Research article
UDC 159.9.07
https://doi.org/10.21702/81awnj76

Does Implicit Response Competition Cause Aftereffects?

Valeria A. Gershkovich[*1], Mariia Elena Zamkovaia[1], Nadezhda V. Moroshkina[1], Aleksandr V. Gulkin[2], Viktor M. Allakhverdov[1], Alexander D. Korotkov[1], Maxim V. Kireev[1], Tatiana V. Chernigovskaya[1,2]

[1] N.P. Bechtereva Institute of the Human Brain, Russian Academy of Sciences, St. Petersburg, Russian Federation
[2] St. Petersburg State University, St. Petersburg, Russian Federation

[*] Corresponding author: valeria.gershkovich@gmail.com

Abstract

Introduction. Information is often ambiguous. Several theories suggest that the resolution of ambiguity involves an implicit selection of solution options, the result of which manifests itself in long-term negative and/or positive after-effects. However, in experimental studies, these effects are often mixed, leading to interpretations of the results. This study aims to identify and distinguish these effects. **Methods.** In this study a within-subject design was used. A total of 56 volunteers (21 males, 35 females; mean age: 25, SD = 5.8) took part in the study. In the first stage, the participants completed unambiguous and ambiguous fragmented word combinations. In the second stage, the participants completed fragmented nouns, some of which appeared in the first stage and some were alternatives not selected in the first stage of completion. **Results.** In the first stage of the experiment, ambiguous stimuli were completed slower and with more errors (ambiguity disadvantage effect). In the second stage, presentation of the same nouns resulted in the positive priming effect for both ambiguous and non-ambiguous stimuli. Positive and negative after-effects of resolving implicit competition have not been identified. **Discussion.** The results obtained can be explained by the fact that the implicit response competition has no long-term aftereffects. Another explanation is that the second stage uses tasks that do not require semantic processing and that the word is retrieved by a low-level letter processing before aftereffects of a previous choice appear.

Conclusion. Experimental data may support theories that consider only the short-term aftereffects of implicit competition. However, additional verification of the results is required using a task involving the semantic level of information processing.

Keywords

response selection, implicit response competition, ambiguity disadvantage effect, word-fragment completion task, priming

Funding

The study was supported by a grant from the Russian Science Foundation, project No. 23-18-00407, The Role of Brain Mechanisms for Inhibitory Control in the Selection of Competing Meanings of Ambiguous Information).

For citation

Gershkovich, V. A., Zamkovaia, M. E., Moroshkina, N. V., Gulkin, A. V., Allakhverdov, V. M., Korotkov, A. D., Kireev, M. V., & Chernigovskaya, T. V. (2024). Does implicit response competition cause aftereffects? *Russian Psychological Journal, 21*(4), 212–232. https://doi.org/10.21702/81awnj76

Introduction

In life, we often encounter information that can be interpreted differently or problems that can have multiple possible solutions. The choice can be made unconsciously at different stages of solving the problem – from the choice of a representation to the choice of an action. A relevant question is whether a previously made choice can be retained for some time and affect the subsequent processing of information, or whether the choice is made again every time? If the choice is still maintained, what are the mechanisms to support its stability? This study **aims** to test the hypothesis of the long-term negative and positive after-effects of implicit choice and to distinguish their mechanisms.

It has been demonstrated with different stimulus material, that the implicit competition between answers in a problem provokes a selection process, which manifests itself in a slowdown in response time and/or an increase in the errors rate – we will call "selection cost". This cost effect in a choice situation has been demonstrated both with homonyms (so-called ambiguity disadvantage effect) (Rodd, Gaskel, & Marslen-Wilson, 2002), which involve the selection of semantic representations (Simpson & Burgess, 1985; Simpson & Krueger, 1991; Maciejewski & Klepousniotou, 2020), and with orthographic neighbors (Coltheart, Davelaar, Jonasson, & Besner, 1977; Alekseeva & Slyusar, 2017), which involve the selection of lexemes (Pollatsek, Perea, & Binder, 1999, see Experiments 2–3; Snodgrass

& Mintzer, 1993, see Experiment 5), as well as the word fragment completion task with two alternative completion options (Heyman, Van Akeren, Hutchison & Storms, 2016) and in the presence of a context word that suggests a relevant choice (Kireev et al., 2022; Chernigovskaya et al., 2020).

The selection mechanisms are fundamental and manifest at different stages of information processing. Consequently, the question is whether a decision in favor of one of the alternatives results in long-term after-effects, i.e. changes in the processing of the selected and not selected options.

Two groups of theories can be distinguished that approach this issue differently.

The first group of theories does not assume any long-term effects specific to the choice situation, and the choice is actually remade each time (see the local inhibition mechanism) (McClelland & Rumelhart, 1981), the reordered access model (Duffy, Morris & Rayner, 1988), and the parallel independent activation model (Dixon & Twilley, 1999). These models assume a positive priming effect from increasing the accessibility of the selected representation, but this effect is not specific to the choice situation.

In the second group, four theories can be distinguished that assume different long-term effects.

Anderson, Bjork & Bjork (1994) proposed a retrieval-induced forgetting (RIF) theory, which emphasizes that the need to selectively retrieve one of the competing representations from memory leads to active suppression of the unselected (alternative) representation (Anderson, 2003; Anderson & Bell, 2001; Shivde & Anderson, 2001). The implicit competition induced by retrieval practice leads to the suppression effect (long-term negative aftereffect), which is consistently observed for explicit memory tests. However, an alternative interpretation of some of the effects obtained in studies in terms of a blocking mechanism is also discussed (Anderson et al., 1994; Raaijmakers & Jakab, 2013; Bäuml & Kliegl, 2017). It is assumed that what occurs is not the suppression of competing options, but the enhancement of selected options, which leads to interference at the retrieval stage – selected options gain an access advantage, blocking the retrieval of irrelevant ones. For example, an argument in favor of such an interpretation can be the absence of the suppression effect in the word fragment completion task (Butler, Williams, Zacks & Maki, 2001), which is an implicit memory test and should be insensitive to interference (Schacter, 1987). However, in another study, the effect was obtained under conditions when the memory test addressed the same lexical representations that were suppressed during retrieval practice (Bajo, Gomez-Ariza, Fernandez & Marful, 2006). It is currently considered that both mechanisms of suppression and blocking can be involved (Rupprecht & Bäuml, 2016).

The Structure Building Theory was proposed by M. A. Gernsbacher to describe the processes of language comprehension (lexical/semantic access, comprehension of metaphors, anaphors, etc.) (Gernsbacher, 1990; Gernsbacher, 1997, Gernsbacher, Keysar, Robertson & Werner, 2001). According to this approach, a central selection mechanism is

involved in ensuring choice, which implies the engagement of two different independent mechanisms – enhancement of the selected representation, as well as suppression of the alternative, non-selected meaning, which in theory is interpreted as a directed reduction in activation also extending to lower levels of processing (Gernsbacher, Robertson & Werner, 2001). Experiments have shown difficulties in retrieving the previously rejected meaning of a homonym (Gernsbacher et al., 2001), but it could appear due to the activation of a previously selected meaning and the need for its conscious rejection in order to select an alternative option or the activation of a blocking mechanism (see Gorfein, 2001).

The approach proposed by D. Gorfein for situations related to resolving ambiguity (activation-selection model) assumes that resolving competition results in an additional enhancement of the selected representation and the author recognizes the suppression mechanism as unnecessary (Gorfein, 2001; Gorfein, Brown & DeBiasi, 2007).

V. M. Allakhverdov (Allakhverdov, 1993; Allakhverdov, 2000; Allakhverdov et al., 2019) proposed a theory of the unconscious negative choice, which suggests two mechanisms of long-term aftereffects of competition resolution and their joint contribution to maintaining the choice. In this framework, it is assumed that when faced with ambiguity, a cognitive mechanism is activated that allows only one meaning to enter consciousness (a positive choice). At the same time, awareness of all other possible meanings (and even their elements) becomes difficult. The unselected option is activated, but is marked as inappropriate for the situation and is stably kept away from awareness. When encounter a similar situation again, a person will strive to repeat not only the previously made positive choice (aftereffect of a positive choice), but also the previously made negative choice (aftereffects of a negative choice). V. M. Allakhverdov's predictions have found their empirical confirmation on the material of ambiguous figures (Filippova, 2011; Filippova & Moroshkina, 2015; Filippova & Allakhverdov, 2020; Filippova, Chernov & Gorbunov, 2023), homonyms (Mamina, 2013; Mamina, Dedova, 2013) and anagrams with two alternative solutions (Lapteva, Valueva, Belova, 2018).

Consequently, in a situation where a task requires an implicit choice between competing answer options, the choice in favor of one of the alternatives may result in long-term aftereffects - the effect of a positive choice (positive priming effect), as well as enhancing the alternative selected as a result of competition, and the effect of a negative choice (negative priming effect), i.e. the difficulty of retrieving the rejected alternative. In most studies, however, these effects may be mixed. Distinguishing between the two aftereffects is a methodological challenge, because the target stimulus for capturing the negative aftereffect is usually either the same multi-alternative stimulus or a related stimulus for which a choice has already been made. This, in turn, can provoke a mechanism for enhancing the processing of a previously chosen alternative due to the previous processing of a similar or the same stimulus. In our previous experiments on the completion of fragmented word combinations (Kireev et al., 2022, Chernigovskaya et al., 2020), we also failed to distinguish between the expected aftereffects of positive and negative choices.

Overview of the study

The purpose of the present study was therefore to identify and distinguish between the positive and negative long-term effects of the implicit choice of solutions. To create the conditions for a choice at the first stage, the word fragment completion task was used, in which a letter was omitted in the same words in such a way that only one option for completion (unambiguous completion) or two options (orthographic neighboring words) (ambiguous completion) could be made. In order to induce an unconscious choice and, at the same time, to prevent awareness of both options to complete the stimulus, the words were presented with a contextual adjective, in which a letter was also omitted, which prevented automatic processing, but allowed the word to be completed to a single meaningful option. Thus, it was assumed that when completing ambiguous fragmented words, there is a competition of representations and, accordingly, a choice of one of them is necessary ("selection for awareness"). According to this hypothesis, we additionally control, whether the participants recognized the ambiguity of the stimuli and such trials were not included in the analysis. Since we expected the facilitation in retrieval of the chosen options / difficulty in accessing the rejected ones, the aftereffects of implicit choice were studied using a cognitive task traditionally employed to investigate implicit memory (Roediger, Weldon, Stadler & Riegler, 1992) – repeated completion of word fragments without a contextual adjective. To distinguish between the effects of positive and negative aftereffects, in the second stage, the word fragments always had only one option for completion, and either a word was presented that corresponded in meaning to the word presented in the first stage (the same word), or was an alternative to the word chosen in the first stage (a neighboring word). We assumed that the repetition of the word itself would provoke the classical priming effect (Tulving, Schacter & Stark, 1982). We expected that this priming effect would be enhanced by competition resolution (see, e.g., Gorfein, 2001; Gorfein et al., 2007) and, therefore, would be more pronounced for situations where ambiguous fragments were presented as a prime task. A negative aftereffect was also expected for the completion of an unambiguous word in the second stage (see Allakhverdov, 2000), which represented an alternative to the option chosen at the first stage. The presentation of words with only one unambiguous option of completion in the second stage should have allowed us to distinguish between the two types of aftereffects.

The following hypotheses were put forward: 1. When completing ambiguous fragments, selection mechanisms will be involved, providing an unconscious choice of one of the representation options, which will manifest in an increase of error rate and response time when completing ambiguous fragments compared to unambiguous ones (ambiguity disadvantage effect). 2. A positive priming effect will be observed, which manifests itself in faster response times and smaller number of completion errors when repeating the meaning of the previously completed word compared to a change in the meaning. 3. The resolution of the ambiguity of the fragment during its initial perception

should lead, on the one hand, to a faster recognition of the repeatedly presented meanings (a positive aftereffect) and smaller number of errors, and on the other, to a slower recognition of the previously non-selected meanings (a negative aftereffect) and larger number of errors compared to the condition in which initially presented stimulus was unambiguous.

Methods

Design

To verify the hypotheses put forward, a two-factor experimental design (2x2) was developed with within-subject varying of independent variables. The first independent variable was the ambiguity/unambiguity of the completion of the fragmented nouns in the first stage; the second independent variable was repetition of the noun from the first stage to the second stage / change to its neighbor. All conditions were counter-balanced. In total eight experimental lists were created. As dependent variables in both stages, the response time was measured (from stimulus onset until pressing the space bar to pronounce the word combination), as well as its accuracy.

Participants

A total of 56 volunteers (21 males, 35 females; mean age: 25 years, SD = 5.8) participated in the study. All participants were native Russian speakers. Advertising on social networks was a means of recruitment. The study was approved by the St. Petersburg Psychological Society Ethics Committee (Protocol No. 31 of 04/18/2024).

Stimulus material

As stimulus material, word combinations containing contextual adjectives and nouns, each with one omitted letter, were used. The stimulus material was compiled as follows: on the basis of previous studies (Kireev et al., 2022; Chernigovskaya et al., 2020) we selected 36 pairs of four- and five-letter neighboring words, differing from each other only by one letter (for example, baron-baton ('baron' – 'bread'), vino-kino ('wine' – 'cinema'). The frequency of selected words is 4.9 to 99.4 ipm (Savchuk et al., 2024), and the difference between the frequency of paired neighboring nouns do not exceed 47.9 ipm. The letter omission was at the beginning, middle or end of the word, and at the same time allowing either a single completion option (as, for example, for a fragmented word "k_tel" (kotel - 'pot'), where only the letter "o" can be placed in the place of omission), or a two-alternative completion (for example, a fragmented word "ko_el" can be completed both to the word

"kotel" ('pot') and to the word "kozel" ('goat')) of the same noun. The number of words with a different letter omission place was balanced between unambiguous and ambiguous conditions. For each of the 72 nouns using the Rusvectōrēs service (Kutuzov & Kuzmenko, 2017), a contextual adjective was selected, suggesting a meaningful option for completing only one of neighboring words (for example, the adjective "rich" was selected to the noun "baron", and the adjective "wheat" was selected to the noun "bread"). It is the contextual adjective, unique for each noun, that indicates which variant of completing the noun is correct in the condition of ambiguous completion. Omissions in adjectives always allow the only option for completing; 30 nouns-fillers were also selected, corresponding to targeted words by frequency and number of letters and accompanied by contextual adjectives. Omissions in fillers allow the only option for completing both the adjective and the noun. The fillers were added to reduce the probability that participants will predict the presence of words with ambiguous completion and search them specifically.

At the second stage, the same 72 target nouns and 30 fillers were used. Compared to the first stage, a different letter was always omitted in the words (for example, for the noun "baron", fragmented words "_aron"/ "ba_on" were compiled at the first stage, and at the second stage "b_ron" was compiled). Therefore, fragmented words in the second stage were used without contextual adjectives and always allowed only one completion option, which differed from the completion in the first stage.

Equipment

The experiment was carried out using the Psychopy and Pavlovia software (Peirce et al., 2019). The study was conducted online, under the supervision of an experimenter, the experimenter asked participants to share their screens and observed them via video communication using Zoom / Telegram / Skype / Microsoft Teams applications.

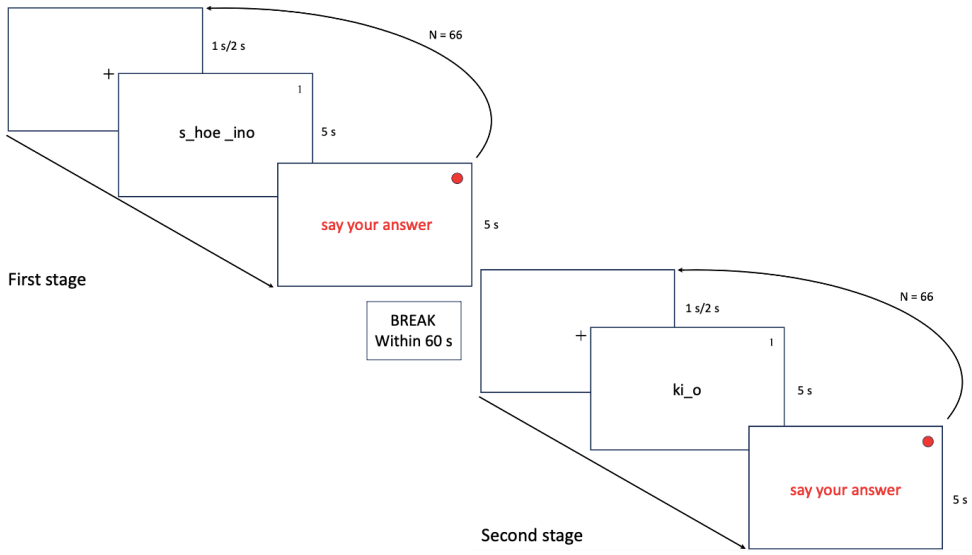
Procedure

Before the experiment started, the experimenter and the participant called each other using a platform to make calls that had screen-sharing function, so that the participant could start a screen demonstration during the experiment. Then the experimenter sent a link to the experiment. The experiment consisted of two stages. The experimental procedure is shown in Figure 1.

In the first stage, the participants performed the task of completing fragmented word combinations composed of contextual adjectives and nouns, each with one omitted letter. The participants were informed that the experiment was devoted to studying the processing of fragmented information; they were not informed of the presence of ambiguity of completion options. Before starting the first stage, the instructions were presented as well as five training combinations, and after the end of the training, the participant could ask the experimenter questions. Then 66 word combinations for completion were presented to the participant in a random order, 36 of which were target

words (in 18 of them, nouns have only one completion option, in 18 – two completion options) and 30 were fillers (always have only one completion option). Word combinations were presented in the center of the screen written in black Times New Roman font on a white background. First, a fixation cross appeared on the screen for 1 or 2 seconds, then a fragmented word combination appeared for 6 seconds, and the participant's task was to complete the fragmented word combination as quickly and accurately as possible into meaningful phrase and then say his answer loud. When the participant was ready to answer, he pressed the space bar – at that moment the phrase disappeared, the microphone was turned on, and the participant pronounced the phrase.

Figure 1
Experimental procedure



After the first stage, the participant could either proceed immediately to the second stage, or take a short break (within a few minutes).

The procedure and instructions for the second stage were identical to those of the first stage, except that in the second stage only fragmented nouns were presented, which participants had to complete as quickly and accurately as possible (see Fig. 1). 66 words were presented to the participant in a random order for completion, 36 of which were target words (18 words were the same as in the first stage, 18 words were changed to their neighboring words) and 30 were fillers.

After the experiment, the participant answered questions from the post-experimental interview, where, among other things, he was shown a list of stimuli from the first stage (in the fragmented form in which they were presented) and asked to mark all the word combinations in which the participant realized several possible options for completion. The trials with these word combinations were later excluded from the analysis.

Results

Data preprocessing

The analysis included only trials in which in the first and second stages it was possible to decipher the participants' oral answers in the audio recordings and in which the participants did not realize the ambiguity in stimuli (95% (1745) of trials). Additionally, the analysis included only nouns for which, after exclusion of the trials with realized ambiguity and trials with errors, there remained at least three presentations in each of the experimental conditions. Thus, the analysis of the results included 33 pairs of neighboring words out of 36, in which each of the nouns was correctly completed by the participants in more than 50 % of cases (both in unambiguous and ambiguous conditions of presentation).

Next, the "error type" variable was encoded. The errors made by the participants were distributed by type as follows: omission errors (no response) – 35 trials, substitution errors (completion of the target noun to its neighboring word) - 61 trials, and all other errors – 37 trials. If the participant correctly recognized the word combination, but did not press the spacebar to pronounce it (2 % of the total number of trials with the correct answer (40 trials)), the response time was recorded as 6 seconds (the maximum time of stimulus presentations).

Results of the first stage

To test the hypothesis of the ambiguity disadvantage effect, an analysis of the proportion of correct responses aggregated by stimuli was conducted during the first stage of completing word combinations, depending on the type of stimulus (unambiguous/ ambiguous) using Student's t-test for paired samples. Significant differences were found: Participants gave less correct answers when completing ambiguous stimuli ($M = 0.88$, $SD = 0.12$), compared with unambiguous ones ($M = 0.96$, $SD = 0.08$), ($t = 4.46$, $df = 65$, $p < 0.001$, $d = 0.549$), see Fig. 2.

The analysis of stimulus completion time in the first stage included only correctly completed stimuli. Using the paired samples t-test, we compared the mean completion time of unambiguous and ambiguous stimuli (see Fig. 3). Significant differences were found: Ambiguous stimuli took longer to complete ($M= 2.19$ sec., $SD = 0.66$) than unambiguous ones ($M = 2.03$ sec., $SD = 0.47$), ($df = 65$, $t = 2.432$, $p < 0.05$, $d = 0.299$).

Figure 2
Comparison of the proportion of correct answers when completing stimuli in the first stage

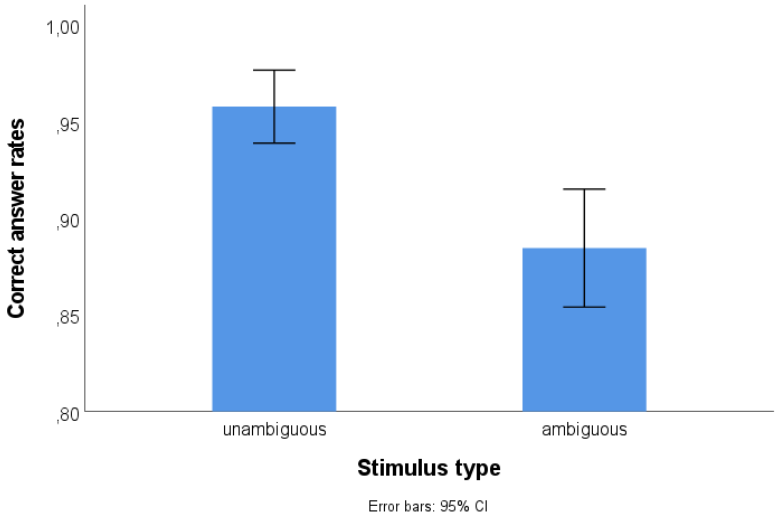
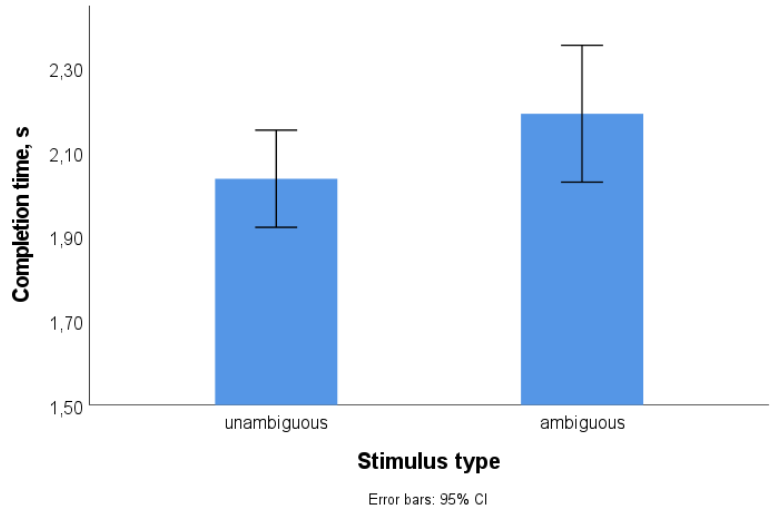


Figure 3
Comparison of completion time for unambiguous and ambiguous stimuli in the first stage



Thus, we discovered the ambiguity disadvantage effect, i.e., the ambiguous stimuli were completed by participants more slowly and with more errors. This confirms that our stimulus material actually models the situation of answers competition and allows us to proceed with the analysis of data from the second stage.

Results of the second stage

To test the hypotheses about priming effects, the influence of the stimulus type in the first stage (unambiguous or ambiguous) and the factor of change in the noun at the second stage (same or "alternative") on the completion of nouns was analyzed. We expected to reveal a positive priming effect – a decrease in the number of errors and a reduction in response times in the condition where the noun was the same as in the first stage for all stimuli – both ambiguous and unambiguous. We also assumed that, for ambiguous stimuli, repeating a noun at the second stage may result in a smaller number of erroneous completions and faster response times (hypothesis of aftereffects of a positive choice), and change in the noun to an alternative, on the contrary, may lead to an increase in the number of erroneous completions and longer response times (aftereffects of a negative choice), compared to unambiguous stimuli. The analysis included only trials from the second stage that corresponded to correctly completed stimuli in the first stage. Due to the small amount of errors (participants almost always completed the nouns correctly; among 1612 trials only 60 (3.7 %) erroneous completions), we decided not to analyze the correctness of completions in the second stage.

To analyze the impact of a stimulus type factor and a factor of change in the noun on the time taken to complete nouns in the second stage, we a ran linear mixed-effects regression model (see table 1). A dependent variable was the time taken to complete the noun in the second stage; fixed factors were the type of stimulus in the first stage and a change in the noun in the second stage; the participant factor was added as a random factor.

Table **1**
The influence of a stimulus factor and a factor of change in the noun on completion time (results of the mixed-effects regression model)

Predictor	β	SE	z	[2.5%	97.5%]	p
Intercept	1.043	0.045	23.316	0.956	1.131	< 0.001
Change in the noun	0.189	0.040	4.676	0.110	0.268	< 0.001

Predictor	β	SE	z	[2.5%	97.5%]	p
Ambiguity of the stimulus	0.003	0.042	0.065	-0.079	0.084	0.948
Change in the noun x Ambiguity of the stimulus	-0.035	0.059	-0.597	-0.152	0.081	0.550
Log-Likelihood			-1421.57			

Note. *Intercept is an unambiguous stimulus in the first stage, repeating a noun in the second stage.*

A significant influence of the factor of change in the noun (β = 0.189, SE = 0.040, Z = 4.676, p < 0.001) was observed. When the noun was the same in the second stage as in the first stage it resulted in faster response times compared to the condition of presenting an alternative noun. The influence of other factors was not found.

Discussion

The purpose of this study was to test the assumption about the presence of negative and positive long-term aftereffects of making an implicit choice and to distinguish between their effects on the material of word fragment completion with a contextual adjective in the first stage and without an adjective in the second stage.

On the basis of available data, indicating that the presence of competition between different solution options leads to slower response times in different cognitive tasks (Heymen et al., 2006; Chernigovskaya et al., 2020; Kireev et al., 2022), we assumed that the presence of implicit competition in the task of completing ambiguous word fragments leads to the need for choice, which would manifest in slower response times and an increase in error rates.

The results of the first stage confirmed the hypothesis of the involvement of selection mechanisms under the condition of the existence of alternatives. Indeed, the time taken to correctly complete word combinations containing two-alternative fragments to meaningful phrases was significantly longer than the time taken to complete unambiguous ones. Also, participants gave, on average, fewer correct answers when completing ambiguous stimuli than when completing unambiguous ones. The obtained results indicate the presence of the ambiguity disadvantage effect when performing this

task and are consistent with the results obtained using homonyms (Piercey & Joordens, 2000; Maciejewski & Klepousniotou, 2020; Rodd et al., 2002), using neighboring words when completing fragmented stimuli with two possible completion options (Heymen et al., 2006), and also replicate the effect we previously obtained using the same task (Chernigovskaya et al., 2020; Kireev et al., 2022). There are some differences between our design and that used by other authors. First, we recorded in our experiment, based on the post-experimental interview data, whether the participants were aware of both possible completion options and excluded those trials in which the ambiguity of the stimuli was realized. This gives us reason to assume that the resolution of competition was more likely to occur unconsciously. However, since we only retrospectively determined whether participants noticed the ambiguity, it is impossible to entirely rule out the interpretation that the slowdown is observed due to conscious competition and the selection of the appropriate option. Secondly, we also provided a contextual adjective that indicated what choice was relevant. To ensure that the choice was not completely determined by the context, the letter was omitted from the adjective. However, the ambiguity disadvantage effect in the completion of ambiguous fragments was evident even in the presence of a contextual adjective.

In our second hypothesis, we assumed that there would be a classical priming effect (Tulving et al., 1982) from word repetition on the word fragment completion task. We found a positive priming effect that manifested itself in faster response time when completing the repeatedly presented words. We should note that in the second stage, although the word itself has been repeated, the omitted letters differ from the ones omitted in the first stage. Since the long-term perceptual priming effect is traditionally most strongly manifested under conditions of identical form repetition, the result obtained cannot be explained exclusively by perceptual priming, sensitive to changes in the surface characteristics of the stimulus between the training and testing stages (Roediger & Blaxton, 1987). Consequently, we assume that the priming effect that occurred is associated with lexical processing. We should also note that the positive priming effect we obtained was observed despite the fact that the priming effect during the repeated reading of words is usually significantly less pronounced if the word was presented in context during the first reading (Levy & Kirsner, 1989; MacLeod, 1989; Smith, 1991).

However, the main assumption of our study was that as a result of resolving implicit competition, a result of the positive choice would be observed – i.e. an increase in the positive priming effect for ambiguous fragments compared to unambiguous fragments, and negative aftereffects of choice would also be observed, i.e. the negative priming effect would be more pronounced for rejected alternatives under the ambiguous condition compared to unambiguous options. Our data did not confirm this hypothesis. The magnitude of the priming effect did not depend on which fragment was completed in the first stage - ambiguous or unambiguous. Our results contradict the models of M. Anderson, M. A. Gernsbacher, D. Gorfein, and V. M. Allakhverdov discussed above, which suggested a long-term positive and/or negative aftereffects of choice in a situation of

implicit competition, as well as the spread of suppression to lower levels, as predicted by the model of M. A. Gernsbacher. The results are consistent with models in which the selection is made each time, depending on the task, and/or the selection is very short-lived, supported only by local inhibition mechanisms (McClelland & Rumelhart, 1981; Duffy et al., 1988; Dixon & Twilley, 1999). It is also worth noting that, in general, the effects of inhibition from neighboring words in the priming paradigm are studied for very short-term intervals (up to 600 ms) (see, e.g., Massol, Molinaro & Carreiras, 2015). In our experiment, we did not find long-term effects. This can indicate that the selection takes place very quickly and that maintaining the chosen option is not necessary in such tasks. It is possible that, since the task of identifying the word from a fragment in the unambiguous condition relies mainly on bottom-up perceptual processing (from letters to words), the word is retrieved automatically. Consequently, this level of processing is sufficient to make the appropriate choice in the second stage, and the higher-level processing required to cause the aftereffects is not engaged.

It is also possible that, although we vary the unambiguity/ambiguity of completion by omitting a letter, thus provoking competition between neighboring words in the ambiguous condition, competition between neighboring words could also arise in the unambiguous condition. Under both the unambiguous and ambiguous conditions, other neighboring words could be activated at the first stage due to the coincidence of letters that were not varied in our experiment (i.e., ba_on/_aron could provoke the activation of not only the lexical units "baron/baton", but also "baran", "barin", etc.). Their number, frequency, and the position of matching letters between the word presented and the neighboring word could affect access to the word (Slyusar, Alekseeva, 2017). For example, the influence of the number and frequency of neighboring words on the short-term priming effect was shown in the lexical decision task. Priming from the repetition of words is more pronounced for words with a smaller number of neighbors than for words with a larger number of neighbors Perea & Rosa, 2000), which indicates the emergence of competition already at the early stages of lexical processing. However, in this study, the prime word was always presented without omitted letters. The number of other orthographic neighbors that could be activated despite the omission of a letter was not controlled in our experiment and, accordingly, competition could have arisen both in the unambiguous condition and in the ambiguous one, provoking an increase in the positive priming effect from word repetition, analogous to the predictions of D. Gorfein's model for ambiguous words (Gorfein, 2001). It is also possible that we did not find any aftereffects due to the fact that a sufficient level of competition between the response options was not achieved in the first stage. Thus, studies of retrieval-induced forgetting suggest that suppression effects depend on the strength of competition in the retrieval practice stage (Anderson, 2003) and are most pronounced for explicit memory tests (e.g., free recall). Our results are consistent with those data in which retrieval-induced forgetting has not been demonstrated in such an implicit memory test as word fragment completion (Butler et al., 2001) and are inconsistent with the results of the experiment by

Bajo et al., where the effect was demonstrated (Bajo et al., 2006). However, the procedure of this experiment was significantly different from ours: firstly, participants in the study performed a memory task in the first stage, and secondly, they then underwent a retrieval practice, which should have increased the competition of lexical representations. Although we demonstrated the presence of implicit competition in the first stage, it may not have been strong enough to produce the desired effect and has therefore not been manifested in implicit memory tests such as word fragment completion task.

Future research directions could focus on testing the suggested explanations, particularly the inclusion of semantic processing in the second stage of the study.

Conclusion

The aim of this study was to test the hypothesis that an unconscious choice made once between the solution options can persist and influence further processing of information related to the choice made by enhancing the processing of the selected option and inhibiting the retrieval of the rejected one. In our study, the ambiguity disadvantage effect was demonstrated on the performance of word fragment completion task with two completion options. The effect was observed in the presence of contextual adjectives and control over the awareness of the choice alternatives. However, neither positive nor negative long-term effects of resolving competition on the task of identifying a word from a fragment in the second stage, involving low-level processing mechanisms, were found.

Overall, the results tend to support models that do not imply long-term selection effects. However, future research should test the hypothesis that aftereffects will emerge in tasks requiring semantic processing.

References

Alekseeva, S. V., & Slyusar, N. A. (2017). Orthographic neighbors: a database on Russian language and experimental studies of morphological decomposition. *Journal of Psycholinguistics, 32*(2), 12–27. (in Russ.).

Allakhverdov, V. M. (1993). *Experience of theoretical psychology (in the genre of scientific revolution).* Pechatnyi dvor Publ. (in Russ.).

Allakhverdov, V. M. (2000*). Consciousness as a paradox.* DNK Publ. (in Russ.).

Allakhverdov, V., Filippova, M. G., Gershkovich, V. A., Karpinskaia, V. Y., Scott, T. V., & Vladykina, N. P. (2019). *Consciousness, learning, and control: On the path to a theory.* A. Cleeremans, V. Allakhverdov, & M. Kuvaldina (Eds.). *Implicit learning: 50 years on* (pp. 71–107). Routledge/ Taylor & Francis Group. https://doi.org/10.4324/9781315628905-4

Anderson, M. C. (2003). Rethinking interference theory: Executive control and the mechanisms of forgetting. *Journal of memory and language*, *49*(4), 415–445. https://doi.org/10.1016/j.jml.2003.08.006

Anderson, M. C., & Bell, T. (2001). Forgetting our facts: the role of inhibitory processes in the loss of propositional knowledge. *Journal of Experimental Psychology: General*, *130*(3), 544–570. https://doi.org/10.1037//0096-3445.130.3.544

Anderson, M. C., Bjork, R. A., & Bjork, E. L. (1994). Remembering can cause forgetting: retrieval dynamics in long-term memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *20*(5), 1063–1087. https://doi.org/10.1037//0278-7393.20.5.1063

Bajo, M. T., Gómez-Ariza, C. J., Fernandez, A., & Marful, A. (2006). Retrieval-induced forgetting in perceptually driven memory tests. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *32*(5), 1185–1194. https://doi.org/10.1037/0278-7393.32.5.1185

Bäuml, K-H.T., & Kliegl, O. (2017) *Retrieval-Induced Remembering and Forgetting*. Wixted, J.T. (ed.). Cognitive Psychology of Memory, Vol. 2 of Learning and Memory: A Comprehensive Reference. Academic Press. http://doi.org/10.1016/B978-0-12-809324-5.21048-1

Butler, K. M., Williams, C. C., Zacks, R. T., & Maki, R. H. (2001). A limit on retrieval-induced forgetting. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *27*(5), 1314–1319. https://doi.org/10.1037//0278-7393.27.5.1314

Chernigovskaya, T. V., Allakhverdov, V. M., Korotkov, A. D., Gershkovich, V. A., Kireev, M. V., & Prokopenya, V. K. (2020). Human brain and ambiguity of cognitive information: A convergent approach. *Vestnik of Saint-Petersburg University. Philosophy and Conflict Studies,* 36(4), 675–686. https://doi.org/10.21638/spbu17.2020.406 (in Russ.)

Coltheart, M., Davelaar, E., Jonasson, J. T., & Besner, D. (2022). Access to the internal lexicon. In *Attention and performance VI* (pp. 535–555). Routledge. https://doi.org/10.4324/9781003309734-29

Dixon, P., & Twilley, L. C. (1999). Context and homograph meaning resolution. *Canadian Journal of Experimental Psychology/Revue canadienne de psychologie expérimentale*, *53*(4), 335–346. https://doi.org/10.1037/h0087321

Duffy, S. A., Morris, R. K., & Rayner, K. (1988). Lexical ambiguity and fixation times in reading. *Journal of Memory and Language*, *27*(4), 429–446. https://doi.org/10.1016/0749-596X(88)90066-6

Filippova, M.G. (2011). Does unconscious information affect cognitive activity?: A study using experimental priming. *Spanish Journal of Psychology*, *14*(1), 20–36. https://doi.org/10.5209/rev_sjop.2011.v14.n1.2

Filippova M. G., & Moroshkina N. V. (2015). Conscious and unconscious ambiguity: Two kinds of cognitive control. *Siberian Journal of Psychology,* (56), 37–55. https://doi.org/10.17223/17267080/56/4 (in Russ.)

Filippova, M. G., & Allakhverdov, V. M. (2020). Concretization of the chosen meaning in the process of ambiguous figures perception. *Psychology: Journal of the Higher School of Economics, 17*(2), 355–366. https://doi.org/10.17323/1813-8918-2020-2-356-366 (in Russ.)

Filippova M. G., Chernov R. V., & Gorbunov I. A. (2023). Unnoticed but not forgotten: eeg-correlates of ambiguous figures priming effects. *I.P. Pavlov Journal of Higher Nervous Activity, 73*(3), 348–356. https://doi.org/10.31857/S0044467723030061 (in Russ.)

Gernsbacher, M. A. (1990). *Language comprehension as structure building*. Hillsdale.

Gernsbacher, M. A. (1997). Two decades of structure building. *Discourse processes*, *23*(3), 265–304. https://doi.org/10.1080/01638539709544994

Gernsbacher, M. A., Keysar, B., Robertson, R. R., & Werner, N. K. (2001). The role of suppression and enhancement in understanding metaphors. *Journal of Memory and Language*, *45*(3), 433–450. https://doi.org/10.1006/jmla.2000.2782

Gernsbacher, M. A., Robertson, R. R. W., & Werner, N. K. (2001). *The costs and benefits of meaning.* In D. S. Gorfein (Ed.). *On the consequences of meaning selection: Perspectives on resolving lexical ambiguity* (pp. 119–137). Washington, DC: American Psychological Association. https://doi.org/10.1037/10459-007

Gorfein, D. S. (2001). An activation–selection view of homograph disambiguation: A matter of emphasis? In D. S. Gorfein (Ed.). *On the consequences of meaning selection: Perspectives on resolving lexical ambiguity* (pp. 157-173). American Psychological Association. https://doi.org/10.1037/10459-009

Gorfein, D. S., Brown, V. R., & DeBiasi, C. (2007). The activation–selection model of meaning: Explaining why the son comes out after the sun. *Memory & Cognition*, 35, 1986–2000. https://doi.org/10.3758/BF03192931

Heyman, T., Van Akeren, L., Hutchison, K. A., & Storms, G. (2016). Filling the gaps: A speeded word fragment completion megastudy. *Behavior Research Methods*, 48, 1508–1527. https://doi.org/10.3758/s13428-015-0663-3

Kireev, M., Korotkov, A., Masharipov, R., Zheltyakova, M., Cherednichenko, D., Gershkovich, V., Moroshkina, N., Slioussar, N., Allakhverdov, V. & Chernigovskaya, T. (2022). Suppression of non-selected solutions as a possible brain mechanism for ambiguity resolution in the word fragment task completion task. *Scientific Reports*, *12*(1), 1829. https://doi.org/10.1038/s41598-022-05646-5

Kutuzov, A., & Kuzmenko, E. (2017). *WebVectors: a toolkit for building web interfaces for vector semantic models*. In: Analysis of Images, Social Networks and Texts: 5th International Conference. Springer International Publishing. https://doi.org/10.1007/978-3-319-52920-2_15

Lapteva, N. M., Valueva, E. A., & Belova, S. S. (2018). Priming effects in a lexical decision task based on transposed-letter word pairs. *Psychology: Journal of the Higher School of Economics, 15*(4), 747–757. https://doi.org/10.17323/1813-8918-2018-4-747-757 (in Russ.)

Levy, B. A., & Kirsner, K. (1989). Reprocessing text: Indirect measures of word and message level processes. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *15*(3), 407–417. https://doi.org/10.1037/0278-7393.15.3.407

Maciejewski, G., & Klepousniotou, E. (2020). Disambiguating the ambiguity disadvantage effect: Behavioral and electrophysiological evidence for semantic competition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *46*(9), 1682–1700. https://doi.org/10.1037/xlm0000842

MacLeod, C. M. (1989). Word context during initial exposure influences degree of priming in word fragment completion. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *15*(3), 398–406. https://doi.org/10.1037/0278-7393.15.3.398

Mamina, T. M. (2013). The influence of non-actualized meanings of the homonym word on the effectiveness of anagram solving. *Vestnik of Saint Petersburg University. Sociology,* (1), 29–34. (in Russ.).

Mamina, T. M., & Dedova, E. A. (2013). Features of perception and recognition of polysemy and homonymy. *Vestnik of Saint Petersburg University. Sociology,* (4), 3–9. (in Russ.).

Massol, S., Molinaro, N., & Carreiras, M. (2015). Lexical inhibition of neighbors during visual word recognition: an unmasked priming investigation. *Brain research*, 1604, 35–51. https://doi.org/10.1016/j.brainres.2015.01.051

McClelland, J. L., & Rumelhart, D. E. (1981). An interactive activation model of context effects in letter perception: I. An account of basic findings. *Psychological review*, *88*(5), 375–407. https://doi.org/10.1037/0033-295X.88.5.375

Peirce, J., Gray, J. R., Simpson, S., MacAskill, M., Höchenberger, R., Sogo, H., Kastman E., & Lindeløv, J. K. (2019). PsychoPy2: Experiments in behavior made easy. *Behavior research methods*, 51, 195–203. https://doi.org/10.3758/s13428-018-01193-y

Piercey, C. & Joordens, S. (2000). Turning an advantage into a disadvantage: Ambiguity effects in lexical decision versus reading tasks. *Memory & Cognition*, *28*(4), 657–666. https://doi.org/10.3758/BF03201255

Perea, M., & Rosa, E. (2000). Repetition and form priming interact with neighborhood density at a brief stimulus onset asynchrony. *Psychonomic bulletin & review*, *7*(4), 668–677. https://doi.org/10.3758/bf03213005

Pollatsek, A., Perea, M., & Binder, K. S. (1999). The effects of "neighborhood size" in reading and lexical decision. *Journal of Experimental Psychology: Human Perception and Performance*, *25*(4), 1142.

Raaijmakers, J. G., & Jakab, E. (2013). Rethinking inhibition theory: On the problematic status of the inhibition theory for forgetting. *Journal of memory and language*, *68*(2), 98–122. https://doi.org/10.1016/j.jml.2012.10.002

Rodd, J., Gaskell, G., & Marslen-Wilson, W. (2002). Making sense of semantic ambiguity: Semantic competition in lexical access. *Journal of memory and language, 46*(2), 245–266. https://doi.org/10.1006/jmla.2001.2810

Roediger, H. L., & Blaxton, T. A. (1987). Effects of varying modality, surface features, and retention interval on priming in word-fragment completion. *Memory & cognition*, *15*(5), 379–388. https://doi.org/10.3758/BF03197728

Roediger, H. L., Weldon, M. S., Stadler, M. L., & Riegler, G. L. (1992). Direct comparison of two implicit memory tests: word fragment and word stem completion. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *18*(6), 1251–1269. https://doi.org/10.1037/0278-7393.18.6.1251

Rupprecht, J., & Bäuml, K. H. T. (2016). Retrieval-induced forgetting in item recognition: Retrieval specificity revisited. *Journal of Memory and Language*, 86, 97–118. https://doi.org/10.1016/j.jml.2015.09.003

Savchuk, S. O., Arkhangelsky, T. A., Bonch-Osmolovskaya, A. A., Donina, O. V., Kuznetsova Yu. N., Lyashevskaya, O. N., Orekhov B. V., & Podryadchikova, M. V. (2024). Russian National Corpus 2.0: New opportunities and development prospects. *Voprosy Jazykoznanija,* 2, 7–34. https://doi.org/10.31857/0373-658X.2024.2.7-34 (in Russ.)

Schacter, D. L. (1987). Implicit memory: History and current status. *Journal of experimental psychology: learning, memory, and cognition*, 13(3), 501. https://doi.org/10.1037/0278-7393.13.3.501

Shivde, G., & Anderson, M. C. (2001). The role of inhibition in meaning selection: Insights from retrieval-induced forgetting. *In D. S. Gorfein (Ed.), On the consequences of meaning selection: Perspectives on resolving lexical ambiguity* (pp. 175–190). American Psychological Association. https://doi.org/10.1037/10459-010

Simpson, G. B., & Burgess, C. (1985). Activation and selection processes in the recognition of ambiguous words. *Journal of experimental psychology: Human perception and performance*, *11*(1), 28–39. https://doi.org/10.1037/0096-1523.11.1.28

Simpson, G. B., & Krueger, M. A. (1991). Selective access of homograph meanings in sentence context. *Journal of Memory and Language*, *30*(6), 627–643. https://doi.org/10.1016/0749-596X(91)90029-J

Slyusar, N. A., & Alekseeva, S. V. (2017). Substitution neighbors in the study of lexical access. *Computational Linguistics and Intellectual Technologies, 16*(23). (in Russ.).

Smith, M. C. (1991). On the recruitment of semantic information for word fragment completion: Evidence from bilingual priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *17*(2), 234–244. https://doi.org/10.1037/0278-7393.17.2.234

Snodgrass, J. G., & Mintzer, M. (1993). Neighborhood effects in visual word recognition: Facilitatory or inhibitory? *Memory & Cognition*, *21*(2), 247–266. https://doi.org/10.3758/bf03202737

Tulving, E., Schacter, D. L., & Stark, H. A. (1982). Priming effects in word-fragment completion are independent of recognition memory. *Journal of experimental psychology: learning, memory, and cognition*, *8*(4), 336–342. https://doi.org/10.1037/0278-7393.8.4.336

Received: July 29, 2024
Revised: August 15, 2024
Accepted: September 14, 2024

Author Contribution

Valeria Aleksandrovna Gershkovich supervised the study, contributed to the research concept and methodology, wrote the text of the manuscript.

Mariia Elena Zamkovaia developed the research methodology, developed the experiment program, collected the data, performed statistical processing of the results, wrote the text of the manuscript.

Nadezhda Vladimirovna Moroshkina contributed to the research concept and methodology, wrote the text of the manuscript.

Aleksandr Vadimovich Gulkin developed the research methodology, collected the data, performed statistical processing of the results, created graphic illustrations, wrote the text of the manuscript.

Viktor Mikhailovich Allakhverdov contributed to the research concept and edited the text of the manuscript.

Alexander Dmitrievich Korotkov contributed to the research concept and edited the text of the manuscript.

Maxim Vladimirovich Kireev contributed to the research concept and edited the text of the manuscript.

Tatiana Vladimirovna Chernigovskaya contributed to the research concept and edited the text of the manuscript.

Author Details

Valeria Aleksandrovna Gershkovich – Cand. Sci. (Psychology), Senior Researcher, N.P. Bechtereva Institute of the Human Brain, Russian Academy of Sciences, St. Petersburg, Russian Federation; WoS Researcher ID: N-1258-2013, Scopus Author ID: 36097387700; RSCI Author ID: 166919; RSCI SPIN code: 1719-7090, ORCID ID: https://orcid.org/0000-0001-9540-4654; e-mail: valeria.gershkovich@gmail.com

Mariia Elena Zamkovaia – Junior Researcher, N.P. Bechtereva Institute of the Human Brain, Russian Academy of Sciences, St. Petersburg, Russian Federation; ORCID ID: https://orcid.org/0009-0006-9846-199X; e-mail: mariaelenazamkovaya@gmail.com

Nadezhda Vladimirovna Moroshkina – Cand. Sci. (Psychology), Senior Researcher, N.P. Bechtereva Institute of the Human Brain, Russian Academy of Sciences, St. Petersburg, Russian Federation; WoS ResearcherID: H-3841-2015; Scopus Author ID: 57128586400; RSCI Author ID: 157210; RSCI SPIN code: 6358-1379; ORCID ID: https://orcid.org/0000-0002-4778-379X; e-mail: moroshkina.n@gmail.com

Aleksandr Vadimovich Gulkin – student, St. Petersburg State University, St. Petersburg, Russian Federation; ORCID ID: https://orcid.org/0009-0006-5064-3268; e-mail: agulkin2001@mail.ru

Viktor Mikhailovich Allakhverdov – Dr. Sci. (Psychology), Professor, Chief Researcher, N.P. Bechtereva Institute of the Human Brain, Russian Academy of Sciences, St. Petersburg, Russian Federation; WoS ResearcherID: N-3175-2013; Scopus Author ID: 23487699200; RSCI Author ID: 130568; RSCI SPIN code: 3831-2224; ORCID ID: https://orcid.org/0000-0002-6753-0300; e-mail: vimiall@gmail.com

Alexander Dmitrievich Korotkov – Cand. Sci. (Medicine), Leading Researcher, N.P. Bechtereva Institute of the Human Brain, Russian Academy of Sciences, St. Petersburg, Russian Federation; WoS ResearcherID: K-3652-2018; Scopus Author ID: 7103063229; RSCI Author ID: 83115; RSCI SPIN code: 6515-2014; ORCID ID: https://orcid.org/0000-0003-3527-7205; e-mail: korotkov@ihb.spb.ru

Maxim Vladimirovich Kireev – Dr. Sci. (Biology), Leading Researcher, N.P. Bechtereva Institute of the Human Brain, Russian Academy of Sciences, St. Petersburg, Russian Federation; WoS ResearcherID: I-2319-2014; Scopus Author ID: 23091140300; RSCI Author ID: 117852; RSCI SPIN code: 4699-8496; ORCID ID: https://orcid.org/0000-0003-3409-6293; e-mail: kireev@ihb.spb.ru

Tatiana Vladimirovna Chernigovskaya – Dr. Sci. (Biology), Dr. Sci. (Philology), Professor, Academician of the Russian Academy of Sciences, Head of the Institute for Cognitive Studies; St. Petersburg State University, St. Petersburg, Russian Federation; Chief Researcher; N.P. Bechtereva Institute of the Human Brain, Russian Academy of Sciences, St. Petersburg, Russian Federation; WoS ResearcherID: M-5092-2013; Scopus Author ID: 6603435351; RSCI Author ID: 2463; RSCI SPIN code: 3464-8285; ORCID ID: https://orcid.org/0000-0002-6690-2627; e-mail: tatiana.chernigovskaya@gmail.com

Conflict of Interest Information

The authors have no conflicts of interest to declare.