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Different Languages, Same Sun, and Same Grass: Do Linguistic Stimuli Influence Attention Shifts in Russian?

Oksana V. Tsaregorodtseva[a], Alex A. Miklashevsky[a]*

[a]*Laboratory for Cognitive Studies of Language, International Center for Research in Human Development, Tomsk State University, 36, Lenin ave., Tomsk, 634050, Russia*

Abstract

The aim of the current study is to test the hypothesis of Dudschig et al. (2012) for native Russian speakers. That hypothesis states that linguistic stimuli, which do not convey spatial information in their meaning (e.g., ‘sun’, ‘grass’), produce vertical attention shifts in the direction to the typical location of the word referent in the world. This effect was found by using English and German stimuli for English and German speakers, respectively. But the question is whether or not this effect is culturally specific, or whether there is a common cognitive basis. Three experiments were conducted in Russian, each using a different type of task in order to investigate (1) whether the effect expresses itself in the same way as for English and German, and (2) whether the type of task also influences the effects produced by the described stimuli. The effect of the original hypothesis was not observed, but there is a significant difference between reaction time to up- and down-stimuli: up-words (e.g. sun) were processed faster than down-words (e.g. grass). This indicates that original effect is both universal and has some cultural variability. A possible explanation of this variability is the cultural specificity of the stimuli themselves: the number of meanings, connotations, symbolic meanings, etc. This study may have a practical application in the sphere of foreign language teaching and cross-cultural communication, because it is important to understand that languages may differ not only by their structure, vocabulary, etc., but also by their way of embodiment and by spatial associations of different words; and it is also important to use this new knowledge to develop appropriate teaching methods and communication support.

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Keywords: Language processing; cultural specificity; attention; spatial information.

* Corresponding author. Tel.:+7-913-857-96-66.
E-mail address: armanster31@gmail.com

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1. Introduction

The idea that the process of understanding natural language is closely associated with human motor, perceptual, social experience (which in part is common to anyone regardless of national language, and is also different in part) has been developed by a number of researchers in the field of cognitive linguistics and psychology (Lakoff, Johnson, 1999; Varela, Thompson, Rosch, 1991; Barsalou, 2008; Zwaan & Madden, 2005). In the process of perceiving and understanding a word the experience associated with that word is activated, and there is a so-called *mental simulation* of a situation or an object. Interrelation between language and spatial orientation has repeatedly been the subject of experimental studies. Experiments in this field are often connected with words or sentences with spatial semantics. It is assumed that the perception of 'spatial' words or sentences activate the same brain processes as if events took place in real life.

For example, if a child hears the phrase '*a bird is flying in the sky*', he or she unconsciously raises his or her head, as if he or she is trying to find this object. This refers to the theory of mirror neurons, according to which the process of an action and its monitoring are operated by the same neurons, which are called mirror neurons (Rizzolatti & Senegalia, 2012).

Experimental studies in this area consist in exploring and researching two kinds of effects: *compatibility effects* and *interferential effects*. The compatibility effect appears to reduce reaction time, in contrast to interferential effects which increase reaction time. Studies of interferential effects are based on the idea that the same group of neurons are responsible for understanding the same meaning (e. g. spatial), regardless of whether these meanings are expressed verbally or visually. Therefore, if we involve appropriate groups of neurons in processing the information suggested in a system (e. g. verbal), the simultaneous solution of the problem requires the participation of the same group of neurons, but presented in another system (e. g. visual), will be slowed down (Richardson, Spivey, Barsalou, et al., 2003).

In our study, we relied on research on the compatibility effect as well as on studies of interferential effects. Studies often use sentences describing any spatial effect as stimuli. The object in question this article is not sentences, but words. These words do not convey spatial meanings, but their referents are usually located at a certain place in the surrounding area, either up or down, that is, they have a typical location in space (*sky, earth, bird, boots*).

These words are the names of objects with a typical location in space, and are giventhe name of *object words*. The word stimuli are divided into so-called *up-words* and *down-words* (i.e. with reference to the upper or lower part of the visual field, respectively).

The interferential effect upon the presentation of object words has been studied in a series of experiments (Estes, Verges, & Barsalou, 2008). Object words were shown in the center of the screen, and then a target (letters X or O) appeared at the top or bottom of the screen. The participant had to perform a task on categorization with respect to the target, responding by pressing the appropriate key on the keyboard (X or O). In these experiments, the stimulus word was followed by another word (from the same semantic field) that was supposed to limit the range of perceived values and specify them. Experiments have shown the presence of a significant interferential effect (e. g. if the word is *heaven*, and then a target is in the upper part of the screen, the time spent on categorizing the target increased).

Another experiment dedicated to the facilitation effect was carried out by Dudschig et al. (2012) in the German language. In the experiment a word was shown on a black screen and at the same time in the top and bottom of the screen there were two boxes. When the word disappeared, one of the squares was painted white, and the objective of the participant was to press the space bar on the keyboard as soon as he sees the solid square. The experiment confirmed the hypothesis expected by researchers: participants reacted quickly to a target at the top or bottom of the perceptual field, after having been prepared for his perception by the semantics of the object word.

The researchers suggest that modeling abstract realities (such as God or the Devil) in space is the same as with concrete realities, and moreover, the authors cite the paper on the effects of shifting attention with example words with abstract referents (Chasteen, Burdzy, & Pratt, 2010).

The same group of researchers (Dudschig, Souman, Lachmair, de la Vega, et al., 2013) conducted an experiment in the German language to study the effect of facilitation by eye-tracking. In this experiment, they studied the effect of stimuli on the speed of language saccades. Participants were asked to perform a lexical decision task, that is, to decide whether a sequence of letters was a word of the language or not. The researchers found a significant interaction between the semantics of the object words and the speed of saccades when performing the task: the speed of saccades was higher if the participant had to make a saccade in the same direction, where there was a referent of the name of the object word.

In general, it can be seen that under similar procedures experimentalists get different results. This is due to the fact that different types of tasks relate variously to the modeling semantics of the object words. In those cases, when the task is easy (i.e. to detect the object), the name of the object word has already prepared the shift of attention in the appropriate direction, and the researcher observes the effect of facilitation. In those cases where the participant is asked to perform more complex tasks (such as the categorization of the object) in the corresponding area of the perceptual field, there is an interferential effect: two processes at the same time appeal to the same neural structures.

The purpose of the experiments of this study was, firstly, to test whether the task is a determining factor that can cause a particular effect. In addition, because we have not seen similar studies in Russian, the second task we defined was a verification of the results of the experiments described above with Russian material.

We have conducted three experiments: the first had a modified procedure different from the experiment of Dudschig et al. (2012), the second replicated Dudschig et al. (2012) in Russian, and the third used a categorization task.

In the first and the second experiments, as in the experiment of Dudschig et al. (2012), we expected to see the effect of facilitation, so we assume that the reaction time for targets will be less due to their arrangement in the typical location of the referents of the object words.

In the third experiment, we expect to see the interferential effect if it is true that the type of task affects the type of effect.

2. Selection of stimuli and pretest

The same set of stimuli was used in both experiments. The stimuli were selected using the vocabulary of frequency (Lyashevskaya, Sharov, 2009), and then passed preliminary testing on a Likert scale, containing seven possible ratings. Sixty-eight respondents were asked to rate the words. As we initially selected a large number of words (240), nouns were divided for convenience into groups, and therefore not every respondent rated all words. On average, each stimulus obtained only about 20 ratings, based on which we calculated the arithmetic mean for each stimulus. At this stage, 80 object words were selected that received the highest (40 words) and the lowest (40 words) scores. Other words (160 words) were not used in subsequent phases.

The frequency of stimuli was taken from the vocabulary of frequency specified above; the length was calculated by the number of letters in each word. In two sets of data these nouns do not differ significantly in length ($p = 0.45$) and frequency ($p = 0.31$), but differ as to the location in space ($p = 0.00$). The significance of differences was tested by a Student's test.

3. Methodology

3.1. Experiment 1

Participants

36 Russian-speakers students (18 – male, age range 17 - 20) participated in the Experiment 1.

Design and procedure

Each trial started with a 500-ms presentation of a central fixation cross. The word appeared centrally for 300 ms. With a delay of 400 ms after word offset, a star appeared randomly on the top or on the bottom of the screen. The task was to press the space bar on a standard keyboard, as soon as participant saw the star (Fig. 1). The next trial started if participants did not respond within 2000 ms. Stimuli were shown in white on a black background. Practice before the experiment consists of 16 trials. Length of the experiment was about 5 min.

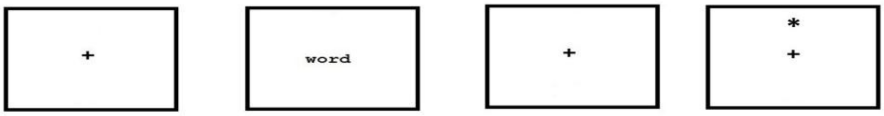

Fig. 1. Procedure of the Experiment 1.

Experiment 1 and the next experiments were performed using E-Prime 2.0.

Results

Trials with a RT of more than 800 ms or less than 100 ms (4.8 %) and outliers (4.8 %) exceeding 2SDs according to the normalized RTs of each participant were excluded. Trials with a RT of more than 800 ms were excluded, because such a task is a very simple task, and so a RT of more than 800 ms may indicate an accidental situation. Trials with a RT of less than 100 ms were excluded because such a short RT may indicate participant remissness. A 2 (word: up-down) x 2 (target: up-down) design was implemented with repeated measurement of both variables in the by-items analysis (F1) and repeated measurement in the by-subjects analysis (F2). Table 1 shows the mean (M) and standard deviation (SD) for each condition. Results showed that there is no significant interaction between the typical localization of the object word referent and target location (analysis by item and by subjects): F1 (1, 78) = 0.00686, p = 0.93418, η2 = 0.00008; F2 (1, 33) = 0.00560, p = 0.94077, η2 = 0.0001. Factor of match/mismatch of the star to localization of the object word referent was also insignificant: F1 (1, 78) = 0.01527, p = 0.90198, η2 = 0.0002; F2 (1, 33) = 0.03712, p = 0.84840, η2 = 0.001. Only a general effect of the word semantics was found: RT to up-words was generally less than RT to down-words: F1 (1, 78) = 3.4375, p = 0.06751, η2 = 0.04; F2 (1, 33) = 5.7250, p = 0.02257, η2 = 0.15.Table 1 shows the mean (M) and standard deviation (SD) for each condition. Consequently, Experiment 1 showed the absence of any expected effects, with the exception of the general effect of the word semantics.

Table 1. Mean and standard deviation per condition (average by item). Experiment 1.

Factors	Match (mean/standard deviation), ms	Mismatch (mean/standard deviation), ms
Words ‘up’	291 (23)	291 (21)
Words ‘down’	297 (19)	296 (22)

3.2. Experiment 2

Participants

42 Russian-speakers students (14 – male, age range 18 - 21) participated in the Experiment 1.

Design and procedure

Each trial started with a 500-ms presentation of a central fixation cross and two unfilled boxes above and below the fixation, which remained on screen throughout the trial. The word appeared in the center for 300 ms. The same duration of word presentation was used as in the original experiment in the German language (Dudschig et al. 2012), because the length of the words in the original experiment and in our experiment have no significant difference. With a delay of 400 ms after word offset, one of the two boxes was randomly chosen and filled white (Fig. 2). Participant’s task was to detect the target and press the space bar on a standard keyboard. The next trials started if participants did not respond within 2000 ms. Stimuli were shown in white on a black background. Practice before the experiment consisted of 16 trials. Length of the experiment was about 5 min.

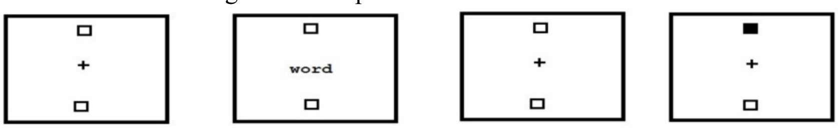

Fig. 2. Procedure of the Experiment 2.

Results

Trials with a RT of more than 800 ms, less than 100 ms (4, 2 %) and outliers (4.2 %) exceeding 2SDs according to the normalized RTs of each participant were excluded. A 2 (word: up-down) x 2 (target: up-down) design was implemented with repeated measurement of both variables in the by-items analysis (F1) and repeated measurement in the by-subjects analysis (F2). Table 2 shows the mean (M) and standard deviation (SD) for each condition. Results showed that there was no significant between the typical localization of the object word referent and target location (analysis by item and by subjects): F1 (1, 78) = 0.29, p = 0.4, η2 = 0.11 (Fig. 4), F2 (1, 41) = 1.11, p = 0.30, η2 = 0.11. Factor of match/mismatch of the filled box to the localization of the object word referent was also insignificant: F1 (1, 41) = 0.04, p = 0.85, η2 = 0.01, F2 (1, 78) = 0.2, p = 0.66, η2 = 0.01. Only a general effect of the word semantics was found: RT to up-words was generally faster than RT to down-words: F1 (1, 78) = 13.17, p = 0.0005, η2 = 0.09, F2 (1, 41) = 8.24, p = 0.01, η2 = 0.15.Thus, Experiment 2 showed the absence of any expected effects, except for the general effect of the word semantics.

Table 2. Mean and standard deviation per condition (average by item). Experiment 2.

Factors	Match (mean/standard deviation), ms	Mismatch (mean/standard deviation), ms
Words 'up'	296 (18)	295 (18)
Words 'down'	283 (21)	287 (17)

3.3. Experiment 3

Stimuli in Experiment 3 were identical to the first and the second experiments, but participants had a task that required more time – the categorization of objects.

Participants

Other students participated in this experiment – 39 Russian native speakers (18 male; age range 18 - 21).

Design and procedure

Instead of filled boxes a circle or square randomly appeared above or below fixation after word offset and after a 400 ms. delay. Participant's task was to detect the target and press 1 on the keyboard if square appeared, and 2 if the circle appeared (Fig. 3). The next trial started if participants did not respond within 2 000 ms. Stimuli were shown in white on a black background.

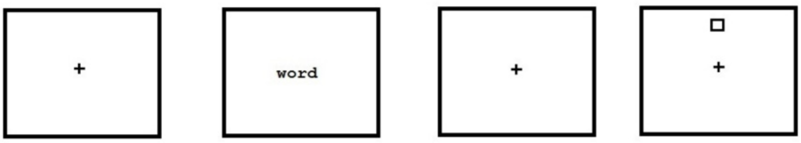

Fig. 3. Procedure of the Experiment 3.

Results

This experiment, identical in design to the first experiment, was run with repeated measurement. Trials with a RT of more than 1000 ms, less than 100 ms (5, 7%) and outliers (3 %) were excluded as in the first and second experiments. Table 4 shows the mean and standard deviation for each condition. Analysis by item and by subject showed a significant effect of localization of the object word referent: (F1 (1, 78) = 7.71; p = 0.01, η2 = 0.09; F2 (1, 37) = 6.71; p = 0.01, η2 = 0.15): RT was slower in trials with words with referents at the bottom than in trials with words with referents at the top (Table 3). The general effect of the factor of the target (target in the top or in the bottom of the screen) was insignificant (F1 (1, 78) = 0.85; p = 0.36; η2 = 0.01; F2 (1, 37) = 0.30; p = 0.58; η2 = 0. 01). Interaction between factors showed (F1 (1, 78) = 9.68, p = 0.00; η2 = 0.11; F2 (1, 37) = 4.47; p = 0.04; η2 =

0.11), that the facilitation effect was manifested only in the up-words ($p = 0.03$; Bonferroni test). If down-words were shown, for example, *grass,* the localization of the targets was not important (Fig. 4).

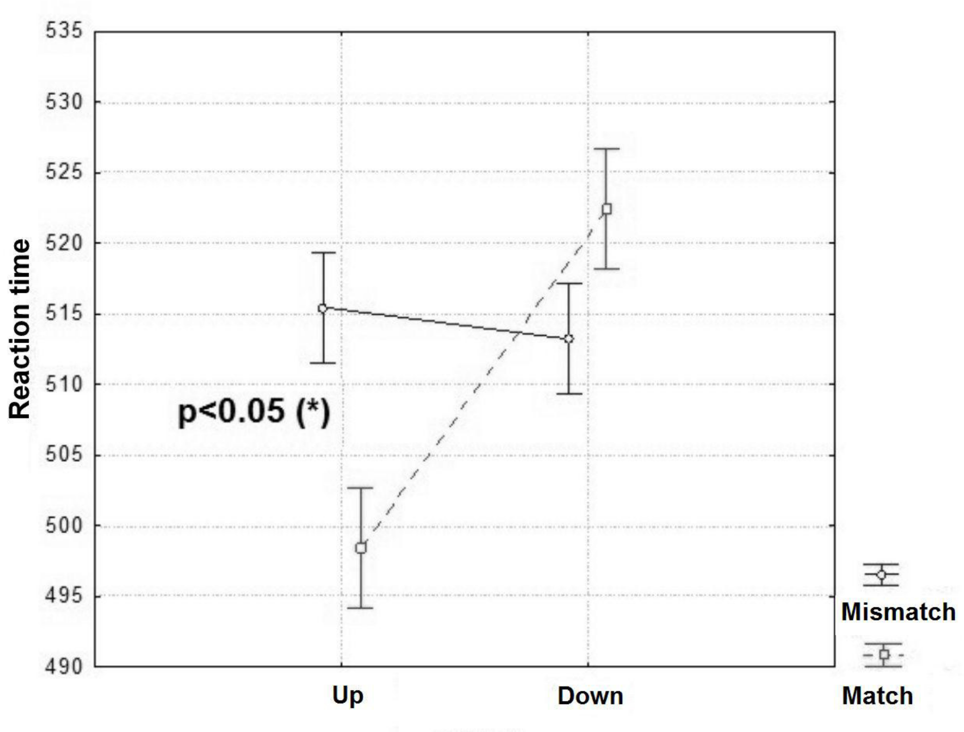

Fig. 4. Interaction between factors «up-down words» x «localization of the target location (match/mismatch)». Experiment 3. Vertical bars show standard deviations.

Table 3. Mean and standard deviation per condition (average by item). Experiment 3.

Factors	Match (mean/standard deviation), ms	Mismatch (mean/standard deviation), ms
Words ‘up’	498 (28)	515 (23)
Words ‘down’	522 (25)	513 (26)

4. Discussion

In the first two experiments there was no sign of the effects hypothesized except for a significant difference in reaction time in response to object words with a referent at the upper/lower part of the visual field (up-words in comparison with down-words). At this stage, we supposed the following:

The task to detect a target was too easy for subjects, the time delay (400 ms) in each sample was the same, and there was only one key used to answer (spacebar), so that after a few samples the subject knew when it was necessary to press the spacebar;

The task that required an answer but did not require an understanding of the stimulus word, so subjects did not read the words.

Nevertheless, none of these suppositions explain why this effect was observed in the original experiment (Dudschig et al. 2012) (all these conditions were observed there); moreover, they do not explain the difference in the resulting reaction time. In the third experiment, instead of the expected interferential effect, we obtained a facilitation effect which, however, appeared only after the object words localized in the upper part of the perceptual field (up-words). In the second experiment the reaction time for words with the referent at the top was greater than the time for words at the bottom of the referent, which differs from the results of the third experiment. This fact can be explained by the interaction of the factors in the third experiment, whereas in the second experiment the influence factor figures target location was not found.

On the other hand, the first experiment shows that the reaction time for words with the up-oriented referent was less than the reaction time for the words with a down-oriented referent. This suggests that there is no uniform pattern in reaction time when using a set of stimuli, and this issue requires further study. A similar difference between up- and down-words was obtained in our eye-tracking study of the effects of attention shift (Janyan et al., 2015).

Since the procedures of our experiments in general do not differ (or only slightly differ) from the original experiments, we assume that the reason for the difference in results may be due to the peculiarities of the stimulus material. This statement requires some explanation: there is, first, a possible difference in language systems (the original experiments were conducted in German and English), and, secondly, features of the wording of the task in the pretest may have had an effect. It is possible that respondents, when taking the pretest, evaluated words within the absolute coordinate system, while the task was to select the word in the relative system. In addition, a Likert scale could be balanced at this stage of the study, requiring one half of the test-takers to give more points to objects in the upper part of the perceptual field and fewer to ones at the bottom, while the other half would offer contrasting assessments for the names of the targets. By differences in language systems we mean, in this case, possible connotative meanings that are assigned to some particular words in some languages, but absent in others. For example, a particular noun '*shlyapa*' (hat) may have in Russian a figurative meaning ' a person who is not active, energetic or witty' and its activation during the experiment may also affect the results (in particular, during the reaction). This problem can be solved by a linguistic analysis of stimuli, and furthermore, by using so-called context words that maintain the desired stimulus value, excluding activation of secondary values.

It is also possible that there are some specific features of language categories (grammar or semantic categories) which differ between different languages and influence behavioral reactions (Rezanova et al., 2014). It seems important that Russian is a language with a complex morphological structure and rich derivational system (Nagel, 2014), especially in comparison with English. Some of these factors might play a role in the cognitive processing of our stimuli and consequently influence the expression of the original effect.

5. Conclusion

We provided a series of three experiments whose aim was to investigate whether the original effect of spatial attention shift caused by linguistic stimuli is manifested in Russian in the same way as in English and German. Another aspect of the present research was the influence of the type of task on this effect.

It was found that the original hypothesized effect does not manifest itself in Russian under the given conditions, but there is a significant difference in respondents' reaction to up-words (e.g. sun) and down-words (e.g. grass): up-words are processed faster than down-words, which suggests that the original effect is both universal and has some cultural variability.

The source of this variability should be investigated in further research. Our assumption is that specific cultural (e.g. cultural symbols, customs connected with objects presented by stimuli words) and language (e.g. number of meanings or connotations, proverbs including stimuli words, language categories or even typological differences between languages) features might influence the manifestation of the spatial attention shift effect.

It is very important to understand at which language level and why these differences appear, because such an understanding would open up opportunities to improve present foreign language teaching methods by taking into account unconscious associations with spatial locations and the physical experience of foreign language speakers. Another possible way of applying the research results is through a linguocultural analysis of world images in different languages. Spatial associations, as it is well known, are ancient and archetypal for any culture, and are expressed in many cultural phenomena and are reflected in their language (e.g. power *vertical*, *the fall* of the ruble, *increase* in crime, the *lower* social strata and so forth), in the very way of thinking of *Kulturträgers* (people of the according culture). That is why understanding appropriate spatial associations might be used in the sphere of cross-cultural communication.

Note

Part of this research (the results of the second and the third experiments) have previously been published in Russian (Miklashevskiy & Tsaregorodtseva, 2014).

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