Phonologic and orthographic routes in word processing

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Abstract

There is a debate whether phonological representations are always activated during lexical access, or silent reading may rely on activating only orthographic representations. Previous studies mostly focused on homophonous lexemes, while we provide a novel piece of evidence in favor of the former from two self-paced reading experiments with homophonous and homographic forms of Russian nouns. We show that homophony affects processing creating mild grammaticality illusions, while homography does not.

Key words: phonological route, orthographic route, sentence processing, silent reading

Introduction

There is an important debate in psycholinguistics concerning visual word processing. Dual-route theories (since Coltheart 1980) argue for two independent access options, relying on phonological and orthographic representations. Single-route models (since Frost 1998) claim that phonological processing is a default procedure and phonological representation is always activated during lexical access, even in silent reading by skilled readers.

Our study provides a novel piece of evidence in favor of the latter approach. Unlike previous studies mostly focusing on homophonous lexemes (e.g. Rayner et al. 1998, Newman et al. 2012, Jared, O'Donnell 2016, Jared, Bainbridge 2017), we conducted two experiments with homophonous and homographic word forms. This allows avoiding problems (in particular, different lexemes have different semantic requirements that are hardly possible to control for).

Russian nouns are inflected for six cases and two numbers and are grouped into several declensions. In all declensions, there are nouns with different stress patterns: stress may always fall on the stem or on the affix or alternate between the two. Some forms in a paradigm may be identical (syncretic), homophonous (have different spelling, but the same pronunciation due to unstressed vowel reduction) or homographic (have the same spelling, but different pronunciation due to different stress placement). We showed that homophony affects processing creating mild grammaticality illusions, while homography does not.

Experiment 1

Method

80 native speakers of Russian participated in Experiment 1. We had 48 stimulus sentences like (1) and (2). In every sentence, there was a 1st declension target noun in genitive or dative singular. In the 1st declension, genitive singular forms end in *-y* or *-i*, depending on the stem-final consonant. *-i* gives rise to homophony with dative and locative singular forms ending in *-e* if the stress is on the stem (the stem-final consonant is palatalized, and unstressed affixes sound the same due to vowel reduction). The forms ending in *-y* and *-e* never sound the same, and the difference is especially salient if the stress falls on the affix (in addition to that, the stem-final consonant is not palatalized before *-y*).

(1) Group 1A: Kiosk u ostanovki/*ostanovke zakryt vsju nedelju.
newsstand near bus-stop$_{GEN/*DAT=LOC}$ is-closed all week
'The newsstand near the bus stop is closed for the whole week.'

(2) Group 1B: Otrytka dlya sestry/*sestre poterjalas' na počte.
postcard for sister$_{GEN/*DAT=LOC}$ was-lost at post-office
'The postcard for the sister was lost at the post office.'

We had target nouns with homophonous forms in Group 1A (unstressed *-i*/*-e* affixes) and with non-homophonous forms in Group 1B (stressed *-y*/*-e* affixes). Every participant saw half of the stimulus sentences in the grammatical condition and another half in the ungrammatical condition: with dative/locative forms where genitive was required, as in (1)-(2), or with genitive forms where dative was required. We also had 72 grammatically correct filler sentences.

The moving window word-by-word self-paced reading methodology was used. To ensure that participants are reading properly, one third of the sentences was followed by questions with a choice of two answers. No participants were excluded based on low accuracy.

Results and discussion

RTs that exceeded a threshold of 2.5 SDs, by region and condition, were excluded. Mixed-effects regressions with random intercepts and slopes by participant and by item were used for the statistical analysis. The fixed factors were homophony of the target noun form and grammaticality. Significant effects were found only in the regions 3 (the target noun) and 4.

In the region 3, both the grammaticality factor and the interaction between grammaticality and homophony reached significance ($\beta = 94.36$, $SE = 6.22$, $t = 15.16$, $p < 0.01$; $\beta = -36.83$, $SE = 8.78$, $t = -4.19$, $p < 0.01$). In the region 4, only the grammaticality factor was significant ($\beta = 27.73$, $SE = 5.72$, $t = 4.85$, $p < 0.01$). Thus, homophony initially makes errors less noticeable (this can be called a mild grammaticality illusion). We can conclude that the phonological route is activated at the early stages of processing, but orthographical and phonological representations are matched during later processing stages.

Experiment 2

Method

65 speakers of Russian participated in Experiment 2. It builds on earlier work on agreement attraction. Speakers of different languages were found to produce a lot of subject-predicate number agreement errors and almost not to notice (i.e. not to slow down on) such errors while reading in the presence of an intervener with certain properties ('an attractor'), like in (3a) as opposed to (3b).

(3)a. The key to the cabinets was/*were rusty.

b. The key to the cabinet was/*were rusty.

Slioussar (2018) demonstrated for Russian that attraction effects depend on syncretism with nominative plural: readers barely slow down on errors with syncretic attractor forms like (5a) and especially like (4b), while similar errors in (4a) and (5b) provoke massive reading time delays.

(4) Group 1A:
a. Abonement na <u>koncert</u> byl/*byli dorogim/*dorogimi + 4 words.
b. ticket for concert$_{ACC.SG\neq NOM.PL}$ was/*were expensive$_{SG/*PL}$
Abonement na <u>koncerty</u> byl/*byli dorogim/*dorogimi + 4 words.
ticket for concerts$_{ACC.PL=NOM.PL}$ was/*were expensive$_{SG/*PL}$

(5) Group 2B:
a. Tkan' dlja <u>jubki</u> byla/*byli natural'noj/*natural'nymi + 4 words.
b. tissue for skirt$_{GEN.SG=NOM.PL}$ was/*were natural$_{SG/*PL}$
Tkan' dlja <u>jubok</u> byla/*byli natural'noj/*natural'nymi + 4 words.
tissue for skirts$_{GEN.PL\neq NOM.PL}$ was/*were natural$_{SG/*PL}$

We used 48 stimulus sentences like (4a-b) and (5a-b), as well as 24 sentences like (6a-b). In (6a), the attractor has the same spelling as the nominative plural form, but different stress. Will it trigger attraction effects compared to (6b)?

(6) Group 2C: a. *Ten' ot <u>sosny</u> byla/*byli četkoj/*četkimi* + 4 words.
shadow from pine$_{GEN.SG(homographic)}$ was/*were sharp$_{SG/*PL}$
b. Ten' ot <u>sosen</u> byla/*byli četkoj/*četkimi + 4 words.
shadow from pine$_{GEN.PL\neq NOM.PL}$ was/*were sharp$_{SG/*PL}$

There were 138 grammatical fillers. The procedure and analysis were the same as in Experiment 1. No participants were excluded based on low accuracy.

Results and discussion

We analyzed data from the three groups separately, and then compared Groups 2B and 2C. The fixed factors were syncretism/homography of the attractor form and grammaticality. Significant effects were found in region 5 (the adjective) and 6 (only the grammaticality factor in all groups, so we do not discuss this below for space reasons).

Firstly, we replicated the results from Slioussar (2018). In Group 2A, the grammaticality factor and the interaction between grammaticality and syncretism were significant in region 5 (β = 73.19, SE = 18.39, t = 3.98, p < 0.01; β = −65.55, SE = 18.97, t = −3.46, p < 0.01). The significance of interaction is an indication of attraction. The same was true for the Group 2B, although the attraction effect was smaller, like in Slioussar (2018) (β = 52.93, SE = 17.36, t = 3.05, p < 0.01; β = −33.46, SE = 11.06, t = −2.60, p = 0.02).

In Group 2C, no attraction was observed: only the grammaticality factor was significant (β = 65.49, SE = 10.24, t = 6.40, p < 0.01). We also compared the conditions with genitive singular attractors in Groups 2B and 2C. The grammaticality factor and the interaction between the grammaticality and the group reached significance (β = 49.62, SE = 19.06, t = 3.03, p < 0.01; β = −25.05, SE = 10.37, t = −2.48, p = 0.02), indicating that the grammaticality effect was significantly smaller in Group 2B due to attraction.

Thus, the same spelling does not trigger grammaticality illusions, even in silent reading, only the same phonology does. This points to the primacy of phonological representation during lexical access. We can conclude that homophonous forms are closely connected in the mental lexicon, while homographic ones are not. These results also contribute to the studies on agreement attraction and on case error processing like (Chernova et al. 2022).

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