected automatically using the joint probability of the recorded activity (probability threshold limit of 5 SDs for both the single-channel and global limits) and kurtosis (local and global limits of 5 SDs; Delorme and Makeig 2004). In addition, we carried out an independent component analysis. Components that were judged by both authors independently to reflect artifacts (eye movements, blinks, muscle artifacts) were removed from the signal. All preprocessing was done in EEGLAB (Delorme and Makeig 2004).

For illustrative purposes (but not statistical analyses; see below in this section), we computed ERPs by averaging the EEG per condition for each subject at each electrode site for a time window from 200 ms prior to the onset to 1,200 ms after the onset of the target verb. We carried out a baseline correction using the 200 ms prior to the onset of the target verb. The mean numbers of averaged and statistically analyzed trials per subject were 37.7 (range: 35–39; control condition), 37.1 (34–39; semantic), 37.9 (34–40; morpho-syntactic), and 37.6 (34–39; aspectual). For statistical analysis, we averaged the electrodes in the six following regions of interest (ROIs) to test the distribution of effects: left anterior (F7, F3, FC5), central anterior (Fz, FC1, FC2), right anterior (F4, F8, FC6), left posterior (CP5, P7, P3), central posterior (CP1, CP2, Pz), and right posterior (CP6, P4, P8).

Statistical analyses were done by calculating linear mixed effects models with crossed random effects (Baayen, Davidson, and Bates 2008) on the amplitudes of each single trial of each subject for each ROI ($n = 12,636$) in the four following time windows: 250–350 ms (reflecting the early negativity; Flecken et al. 2015), 350–550 ms (early P600), and 800–1,000 ms (late P600). In including two late time windows, we followed Hagoort and Brown (2000) and Barber and Carreiras (2005). Contrary to Flecken et al. (2015), we did not use the difference waves, but we also included the control condition in our model, testing explicitly for a difference between the conditions containing linguistic violations and the control condition. The fixed factors were Condition (Control, Semantic, Morpho-Syntactic, Aspectual), Laterality (Left, Central, or Right), and Anteriority (Anterior or Posterior). The random factors were Subject ($n = 14$) and Sentence Quadruple ($n = 40$), allowing the effects of individual verb–context combinations and individual processing to be considered. We also included random slopes for the Condition effect in subjects and sentence quadruples, not assuming that the effect of, for example, aspectual violations was the same for each subject and each aspectual pair but allowing the effect of Condition to vary per subject and per verb–context combination. We started with a zero model, including only random effects and random slopes. We then sequentially added the following: Anteriority, Laterality, the Anteriority*Laterality interaction, Condition, Anteriority*Condition, Laterality*Condition, and Anteriority*Laterality*Condition, assessing whether the added variable / interaction improved the model significantly. We tested whether the factor / interaction overall significantly improved the simpler model using log-likelihood-ratio tests. We kept significant ($p < 0.05$) and marginally significant ($p < 0.10$) factors and interactions in the model and used contrasts to detect which of the factor values differed significantly from each other (Field, Miles, and Field 2012), with $t$-tests using Satterthwaite’s degrees of freedom method. All statistical analyses were done in R using the lme4-package (Bates et al. 2015) and lmerTest-package (Kuznetsova, Brockhoff, and Christensen 2017).
3 Results

3.1 Task performance

Participants answered 95.2% (SD: 3.6) of the 80 questions in the decision task correctly on average. This indicates that participants read the sentences carefully and paid attention to their content.

3.2 ERP data

3.2.1 Overview

Figure 2 shows the grand averages for selected electrodes in the four conditions. Figure 3 shows the distribution of the amplitude difference between the three conditions containing linguistic violations and the control condition for the four tested time windows.

The factors Anteriority and Laterality, as well as the Anteriority*Laterality interaction, were always significant. In the following, we discuss only effects for Condition and interactions with Condition.

3.2.2 Early negativity time window (250–350 ms)

In this early time window, there was no significant effect of Condition ($\chi^2(3) = 5.55, p = 0.136$) or significant interactions of Condition and Anteriority ($\chi^2(6) = 7.74, p = 0.258$) or Laterality ($\chi^2(9) = 6.82, p = 0.656$). Moreover, no three-way interaction was detected ($\chi^2(18) = 9.11, p = 0.957$).

3.2.3 N400 time window (350–550 ms)

In the time window typically associated with N400, we found a marginally significant effect of Condition ($\chi^2(3) = 7.67, p = 0.053$). The aspectual condition did not differ from the control condition ($b = 0.21, t(35) = -0.525, p = 0.603$), nor did the morpho-syntactic condition ($b = -0.38, t(36) = -0.871, p = 0.389$). There was also no difference between the aspectual and morpho-syntactic conditions ($b = -0.59, t(37) = -1.47, p = 0.15$). As expected, the semantic condition resulted in more negative responses than the control condition did, but this difference was only marginally significant ($b = -0.92, t(26) = -1.85, p = 0.076$). The semantic condition differed significantly from the aspectual condition ($b = -1.14, t(31) = -2.69, p = 0.011$). There were no significant interactions between Condition and Anteriority ($\chi^2(3) = 2.44, p = 0.486$) or Laterality ($\chi^2(6) = 3.23, p = 0.779$), nor was a three-way interaction of these factors observed ($\chi^2(15) = 5.98, p = 0.980$).

3.2.4 Early P600 time window (550–800 ms)

There was no effect for Condition in this time window ($\chi^2(3) = 3.13, p = 0.372$). There were also no significant interactions between Condition and Anteriority ($\chi^2(6) = 3.74, p = 0.712$) or Laterality ($\chi^2(9) = 5.47, p = 0.791$), nor was there a three-way interaction of Condition, Anteriority and Laterality ($\chi^2(18) = 7.49, p = 0.985$).
Figures 2 and 3 indicate a positivity for the aspectual condition when compared with the control condition in the latest time window. Indeed, we found a significant effect of Condition (Condition: $\chi^2(3) = 8.67, p = 0.034$). Adding an interaction term for Condition and Anteriority further improved the model ($\chi^2(3) = 9.62, p = 0.022$), indicating that the effect of Condition differed at anterior and posterior sites. There was no significant interaction of Condition and Laterality ($\chi^2(6) = 0.92, p = 0.989$) and no significant three-way interaction of Condition, Anteriority and Laterality ($\chi^2(12) = 2.51, p = 0.998$), so the final model included only the interaction of Condition and Anteriority.

3.2.5 Late P600 time window (800–1,000 ms)

Fig. 2 Event-related potentials (grand averages, $n = 14$) of selected electrodes for the four conditions

- F3
- Fz
- F4
- C3
- Cz
- C4
- P3
- Pz
- P4

| Control | Aspect mismatch | Semantic violation | Morpho-syntactic violation |
|---------|-----------------|--------------------|---------------------------|

- Time (ms) 0 400 800 1200
- Voltage (µV) 6 4 2 0 -2 -4
The semantic condition did not differ from the control condition at anterior ($b = 0.65$, $t(33) = 1.069$, $p = 0.293$) or posterior sites ($b = 0.29$, $t(33) = 0.47$, $p = 0.639$), and the effect for the semantic condition did not differ at the anterior and posterior sites ($b = -0.36$, $t(12,420) = -0.993$, $p = 0.321$). The morpho-syntactic condition did not differ from the control condition at anterior ($b = -0.11$, $t(12,420) = -0.192$, $p = 0.849$) and posterior ($b = 0.62$, $t(49) = 1.09$, $p = 0.282$) sites, but contrary to the other conditions, it had significantly different effects at anterior and posterior sites, with the latter exhibiting more positive responses ($b = 0.73$, $t(12,420) = 2.014$, $p = 0.044$). Finally, the aspectual condition differed from the control condition, both at anterior ($b = 1.34$, $t(31) = 2.525$, $p = 0.017$) and posterior sites ($b = 1.61$, $t(31) = 3.04$, $p = 0.005$), with no hint as to different effects at anterior and posterior sites ($b = 0.27$, $t(12,420) = 0.753$, $p = 0.451$). When compared with the morpho-syntactic condition, the aspectual condition resulted in more positive responses at anterior sites ($b = 1.45$, $t(51) = 2.57$, $p = 0.013$), and marginally significantly, at posterior sites ($b = 1.00$, $t(51) = 1.76$, $p = 0.084$). The aspectual condition also differed from the semantic condition at posterior sites, resulting in more positive responses ($b = 1.33$, $t(36) = 2.19$, $p = 0.035$), but this was not evident at anterior sites ($b = 0.69$, $t(36) = 1.15$, $p = 0.259$).

### 3.3 Behavioral data: offline test

Table 2 shows the results from the grammaticality judgement task.
Table 2  Results from the grammaticality judgment task (scale from 1: not grammatical at all to 5: grammatical)

| Condition                        | Mean  | Standard deviation |
|----------------------------------|-------|--------------------|
| Control                          | 4.88  | 0.25               |
| Aspectual violation              | 2.27  | 0.49               |
| Morpho-syntactic violation       | 2.44  | 0.49               |

We used a linear mixed effects model with Judgment Score \( (n = 1,632) \) as the dependent variable and Condition as the fixed factor. Subject \( (n = 14) \) and Sentence Quadruple \( (n = 40) \) were treated as random factors, and random slopes for Judgment Score by Subject and by Sentence Quadruple were included. Both aspectual \( (b = -2.66, t(13.044) = -9.18, p < 0.001) \) and morpho-syntactic violations \( (b = -2.49, t(13.095) = -8.41, p < 0.001) \) were judged as less grammatical than the control sentences. Still, the means for both mismatch sentence types were bigger than 2, which indicates that not all sentences were judged by all participants as completely ungrammatical. The aspectual violations were judged as slightly, but marginally significantly less grammatical than the morpho-syntactic violations were \( (b = -0.18, t(14.066) = -2.11, p = 0.053) \).

4 Discussion

We shall begin with the two conditions that are not of primary interest to us, i.e. the semantic and morpho-syntactic conditions. As for semantic violations, we expected to find an N400 effect. Indeed, semantic violations elicited a negativity in the corresponding time window, which we interpret as an N400 effect, although this effect was only marginally significant, and there was no statistically valid posterior distribution. This lack of clarity of the N400 effect may be because, for reasons of experimental design—in particular, the decision to choose only telic verbs—the verbs used in the control condition were not as highly expectable as those in Flecken et al.'s (2015) study (e.g., *swim in a basin* vs. *sogrevat’sja v vanne* ‘(to) warm up in the bathtub’).

For the morpho-syntactic condition, we expected to find a P600, that is, a posteriorly centered positivity in one of the later time windows. However, in the early P600 time window, we did not find such a pattern. In the later P600 time window, there was no significant difference between the control sentences and those including morpho-syntactic violations overall either. Still, when posteriority versus anteriority on the scalp is considered, the morpho-syntactic violations resulted in the typical P600 distribution, namely, significantly more positive responses at posterior sites than at anterior sites compared with the control condition. We would argue that this pattern should be interpreted as a P600 effect; however, the effect is not as clear as in many other studies on morpho-syntactic violations, or more specifically, on violations of grammatical agreement. This less pronounced P600 effect is hard to explain, since the effect is highly robust for morpho-syntactic violations (Molinaro et al. 2011). We do not find it likely that this lack of clarity occurred because our final sample was smaller than the sample size of 20 subjects recommended by Molinaro et al. (2011, p. 917) for studies on agreement errors. Rather, we offer two explanations for it: First, the absence of a clear P600 may be due to our material; as a result of our restriction on telic aspectual partners, we

\footnote{Note that, when random slopes were not included in the model, the semantic condition was highly significantly different from the control condition. The same holds for the morpho-syntactic condition in the two later time windows. This underlines that random slopes must be controlled for.}
had to include much longer verbal forms than most other studies on verbal agreement have (including that of Flecken et al. 2015). In some cases, the morpho-syntactic violation manifesting only in one grapheme at the end of the verbal form may simply have been undetected, and therefore not processed by the participants. The length may be especially problematic in combination with Cyrillic script, since small letters in Cyrillic contain only a few ascenders and descenders, which are known to facilitate reading (Kempgen 1993, pp. 121–122).

Second, the P600 component is known to be task dependent, that is, sensitive to the degree of attention. When a task draws attention to, for example, agreement errors, the P600 is more pronounced than it is without such a task (Molinaro et al. 2011, p. 918). We did not make use of such a task, but since Flecken et al. (2015) did not do so either, this cannot be the only explanation. Still, what both studies have in common is that two types of grammatical mismatches were presented, namely, morpho-syntactic/agreement errors and aspectual errors, and only one of them resulted in a clear P600. While Flecken et al. (2015) found a robust P600 for morpho-syntactic errors, they did not find the same result for aspectual ones. In our case, it was the other way around. It may be that the presence of violations in one category, which was more salient for the participants for some reason, led to a lower degree of attention to the other. This may have also been the case in the studies conducted by Błaszczak and colleagues (Błaszczak et al. 2014; Błaszczak and Klimek-Jankowska 2016), who had a condition that involved arguably striking morphological violations and did not find significant effects for aspectual mismatches only. This argument is further supported in that the P600 depends on the saliency of (morpho-syntactic) violations. Coulson, King, and Kutas (1998) compared violations of verb agreement with violations of pronoun case. Not only did the arguably more salient pronoun violations elicit a larger P600 than the verb agreement violations did, but the verb agreement violations also elicited a less clear positivity than agreement violations in other studies did. More precisely, they elicited more positive responses in central and posterior sites compared with anterior sites, quite similar to the pattern found in our study.

Our main interest was the processing of aspectual violations. Given the characteristics of Russian verbal aspect (see Sect. 1.3.1), we did not expect to find an early negativity as reported by Flecken et al. (2015) nor did we expect to find an N400. Instead, we expected to find a P600. Indeed, we did not find an early negativity. This supports the interpretation that the early negativity found by Flecken et al. (2015) has nothing to do with aspect per se, but it may be attributed to a processing of unexpected events at the graphemic form level. Whereas one would know that any English verbal phrase starts with <is> or <are> when it is in the present progressive, the graphemic form of an upcoming Russian verb cannot be predicted when one only knows its aspectual value, since Russian aspect is a derivational category and uses different morphological strategies.

Like Flecken et al. (2015), we did not find an N400 effect for aspectual violations, which would indicate higher costs in lexico-semantic processing. We take this as evidence that aspectual partners are processed as one, not two separate lexemes. Unlike for English, in the case of Russian, this is not self-evident in our view, since it is still controversial whether aspectual forms of Russian are stored as one lexeme or separately, or more precisely, which forms are stored in the same way as non-controversial forms of one lexeme, and which forms—if they exist at all—are stored like non-controversial separate lexemes (Roussakova et al. 2002; Anstatt and Clasmeier 2012; Clasmeier 2012). Although interpreted as a grammatical category, Russian aspect shares some features with lexical word formation. Aspectual partners are mostly connected by means of derivational morphology and the affixes differ in regularity of the morphological form: While the suffixes used for imperfectization are quite regular, there are many prefixes used for perfectization. Moreover, the same prefixes serve for lexical derivation in other cases, modifying the semantic content of the verb. The lack of
an N400 indicates that, despite this, aspectual deviations in our study are not processed in the way lexico-semantic violations are. Note that our material consisted only of telic verbs and mostly of aspectual pairs that make use of the morphologically quite regular imperfectization. It may be the case that aspectual partners, which are more irregular at the formal level (prefixation, suppletive forms) or at the functional level (e.g. in the case of atelic verbs), cause problems in lexical retrieval (in line with Roussakova et al. 2002; see Sect. 1.1).

As the use of a perfective verb in a Russian sentence with unrestrictedly iterative meaning renders the sentence clearly ungrammatical, we expected aspectual violations to elicit a P600. This expectation is also in line with studies on agreement errors (Hagoort and Brown 2000; Barber and Carreiras 2005) and mismatches between temporal adverbials and verb tense (Steinhauer and Ullman 2002; Baggio 2008). We analyzed two late time windows aiming at the P600 effect. We did not find a statistical effect for aspectual violations in the early P600 time window (550–800 ms). However, in the later P600 time window (800–1,000 ms), we found such an effect. Aspectual violations resulted in a broad positivity not only at posterior but also at anterior sites. Given the usual interpretation of the P600, this indicates that aspectual deviating verbs cause higher processing costs in integrating the aspectual information into the context. It should be noted that, at least in a non-aspectual language like German, iterative telic events—as we used them in our control condition—elicit higher processing costs (Bott 2008) than non-iterative telic events do. This makes the higher processing costs for the non-iterative perfective form for telic verbs even more remarkable. This result is clearly different from the results of Flecken et al. (2015), where there was no such effect for aspectual violations in English. Flecken et al. (2015) explained this zero result as either a consequence of participants’ exposure to learner varieties of English or to the tolerance of English toward uses of the aspectual opposition for other purposes than the progressive/non-progressive opposition, for example, for stylistic or emphasis reasons. However, Russian is less tolerant of aspectual deviations, at least in the unrestrictedly iterative meaning we employed in our experiment, and this can explain the differences between the results of the two studies. In connection with the discussion of our morpho-syntactic condition above, one may alternatively guess that the non-result by Flecken et al. (2015) is due to the presence of the agreement violations in their study.

The interpretation of the P600 and whether it reflects one or several subprocesses in psycholinguistic processing is still controversial. More precisely, Hagoort and Brown (2000) differentiated an early subcomponent that is distributed both anteriorly and posteriorly and a later, clearly posterior subcomponent. Hagoort and Brown (2000) attributed the first subcomponent to the complexity of integration into the preceding context and the second to (failing) parsing operations and/or reanalysis procedures (Kaan et al. 2000; Molinaro et al. 2011). The effect of aspectual violations in our study does not fit unequivocally into this classification. As for latency, it falls into the time window of the late P600. In terms of distribution, it corresponds to the early P600, since the positivity was elicited at anterior sites as well. More research is needed to account for this pattern.

5 Conclusion

Our results show that the processing of Russian sentences with aspectual violation clearly differs from the processing of correct sentences and that of sentences with semantic violations. In our study, it also differed from morpho-syntactic violations. However, the observed pattern shows similarity to the processing of morpho-syntactic violations found in other studies and
to the processing of mismatches between grammatical tense and temporal lexical information. Moreover, the observed ERP pattern did not resemble the pattern observed by Flecken et al. (2015) for English. In particular, aspect mismatches elicited a positivity, albeit only in the latest analyzed time window (800–1,000 ms), which was distributed both posteriorly and anteriorly. This pattern indicates that processing aspectual violations in unrestrictedly iterative contexts relates to higher processing costs in integrating the aspectual information into the sentence context.

The differences between our results and those of Flecken et al. (2015) concerning aspectual violation processing meet our expectations, as aspect in Russian and English differs at both the formal and functional levels. Flecken et al. (2015) attributed their lack of results for aspectual violations in English as either a consequence of participants’ exposure to learner varieties of English, or perhaps more likely, the tolerance of English toward uses of the aspectual opposition for other purposes than the progressive/non-progressive opposition, for example, for reasons of style or emphasis. Russian is less tolerant here, and this is likely to explain why we did observe the P600.

If the assumption is right that the presence of another type of grammatical violation is responsible for the non-result in Flecken et al. (2015; see Sect. 4), one should ask how aspectual violations in English will be processed if they are the only type of violation presented in an experiment. Furthermore, if this assumption holds, the not arbitrary questions arise of why and how grammatical categories differ in their relative saliency between different languages.

On a more general level, our results—in connection with those found by Flecken et al. (2015)—clearly show that grammatical categories and their psycholinguistic representation must not be investigated without paying attention to the peculiarities of the single language. Instead, the psycholinguistic discussion of grammatical categories must consider their individuality in different languages.

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