

PRODUCING REGULAR AND IRREGULAR VERBS IN RUSSIAN: A PPI ANALYSIS

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The generation of regular and irregular past tense verbs has long been a testing ground for different models of inflection in the mental lexicon. According to the dual-route view, regular forms are generated by a rule and irregular forms are retrieved from memory. The single-route view postulates a single integrated system for all forms. Behavioral studies examined a variety of languages, but neuroimaging studies rely almost exclusively on English and German data. In our fMRI experiment, participants inflected Russian verbs and nouns of different types and corresponding nonce stimuli. Russian is a morphologically rich language with a very complex verb class system, where the notion of regularity is even hard to define (in this study, we took the most frequent out of five productive verb classes and verbs from several infrequent non-productive classes, which we further call 'regular' and 'irregular').

Subtractive analysis of the data reported in (self-identifying reference) showed that functional activity within the fronto-parietal network was greater for irregular verbs than for regular ones and for nonce verbs than for real ones. A similar pattern was found for nouns. We demonstrated that the effects of (ir)regularity and lexicality were very similar and concluded that they were induced not by these factors as such, but by the increase of processing load.

In this paper, we subjected our data to a ROI – whole brain voxel-wise analysis of context dependent changes in functional connectivity (PPI analysis). Subtractive analysis allows revealing functionally segregated brain areas that change their activity in response to experimental manipulations, while PPI is a measure of functional connectivity, which provides complementary information showing how these segregated brain areas are integrated. Firstly, we found that functional connectivity between the left inferior frontal gyrus (LIFG) and bilaterally distributed clusters in the superior temporal gyri was significantly greater in regular real verb trials than in irregular ones. No other comparisons gave significant results. Secondly, we observed a significant positive covariance between the number of mistakes in irregular real verb trials and the increase in functional connectivity between LIFG and the right anterior cingulate cortex in these trials as compared to regular ones. Thus, we could dissociate regularity and processing difficulty effects.

Only one previous PPI study of inflectional morphology was found (Stamatakis et al. 2005). In this study, functional connectivity between functionally predefined ROIs was assessed during the same/different judgment task. Stimuli were orally presented pairs of English words and nonce words, in particular, regular and irregular verb pairs like *jumped– jump* and *thought – think*. Thus, the method and materials were very different from ours. Our first finding is similar to what Stamatakis et al. reported, which shows that the observed regularity effect is very robust, being valid crosslinguistically both for production and comprehension.

As for the second finding, Stamatakis et al. have similar results going in the opposite direction. This is also true for the subtractive analysis of their data reported in (Tyler et al., 2005). We hypothesize that this is because the processing difficulty goes in the opposite directions in the two studies. Tyler et al. and Stamatakis et al. looked at stimulus pairs like *stayed – stay* vs. *taught – teach*. In the regular pairs, the first stimulus was morphologically complex and the second was not, while in irregular pairs, both stimuli were morphologically simple. Thus, regular verb trials induced more processing load. Due to the nature of Russian

language, in our study all verb stimuli the participants read or produced were morphologically complex: e.g. *nyr-ja-t'* 'to dive' – *nyr-ja-ju* (1 person singular present tense form participants were asked to generate, regular) and *mol-o-t'* 'to grind' – *mel-ju* (irregular). But irregular verbs involved various alternations in the stems etc., so irregular verb trials induced more processing load.

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References: Stamatakis, E. A., Marslen-Wilson, W. D., Tyler, L. K., and Fletcher, P. C. (2005). Cingulate control of fronto-temporal integration reflects linguistic demands: a three-way interaction in functional connectivity. *Neuroimage* 28, 115–121. doi: 10.1016/j.neuroimage.2005.06.012. • Tyler, L. K., Stamatakis, E. A., Post, B., Randall, B., and Marslen-Wilson, W. D. (2005). Temporal and frontal systems in speech comprehension: An fMRI study of past tense processing. *Neuropsychologia* 43, 1963–1974. doi: 10.1016/j.neuropsychologia.2005.03.008.

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