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Register switching involving lexical-semantic processing in Russian: An ERP study

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ABSTRACT

During a conversation, we are able to switch between different registers, which affects linguistic characteristics of the discourse. However, little is known about the influence of these changes on language processing. In the present study, we investigated the electrophysiological effect of register switching, reflected in vocabulary use (standard vs. non-standard vocabulary, e.g., slang). We analysed event-related potentials (ERPs) accompanying the processing of words that belong to a different register, relative to the sentence context (a slang word in a standard Russian sentence or a standard word in a slang sentence). As compared to the register congruent condition, these words elicited a prolonged N400, similarly to the semantically anomalous sentences. This indicates that integration of a word from incongruent vocabulary, during register switching, implicates additional lexical-semantic processing.

1. Introduction

Processing word meanings in a context is affected by various linguistic factors, including lexical-semantic and pragmatic ones. Lexical-semantic factors are critical for the integration of a word's lexical meaning into the preceding context. However, the integration of lexical-semantic material with world and situation knowledge is necessary for language comprehension, especially for expressions with non-literal meanings, such as metaphor, irony, or humour (Bambini & Bara, 2012; Carston, 2002). Similarly, pragmatic factors, including the situation and discourse topic, its mode, and the degree of formality between the interlocutors, determine the *discourse register* that defines different linguistic features of the discourse and influences the interpretation (Biber & Conrad, 2019; Esser, 2014; Thomas, 2014). In particular, slang lexical material is determined as deviant relative to the standard language, it helps to convey the speaker's emotional or psychological attitude and identify the speaker with a certain social group (Agha, 2015; Amari, 2010). In the present study, using event-related potentials (ERPs), we show that register switching, between standard and slang vocabulary, in a sentence context affects lexical-semantic integration of the target word similarly to semantic incongruencies.

In ERP studies, lexical access and lexical selection combining form-based and content-based (single-word meaning) information during word comprehension begin earlier or around 200 ms after word presentation (e.g., 120 and 180 ms peaks in Penolazzi, Hauk,

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and Pulvermüller (2007); the Recognition Potential in Hinojosa et al. (2001), Martín-Loeches, Hinojosa, Casado, Muñoz, and Fernández-Frías (2004), and Zhang, Liu, and Zhang (2009), the N250 effect in Hagoort and Brown (2000)). These effects characterisse early semantic processing and are influenced by the physical characteristics of words (e.g. length, presentation modality) as well as word frequency and the difference between experimental stimuli and their background stimuli (in the rapid stream stimulation paradigm) (Hagoort & Brown, 2000; Penolazzi Hauk, & Pulvermüller, 2007; Pu et al., 2005).

The following step – lexical-semantic integration – is reflected in the N400 effect, and its amplitude depends, in particular, on the degree to which the word is (in)congruent with the previous semantic context (for a review, see Kutas, Van Petten, & Kluender, 2006; Kutas & Federmeier, 2011). Based on real-world knowledge, the preceding context allows semantic priming and the anticipation of the target word, with different degree of predictability (Federmeier & Kutas, 1999; Grisoni, Tomasello, & Pulvermüller, 2021; Kutas & Hillyard, 1984). The N400 amplitude is influenced by both the local context of a single sentence, as well as the situation presented in a wider discourse context (Van Berkum, Hagoort, & Brown, 1999; Van Berkum, Zwitserlood, Hagoort, & Brown, 2003). It was investigated in a wide variety of languages (e.g., English: Kutas & Hillyard, 1980; Connolly & Phillips, 1994; German: Friederici, Pfeifer, & Hahne, 1993; Dutch: Brown & Hagoort, 1993; Spanish: Wicha, Moreno, & Kutas, 2004), where it was shown that the N400 amplitude becomes higher if the meaning of the word does not match the semantics of the context.

In addition to the N400 effect, sometimes, semantic incongruency can be accompanied by a P600 effect that is commonly associated with processing syntactic information (e.g., Hagoort, Brown, & Groothusen, 1993; Osterhout & Holcomb, 1992). The "semantic P600" can be elicited by a thematic role animacy violation and is associated with detection of a mismatch and attempt to construct a thematically repaired version of the sentence (Kim & Osterhout, 2005; Kolk, Chwilla, Van Herten, & Oor, 2003; Kuperberg, Sitnikova, Caplan, & Holcomb, 2003; for a review, see Kuperberg, 2007). In addition, the acceptability judgement task makes it more likely that semantic violations will be accompanied by the P600 effect, which is supposed to reflect a revision of the current mental representation following a conflict (Brouwer, Fitz, & Hoeks, 2012; Kuperberg, 2007).

Similarly to semantic (in)congruency with the context, the influence of pragmatic factors on processing expressions with non-literal meanings, such as metaphor, humour, and irony, is associated with the N400 effect. Metaphoric expressions can elicit the N400 effect relative to their literal counterparts, as well as the N400 effect followed by the P600 effect (Coulson & Van Petten, 2002; De Grauwe Swain, Holcomb, Ditman, & Kuperberg, 2010; Klepousniotou, Pike, Steinhauer, & Gracco, 2012; Lai, Curran, & Menn, 2009; Yurchenko, Lopukhina, & Dragoy, 2020). These effects are supposed to reflect a retrieval of the appropriate metaphorical meaning and its integration into the preceding context, through overcoming the conflict with the incongruent literal meaning. Similarly, humour and irony processing are also accompanied by the N400 effect pointing to the detection of incongruency and further semantic integration. The subsequent P600 effect might reflect the resolution of the conflict between the literal and non-literal meanings, creating a coherent pragmatic interpretation and an emotional arousal (for humour; Caffarra, Wolpert, Scarinci, & Mancini, 2020; Cornejo et al., 2007; Coulson & Kutas, 2001; Du et al., 2013; Feng, Chan, & Chen, 2014; Filik, Leuthold, Wallington, & Page, 2014; Li, Pesonen, Haimi, Wang, & Astikainen, 2020).

Pragmatic processing, reflecting social aspects of communication (voices of interlocutors, emotions, etc.), was associated with similar ERP responses. A study by Van Berkum and coauthors (Van Berkum, Van den Brink, Tesink, Kos, & Hagoort, 2008) shows that information about a speaker (e.g., age and gender) is considered by a listener at an early stage (200–300 ms poststimulus) of word interpretation: the incongruency between the linguistic meaning and pragmatic information, inferred from the speaker's voice, results in the N400 effect. Slang words are also associated with positive or negative emotions (Asghar, Khan, Bibi, Kundi, & Ahmad, 2017; Coleman, 2012; Manuel, Indukuri, & Krishna, 2010). An eye-tracking study by Liu and colleagues (Liu, Gui, Zuo, & Dai, 2019) demonstrated that internet slang words in standard language advertisements attract audience attention and form more positive emotional responses toward them. According to Zhang and coauthors' results (Zhang, Yang, & Yang, 2019), updating of emotional information in a discourse, caused by an inconsistency in the emotional valence between the context and the target word, elicits a prolonged N400 effect.

The temporal characteristics of the N400 effect typically reflect a negative deflection in a 250–600 ms time interval (Kutas & Hillyard, 1980; Friederici et al., 1993; Brown & Hagoort, 1993). However, it can take the form of a shift with a longer duration. A prolonged N400 effect (until 800–1000 ms poststimulus) was observed for semantic anomalies, processing metaphors and emotional shift (Arzouan, Goldstein, & Faust, 2007; De Grauwe, Swain, Holcomb, Ditman, & Kuperberg, 2010; Rutter et al., 2012; Wicha et al., 2004; Zhang et al., 2019). It was associated with additional difficulties related to the activation of relevant (non-literal) word meaning, semantic integration and reanalysis, as well as processing of emotional information and its integration into the previous representation. Mołczanow and colleagues (Mołczanow, Domahs, Knaus, & Wiese, 2013) also reported a similar effect for word stress violations in Russian: metrical incongruity was supposed to enhance the costs of lexical retrieval.

The goal of the present study was to investigate, for the first time, the effect of register switching, reflected in vocabulary use, on language comprehension. For this purpose, we analysed the ERP response to a word that belongs to another register, relative to the sentence context (i.e., register-incongruent condition): a slang word in a standard Russian sentence, or a standard word in a slang sentence. In the register-congruent conditions, a word in the sentence was from the same register (i.e., standard-standard versus slang-slang) (Experiment 2). When creating materials for both experiments, we used a balanced design (Steinhauer & Drury, 2012): all target words and contexts were included in both experimental conditions, which helps to avoid the effect of single word characteristics (e.g., frequency) on language processing. We hypothesised that, similarly to semantically incongruent sentences (Experiment 1), processing of the register-incongruent words (Experiment 2) would be characterised by an N400 effect as compared to register-congruent words. Such an effect would be expected, based on the assumption that words belonging to a register that differs from the context are more difficult to access and integrate into such a context. However, in contrast to processing non-literal meanings (metaphor, humour or irony), integration of register-incongruent words into the context does not presuppose resolution of a conflict between different meanings or creating a new interpretation. Thus, we did not expect a significant P600 effect for the register-incongruent words.

2. Experiment 1: semantic processing

2.1. Materials and methods

2.1.1. Participants

24 native speakers of Russian (one man, mean age = 22.6 years, *SD* = 6.2, age range = 18–42) participated in the study. All the participants were right-handed, had normal or corrected to normal vision and no hearing problems or history of neurological disorders. They all volunteered for participation and signed an informed consent. The study was approved by the HSE Committee on Inter-university Surveys and Ethical Assessment of Empirical Research.

2.1.2. Stimuli

The experimental materials were 40 quadruples, as shown in examples (1) and (2), presented auditorily. Following Steinhauer and Drury (2012), the balanced 2 × 2 design was used: Target Word (e.g., *scoop* vs. *curve*) was crossed with the Semantic Congruency (SEM-CON: congruent (1a), (2a) vs. SEM-INC: incongruent (1b), (2b) conditions). Each quadruple included two sentences in the two semantic congruency conditions that differed in the target word, but all target words were used in both conditions, SEM-CON and SEM-INC. All target words were two syllables in length with the stress position on the second syllable. The target word is set out in bold.

	МалыШ	выМыл	совок	в Море.
(1) a.	*Malysh*	*vymyl*	***sovok***	*v more.*
	Child	washed	**scoop**	in sea
	'The child washed the scoop in the sea.'			
b.	*МалыШ	выМыл	**вираЖ**	в Море.
	**Malysh*	*vymyl*	***virazh***	*v more.*
	Child	washed	**curve**	in sea
	*'The child washed the curve in the sea.'			
(2) a.	Гонщик	преодолел	**вираЖ**	без задерЖки.
	Gonshchik	*preodolel*	***virazh***	*bez zaderzhki.*
	racer	passed	**curve**	without delay
	'The racer passed the curve without a delay.'			
b.	*Гонщик	преодолел	**совок**	без задерЖки.
	**Gonshchik*	*preodolel*	***sovok***	*bez zaderzhki.*
	racer	passed	**scoop**	without a delay
	*'The racer passed the scoop without delay.'			

Prior to Experiment 1, 20 other neurologically healthy Russian speakers participated in a preliminary norming of the materials. The experimental sentences were presented in a random order on a piece of paper, and the participants were asked to judge the congruency of the sentences, on a scale from '1' (fully unacceptable) to '7' (fully acceptable). The semantically congruent sentences (1a, 2a; $M = 6.5$, $SD = 0.44$) were rated as significantly more acceptable than their semantically incongruent counterparts ($M = 1.5$, $SD = 0.42$; $U = 0$, $p < 0.001$).

There were two lists in the experiment with 80 experimental sentences each. Sentences with the same target word and different contexts were assigned to one of the two lists (for example, (1a) and (2b) were in List 1 and (1b) and (2a) in List 2). Sentences with the same target word (e.g., *scoop* vs. *curve*) presented in the two different contexts (congruent vs. incongruent) were separated into two different blocks so that each target word occurred in each block only in one condition. In Block 1, 40 experimental sentences were interspersed with 80 semantically congruent fillers of different length and syntactic structure, for 120 items in total. The same design was repeated for Block 2. This resulted in 240 items in each version of the experiment. The experimental blocks were preceded by six practice trials. In order to keep participants' attention, 25% of the sentences were followed by a separate word. Participants were asked to answer whether this word was part of the sentence they had just heard or not. Materials were pseudorandomised with 12 participants assigned to List 1 and 12 participants to List 2.

The sentences were audio recorded by a professional female speaker, with 44,100 Hz mono format as separate audio files. For the purposes of analysis, a pause of a variable length was inserted at the beginning of each audio file in order to set the start of a target word at 2830 ms.

2.1.3. Procedure

Participants sat in a comfortable chair in front of a computer screen in a sound-attenuating, electromagnetically shielded room. Stimuli were presented auditorily using E-prime software 2.0. (Psychology Software Tools, Inc.). In order to reduce the amount of blink artefacts, each trial was preceded by four asterisks presented for 4000 ms in the centre of the computer screen, during this period participants were asked to blink. After this, a fixation cross appeared and after 1000 ms the audio file was played through the headphones. Participants were asked to listen attentively to the sentences, fix their eyes on the cross and avoid blinking during the sentence presentation. After 25% of the sentences, participants heard a word and were asked to identify whether this word was present or absent in the preceding sentence by pressing the left (for "yes") or right (for "no") arrow button on the keyboard. The experiment lasted 45 min on average with a short break between the blocks.

2.1.4. EEG recording and preprocessing

The electroencephalogram (EEG) was recorded using 128 high-impedance ActiCap active electrodes (Brain Products Gmbh, Germany) mounted on an elastic cap and positioned according to the international 10–20 system. The EEG signal was recorded continuously with the ground electrode positioned on Fpz and referenced online to the averaged mastoids. The sampling rate was 500 Hz. Electrode impedances were kept below 10 kΩ before recording.

The data analysis was performed using the Brainstorm software package (Tadel et al., 2011). The EEG signal was downsampled to 200 Hz and band-pass filtered in the 0.01–40 Hz frequency range. Ocular artefact removal was performed using Independent Component Analysis (ICA). The ICA components were removed based on visual inspection (1.71 ICA component pro subject, $SD = 0.84$). Continuous data were then segmented according to experimental conditions with 200 ms before the target word onset and 1200 ms after. Segments with other artefacts were removed manually. As a result, 97.7% ($SD = 5.27$) of segments were included in the further analysis. The prestimulus interval from −200 to 0 ms was used as a baseline. The ERP data were then averaged for each participant and each experimental condition.

2.1.5. Statistics

2.1.5.1. Cluster-based permutation analysis. The difference between the two experimental conditions was assessed using non-parametric cluster-based permutation testing to correct for multiple comparisons (Maris & Oostenveld, 2007). The first step of this procedure – identification of the spatio-temporal clusters – is based on the ERP property, according to which, observations on contiguous electrodes and time points are often correlated because the electrical effects spread over the scalp and persist across tens or hundreds of ms. In our analysis, the clusters consisted of adjacent electrodes (at least two) demonstrating positive or negative t-values (based on a t-test comparison of the two experimental conditions at each sampling point, with $\alpha = 0.05$) continuously in a 20 ms interval. During the second step – the permutation step – the real clusters were compared to those observed in 1000 random permutations of experimental conditions (Monte-Carlo randomisation procedure). The clusters with the statistics larger than 95% of the maximum cluster statistics in the permutation distribution were considered significant ($\alpha = 0.05$). The statistical analysis was performed with FieldTrip (Oostenveld, Fries, Maris, & Schoffelen, 2011) implemented in Brainstorm.

2.1.5.2. Anova. The effect of semantic/register congruency was examined in the standard N400 and P600 time windows – 300–500 ms and 500–800 ms, correspondingly. For the statistical analysis, the electrodes were divided into groups: six groups of lateral electrodes were created in the left and right hemispheres as well as three midline groups (see Table 1). The lateral and midline group values were calculated as an average of the electrodes included.

ERP effects were analysed using repeated measures ANOVAs with *Semantic Congruency* (SEM-CON, SEM-INC), *Posteriority* (lateral groups: frontal, fronto-central, central, centro-parietal, parietal, occipital; midline groups: frontal, central, posterior) and *Hemisphere* (for lateral groups only: left, right) as within-subject factors. Post-hoc analysis was performed if there was a significant interaction of *Semantic Congruency* and *Posteriority* factors, with false discovery rate (FDR) correction of p-values (Benjamini & Hochberg, 1995) for multiple comparisons. When the assumption of sphericity was violated, the Greenhouse-Geisser correction was applied.

2.2. Results

2.2.1. Behavioural results

Participants correctly identified at least 85% of the words as present or absent in the preceding sentence ($M = 98.1\%$, $SD = 4.3$). This suggests that they were listening to the sentences attentively and comprehended them.

2.2.2. ERP results

As Fig. 1 illustrates, processing semantically incongruent sentences was characterised by a larger N400 amplitude as compared to their semantically congruent counterparts. Cluster-based permutation analysis demonstrated a significant negative cluster for the incongruent (SEM-INC) as compared to the congruent (SEM-CON) condition between approximately 310 ms and 950 ms poststimulus

Table 1
Electrode groups for statistical analysis.

Lateral groups	Hemisphere		Midline groups	
	Left	Right		
Frontal	AFp1, AF3, AF7	AFp2, AF4, AF8	*Frontal*	AFz, Fz
Fronto-central	AFF1h, AFF5h, F1, F3, F5, FFC1h, FFC3h, FFC5h	AFF2h, AFF6h, F2, F4, F6, FFC2h, FFC4h, FFC6h		
Central	FC1, FC3, FC5, FCC1h, FCC3h, FCC5h, C1, C3, C5	FC2, FC4, FC6, FCC2h, FCC4h, FCC6h, C2, C4, C6	*Central*	FCz, Cz, CPz
Centro-parietal	CCP1h, CCP3h, CCP5h, CP1, CP3, CP5, CPP1h, CPP3h, CPP5h	CCP2h, CCP4h, CCP6h, CP2, CP4, CP6, CPP2h, CPP4h, CPP6		
Parietal	P1, P3, P5, PPO1h, PPO5h	P2, P4, P6, PPO2h, PPO6h	*Posterior*	Pz, POz, Oz
Occipital	PO3, PO7, POO1, O1	PO4, PO8, POO2, O2		

($p = 0.002$, $c = 27025$, $s = 7245$).

The ANOVA results demonstrated in the *300*–500 ms time window a main effect of *Semantic Congruency* (F(1,23) = 6.39, $p = 0.019$, $\eta_p^2 = 0.217$) in the lateral electrode groups that was modulated by a significant *Semantic Congruency* by *Posteriority* interaction (F(5,115) = 4.14, $p = 0.031$, $\eta_p^2 = 0.153$). Post-hoc analysis showed that the N400 amplitude was larger in the SEM-INC condition compared to the SEM-CON condition in the centro-parietal (F(1,23) = 10.77, $p = 0.006$, $\eta_p^2 = 0.319$), parietal (F(1,23) = 23.95, $p = 0.003$, $\eta_p^2 = 0.510$) and occipital (F(1,23) = 23.88, $p = 0.003$, $\eta_p^2 = 0.509$) electrode groups. Similarly, statistical analysis in the midline electrode groups revealed a significant *Semantic Congruency* effect (F(1,23) = 7.87, $p = 0.010$, $\eta_p^2 = 0.255$) and a marginally significant *Semantic Congruency* by *Posteriority* interaction (F(2,46) = 3.20, $p = 0.069$, $\eta_p^2 = 0.122$). Simple main effects showed that the difference between the two experimental conditions was significant in the central (F(1,23) = 6.40, $p = 0.029$, $\eta_p^2 = 0.218$) and posterior (F(1,23) = 27.29, $p = 0.003$, $\eta_p^2 = 0.543$) groups.

Similarly to the previous time window, statistical analysis in the *500*–800 ms time window resulted in a main effect of *Semantic Congruency* (F(1,23) = 18.86, $p = 0.001$, $\eta_p^2 = 0.451$) and a significant *Semantic Congruency* by *Posteriority* interaction (F(5,115) = 11.71, $p = 0.001$, $\eta_p^2 = 0.337$) in the lateral electrode groups. Post-hoc analysis showed that the N400 effect was observed for the SEM-INC condition compared to the SEM-CON condition in the central (F(1,23) = 9.66, $p = 0.008$, $\eta_p^2 = 0.296$), centro-parietal (F(1,23) = 34.05, $p = 0.002$, $\eta_p^2 = 0.597$), parietal (F(1,23) = 58.54, $p = 0.002$, $\eta_p^2 = 0.718$) and occipital (F(1,23) = 51.28, $p = 0.002$, $\eta_p^2 = 0.690$) electrode groups. The midline analysis also showed a significant effect of *Semantic Congruency* (F(1,23) = 22.14, $p = 0.001$, $\eta_p^2 = 0.490$) as well as a significant *Semantic Congruency* by *Posteriority* interaction (F(2,46) = 8.40, $p = 0.003$, $\eta_p^2 = 0.268$). Post-hoc analysis indicated that the difference in the N400 amplitude between the SEM-INC and SEM-CON conditions reached significance in the central (F(1,23) = 17.50, $p = 0.002$, $\eta_p^2 = 0.432$) and posterior (F(1,23) = 55.19, $p = 0.002$, $\eta_p^2 = 0.706$) electrode groups.

According to the ANOVA results, the N400 amplitude was significantly larger in the SEM-INC condition compared to the SEM-CON

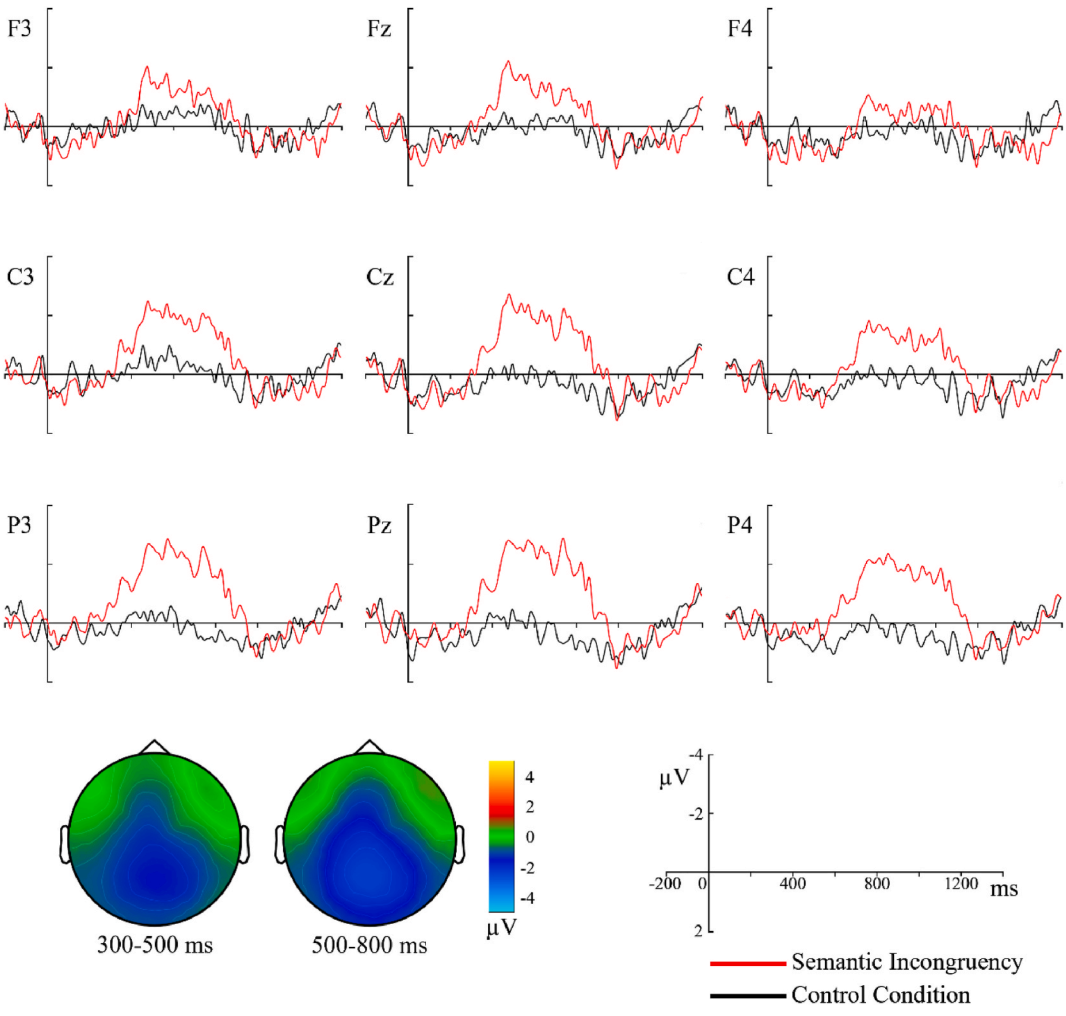

Fig. 1. The grand average ERPs for semantically incongruent sentences (SEM-INC) and the control condition (SEM-CON). The topographic distributions show the mean differences between the SEM-INC and SEM-CON conditions for the 300–500 ms and 500–800 ms time windows. Negative is plotted up.

condition in lateral (central (only in the 500–800 ms time window), centro-parietal, parietal, and occipital) and midline (central and posterior) electrode groups in the 300–500 ms and 500–800 ms time windows.

3. Experiment 2: register switching

3.1. Materials and methods

3.1.1. Participants

24 native speakers of Russian (nine men, mean age = 22.2 years, SD = 3.5, age range = 18–28) participated in the study. All the participants were right-handed, had normal or corrected to normal vision and no hearing problems or history of neurological disorders. They all volunteered for participation and signed an informed consent. The study was approved by the HSE Committee on Inter-university Surveys and Ethical Assessment of Empirical Research.

3.1.2. Stimuli

The design of Experiment 2 was similar to Experiment 1. The experimental materials were 40 quadruples, as shown in examples (3) and (4), presented auditorily. The quadruples presented the balanced 2 × 2 design (Steinhauer & Drury, 2012): Target Word (e.g., *clercs* vs. *dudes*) was crossed with the *Register Congruency* (REG-CON: congruent (3a), (4a) vs. REG-INC: incongruent (3b), (4b) conditions). In each sentence, the critical word was a noun in the subject position denoting a single person (of the same gender in the two conditions) or a group of people. It was preceded by at least four words that constituted the context of a definite register. In the REG-CON condition (3a), standard Russian words that belong to the high register were coherently used (e.g., *preferans* '*preference*', *klerki 'clercs'*, *nebylitsy 'fables'*, *gossluzhashchije 'employees'*). In contrast, in the REG-INC condition (3b), the target high register word *klerki 'clercs'* was replaced by the low register word *patsany 'dudes'*. Similarly, in (4a), words that belong to the low register – slang (e.g., *ochko 'pontoon'*, *patsany 'dudes'*, *fignja* '*bullshit*', *chiksy 'mollies'*) – were used (see, for example, Baldaev, Belko, & Isupov, 1992; Nikitina, 2009). In the REG-INC condition (4b), the critical word *patsany 'dudes'* was replaced by the high register word *klerki 'clercs'*. The target words in the two experimental conditions did not differ significantly, relative to their length in syllables (standard Russian: $M = 3.3$, $SD = 1.4$, range = 1–6; slang: $M = 2.5$, $SD = 0.7$, range = 1–4; Mann-Whitney $U = 531$, $p = 0.012$) and stress position (standard Russian: $M = 2.4$, $SD = 1.2$, range = 1–6; slang: $M = 2.0$, $SD = 0.8$, range = 1–4; Mann-Whitney $U = 676$, $p = 0.201$).

	За веселой игрой в преферанс	клерки	сочиняли		небылицы	о госслуЖащих.	
3a.	*Za vesjoloy igroj v preferans*	***klerki***	*sochinjali*		*nebylitsy*	*o gossluzhashchih.*	
	During joyful preference game	**clercs**	were composing		fables	about employees.	
	'During a joyful preference game, the **clerks** were composing fables about the employees.'						
3b.	За веселой игрой в преферанс	**пацаны**	сочиняли		небылицы	о госслуЖащих.	
	Za vesjoloy igroj v preferans	***patsany***	*sochinjali*		*nebylitsy*	*o gossluzhashchih.*	
	During joyful preference game	**dudes**	were composing		fables	about employees.	
	*'During a joyful preference game, the **dudes** were composing fables about the employees.'						
4a.	В угаре от резни в очко		**пацаны**	несли		фигню	о чиксах.
	V ugare ot rezni v ochko		***patsany***	*nesli*		*fignju*	*o chiksah.*
	Getting high on the pontoon carnage		**dudes**	were talking		bullshit	about mollies.
	'Getting high on the pontoon carnage, the **dudes** were talking bullshit about the mollies.'						
4b.	В угаре от резни в очко		**клерки**	несли		фигню	о чиксах.
	V ugare ot rezni v ochko		***klerki***	*nesli*		*fignju*	*o chiksah.*
	Getting high on the pontoon carnage		**clerks**	*were talking*			*about mollies.*
	*'Getting high on the pontoon carnage, the **clerks** were talking bullshit about the mollies.'						

Prior to Experiment 2, a preliminary norming of the materials was conducted. Twenty healthy Russian speakers were asked to judge the congruency of experimental sentences presented visually on a piece of paper – from '1' (fully incongruent) to '7' (fully congruent). As a result, pragmatically incongruent sentences ($M = 4.2$, $SD = 0.92$) were rated as significantly less congruent as compared to their pragmatically congruent counterparts ($M = 6.4$, $SD = 0.43$; $U = 66.5$, $p < 0.001$). The norming results did not differ significantly from Experiment 1 for congruent sentences (6.4 vs. 6.5; $U = 1.59$, $p = 0.207$). In contrast, a significant difference was observed for incongruent sentences: sentences with pragmatic incongruency were rated as more congruent as compared to semantically anomalous sentences (4.2 vs. 1.5; $U = 119.4$, $p = 0.002$).

160 experimental sentences were divided into two lists. In order to avoid register switching between the experimental items, sentences with the same context and different critical words were assigned to one of the two lists (for example, (1a) and (1b) were in List 1 and (2a) and (2b) – in List 2). Sentences with the same context were separated into two different blocks so that each sentence occurred in each block only in one condition. Since experimental stimuli of Experiment 2 were longer, as compared to Experiment 1, a lower number of filler sentences were included into each block in order to reduce the difference in length between the two experiments: 40 experimental sentences in each block were interspersed with 40 filler items of different length and syntactic structure belonging to the same register (standard Russian (high register) vs. slang (low register)). This resulted in 160 items in each experimental list. The experimental blocks were preceded by six practice trials. Similarly to Experiment 1, 25% of the sentences were followed by a separate word and participants were asked to answer whether this word was part of the preceding sentence or not. Materials were pseudorandomised with 12 participants assigned to List 1 and 12 participants to List 2.

The sentences were audio recorded by a professional male speaker, with characteristics and preparation similar to those used in Experiment 1. At the beginning of each audio file, a pause of a variable length was inserted in order to make sure that the target word started at the position of 5100 ms.

3.1.3. Procedure

The experimental procedure was identical to that of Experiment 1.

3.1.4. EEG recording and preprocessing

The data acquisition and analysis were similar to those of Experiment 1. As a result of the ICA artefact correction, 1.67 ICA component (*SD* = 0.90) was removed pro subject. After the artefact removal, 96.8% (*SD* = 4.33) of data were included in the further analysis. Following baseline correction, the ERP data were averaged for each participant and each experimental condition, REG-CON and REG-INC.

3.1.5. Statistics

The statistical analysis was performed in a similar way as in Experiment 1.

3.2. Results

3.2.1. Behavioural results

Participants answered correctly at least 85% of the questions (*M* = 95.5%, *SD* = 4.8). This suggests that they were listening to the

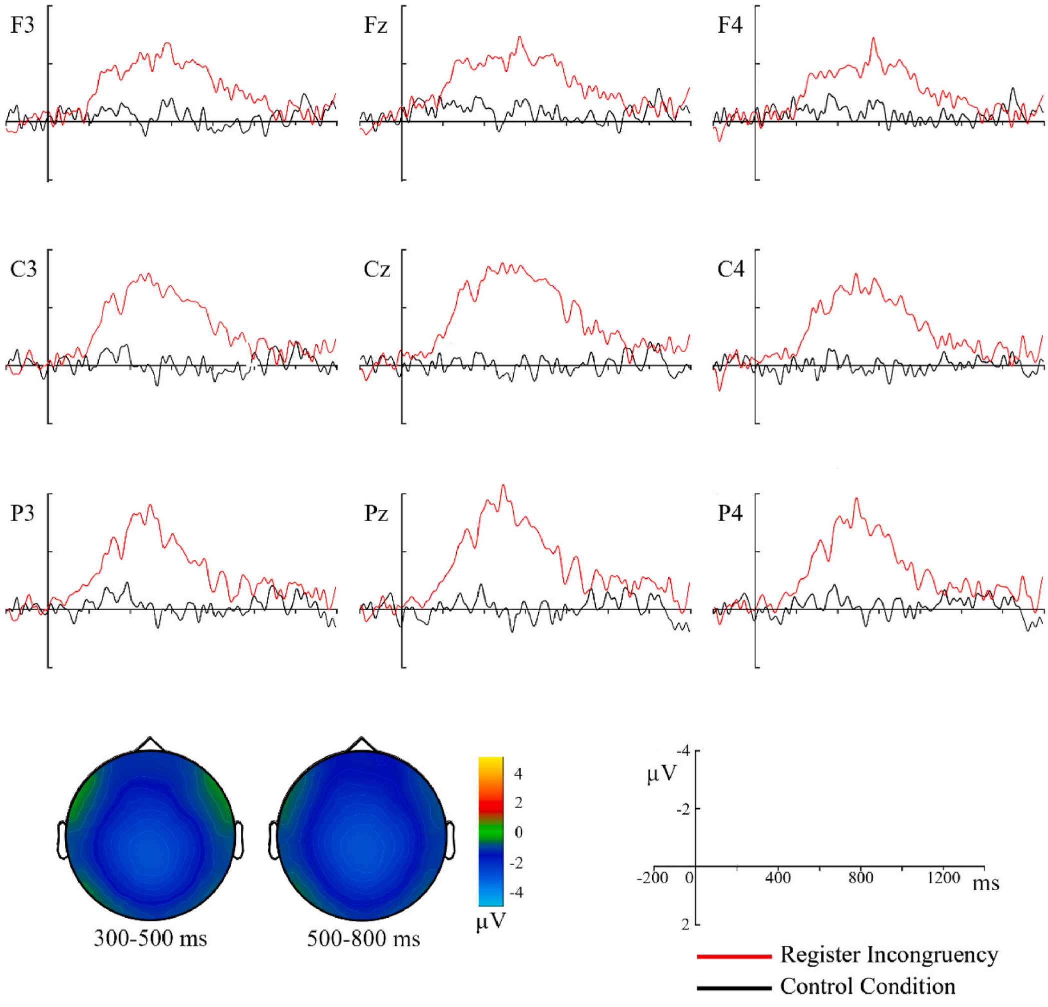

Fig. 2. The grand average ERPs for register incongruent sentences (REG-INC) and the control condition (REG-CON). The topographic distributions show the mean differences between the REG-INC and REG-CON conditions for the 300–500 ms and 500–800 ms time windows. Negative is plotted up.

sentences attentively and comprehended them.

3.2.2. ERP results

According to the ERP results, processing register incongruent sentences was accompanied by a larger N400 amplitude as compared to their congruent counterparts (see Fig. 2). Statistical analysis showed a significant negative cluster for the incongruent (REG-INC) as compared to the congruent (REG-CON), between approximately 260 ms and 930 ms poststimulus ($p = 0.0007$, $c = 43154$, $s = 9276$).

According to the ANOVA results, in the *300*–500 ms time window, a main effect of *Register Congruency* ($F(1,23) = 8.67$, $p = 0.007$, $\eta_p^2 = 0.274$) and a marginally significant *Register Congruency* by *Posteriority* interaction ($F(5,115) = 11.64$, $p = 0.077$, $\eta_p^2 = 0.117$) were observed in the lateral electrode groups. Post hoc analysis showed that processing critical words in the REG-INC condition was characterised by a significant N400 effect as compared to the REG-CON condition in the central ($F(1,23) = 7.11$, $p = 0.021$, $\eta_p^2 = 0.236$), centro-parietal ($F(1,23) = 11.63$, $p = 0.006$, $\eta_p^2 = 0.336$), parietal ($F(1,23) = 12.12$, $p = 0.006$, $\eta_p^2 = 0.345$) and occipital ($F(1,23) = 10.03$, $p = 0.008$, $\eta_p^2 = 0.304$) groups. The midline analysis also indicated a significant effect of *Register Congruency* ($F(1,23) = 7.87$, $p = 0.010$, $\eta_p^2 = 0.255$) and a marginally significant *Register Congruency* by *Posteriority* interaction ($F(2,46) = 3.12$, $p = 0.077$, $\eta_p^2 = 0.119$). Post hoc analysis revealed a significant effect of *Register Congruency* in the central ($F(1,23) = 9.48$, $p = 0.008$, $\eta_p^2 = 0.292$) and posterior ($F(1,23) = 9.44$, $p = 0.008$, $\eta_p^2 = 0.291$) group.

In the *500*–800 ms time window, statistical analysis showed a significant main effect of *Register Congruency* ($F(1,23) = 16.42$, $p = 0.001$, $\eta_p^2 = 0.417$) in the lateral groups. Similarly, the midline analysis indicated a significant main effect of *Register Congruency* ($F(1,23) = 13.95$, $p = 0.001$, $\eta_p^2 = 0.378$).

4. Discussion

This study aimed to investigate the electrophysiological correlates of register switching, as an aspect of pragmatic processing. For this purpose, we, for the first time, analysed the effect of incongruent vocabulary use (a slang word in a standard sentence or a standard word in a slang sentence, Experiment 2) and compared it to the effect accompanying processing of semantically incongruent sentences (Experiment 1).

The results of Experiment 1 demonstrated that semantic incongruencies elicit an N400 effect as compared to semantically congruent counterparts, which might reflect difficulties in lexical access and semantic integration of the target word into the preceding context (for a review, see Kutas & Hillyard, 1984; Kutas & Federmeier, 2011). Since our experimental task did not involve acceptability judgement, we did not expect an increase in the P600 amplitude in the semantically incongruent condition, and our results confirmed this hypothesis. Thus, the results of this experiment demonstrate the ERP correlates characterising semantic processing in Russian at the sentence level, which correspond to those previously observed for other languages (Brown & Hagoort, 1993; Friederici et al., 1993; Kutas & Hillyard, 1980; Wicha et al., 2004).

Similarly to Experiment 1, the results of Experiment 2 showed that processing of sentences with register switching was accompanied by an N400 effect. It might indicate that processing the target word that differs in register from the preceding context causes difficulties, as compared to the congruent condition, and involves additional resources underlying lexical and semantic processing (Kutas et al., 2006, Kutas & Hillyard, 1984; Van Berkum et al., 1999, 2003). At the same time, sentences with pragmatic incongruencies were rated during the norming stage as significantly less incongruent, as compared to sentences with semantic anomalies (4.2 for Experiment 2 vs. 1.5 for Experiment 1 at the 1–7 scale). According to the previous research, modulation of the N400 amplitude characterised other pragmatic aspects of language processing and was associated with detection of the incongruency and activation of the non-literal meaning (i.e., metaphorical, humourous, ironic; De Grauwe et al., 2010; Lai et al., 2009; Li et al., 2020; Du et al., 2013). The N400 effect observed in our study might reflect the access to the word meaning from the incongruent vocabulary that cannot be pre-activated based on the preceding context. In addition, the N400 modulation may reflect an emotional change (Zhang et al., 2019).

In contrast to the revealed N400 effect, accompanying processing sentences with register incongruencies, no P600 effect was observed in this experimental condition. Again, these results correspond to our hypothesis and the results observed in Experiment 1 for semantic incongruencies and can be partly related to the absence of the acceptability judgement task (Brouwer et al., 2012; Kuperberg, 2007). Concerning previous results on pragmatic processing, a P600 effect was reported for the processing of metaphors, irony, and humour, being associated with resolving the conflict between different meanings and creating a coherent interpretation based on the pragmatic information (e.g., Du et al., 2013; Feng et al., 2014; Filik et al., 2014; Li et al., 2020). Integration of the target words that differ in register from the preceding context in our experiment might involve additional processing resources (as reflected in the N400 effect) but it does not require any conflict resolution. This characteristic differentiates register switching from the pragmatic factors addressed in the previous research.

In both experiments, the duration of the registered N400 effect exceeded its standard time window (300–500 ms): it also reached significance in the 500–800 ms time window, according to the ANOVA analysis, and the negative clusters observed during the permutation analysis lasted until approximately 930–950 ms. Two explanations of this prolonged duration are possible. Firstly, it could reflect additional difficulties associated with lexical retrieval and semantic analysis in the experimental conditions (Arzouan et al., 2007; Rutter et al., 2012; Wicha et al., 2004). However, the comparable effect durations in the two experiments indicate that this prolongation accompanies processing semantic anomalies as part of short sentences (Experiment 1), which cannot be associated with an extra processing load. Secondly, it can be related to auditory presentation of the experimental materials, which can extend the comprehension process in time: according to Mołczanow and colleagues' (2013) results, word stress violations for two-syllable words in Russian were accompanied by an N400 effect of prolonged duration (350–950 ms and 450–1000 ms, depending on the stress position). In our study, all the target words in Experiment 1 were two-syllable, with a longer mean word length in Experiment 2.

To sum up, the results of our study show that register switching, reflected in vocabulary use, elicits a similar ERP response as compared to semantic anomalies. It means that integration of these pragmatically incongruent components into a preceding context involves additional lexical-semantic processing. Our results allow us to observe the difference between such pragmatic characteristics as register switching and previously addressed aspects of pragmatic processing – metaphors, irony, and humour – which can be associated with the absence of any conflict between different meanings and the necessity to create a new coherent interpretation.

CRediT authorship contribution statement

Anna Yurchenko: Methodology, Software, Investigation, Formal analysis, Writing – original draft, Preparation. **Vardan Arutiunian:** Investigation, Writing – review & editing. **Natalia Maas Shitova:** Methodology. **Mira Bergelson:** Conceptualization, Methodology, Writing – review & editing. **Olga Dragoy:** Conceptualization, Methodology, Writing – review & editing, Supervision.

Data availability

Data will be made available on request.

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