Entrenchment Determinants Are Relevant throughout Spoken Language Production: A Study of Speech Errors

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Abstract

Spontaneously produced Russian speech errors were analyzed for factors that may be expected to determine cognitive entrenchment. The results suggest that entrenchment determinants are relevant throughout the process of spoken language production, including phonological encoding, lemma retrieval, selection of inflected word forms, and grammatical agreement computation, and that the degree of entrenchment of linguistic units is predictive of speech errors.

Keywords: entrenchment; word frequency; age of acquisition; word length; associative relatedness; cooccurrence strength; phonological substitutions; semantic substitutions; inflected word forms; grammatical agreement

Introduction

Spreading-activation theories of production posit that whole networks of units are activated during language production, and the selected item is the one that receives the highest proportion of activation (Dell, 1986; McNamara, 1992; Stemberger, 1985). The degree to which a unit is entrenched in long-term memory may be assumed to affect the amount of activation that it receives, and consequently strongly entrenched units have a better chance of being selected (Schmid, 2007).

Usage-based cognitive-linguistic theories claim that the frequency of use of a linguistic unit correlates with its degree of cognitive entrenchment (Evans & Green, 2006; Hudson, 2007; Langacker, 1987; Rosch et al., 1976; Schmid, 2007) and that frequency is thus a major entrenchment predictor. Importantly, entrenchment of linguistic units is arguably determined not only by the frequency of their activation by individual speakers but also by the frequency of their occurrence in a speech community as a whole.

It has been suggested that apart from frequency, entrenchment is likely to be determined by the age of acquisition (AoA) of a linguistic unit (Gerhand and Barry, 1999; Ghyselinck, Lewis, & Brysbaert, 2004; Morrison and Ellis, 1995, 2000) and the length of a linguistic string (Blumenthal-Drame, 2012).

Although frequency and AoA are important explanatory mechanisms used by cognitive linguistic and psycholinguistic theories, the available experimental data on the role and the locus of the frequency and AoA effects in lexical retrieval are controversial. While many authors argue that the frequency effect is located at the stage of accessing phonological forms (Jescheniak and Levelt, 1994; Jurafsky, 2003 etc.) rather than the semantic lemma level, there is some evidence to suggest that lexical selection (lemma retrieval) is also affected by word frequency (Gorokhova, 2013; Kittredge et al., 2008; Navarrete et al., 2006). Furthermore, recent studies provide evidence for the availability of probabilistic information about individual inflectional variants of a word in lexical memory (see Baayen et al., 2003; Fleischhauer & Clahsen, 2012; Gorokhova, 2011; Smolka, Zwitserlood, & Rösler, 2007).

Similarly, a number of experimental studies propose that AoA is only relevant at the stage of phonological retrieval (Barry et al., 2001; Kittredge et al., 2008) although other authors argue that both frequency and AoA are fundamental for lexical retrieval (Catling et al., 2010; Meschyan & Hernandez, 2002), including its earlier stages (Brysbaert, Van Wijnendaele, & De Deyne, 2000).

Data

To explore the effect of entrenchment predictors on spoken language production, spontaneously produced Russian speech errors (slips of the tongue) of phonological, semantic, and syntactic types were analyzed for factors that may be regarded as determinants of entrenchment — frequency, age of acquisition (AoA), target-error co-occurrence strength, word association norms, and word length. The analyses used the data from the Russian National Corpus, Russian Word Association Thesaurus, and experimentally obtained AoA ratings for target and error words. The study involved 657 context-free sound-based noun substitution errors, 1378 context-free meaning-based noun substitution errors, 242 context-free errors that resulted in the selection of a wrong inflectional variant of the target word, and 274 agreement errors in modifier-head constructions. The errors were collected by tape recording and digitally recording everyday conversations, telephone conversations, and live TV and radio programs. In case the speaker themselves did not catch the error and did not correct it, where possible, they were questioned as to what they had intended to say. If this was not possible (e.g. in the case of an error produced by a participant of a talk show), the error was only included in the corpus after being attested by two professional linguists.

Results and Discussion

Sound-based substitution errors

Phonological substitution errors were analyzed for word frequency and word length. Not surprisingly, the results of the length comparison did not reveal any target vs. error word length difference as target and errors words in phonological substitution errors are known to frequently

have similar beginning segments and equal lengths.

Examples

1. *Da, kstati, mne* ***pyatno*** [pitnO] *otčistili*
→ *...* ***pis'mo*** [pis′mO]...
By the way, I've had the ***spot*** *cleaned →* ... ***letter*** ...

2. *Nas vstretili s bol'šim* ***vnimanijem*** [vnimAnijəm]
→…***vlijanijem*** [vlijAnijəm]
They met us with great ***care →*** …***influence***

At the same time, the results of the frequency analysis show that lower-frequency nouns tend to be replaced by phonologically related higher-frequency nouns (t(656)=3.41, p<0.001) (fig. 1).

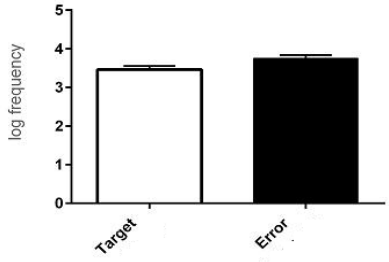

Figure 1: Target vs. error log-transformed frequencies (Mean and SEM): Phonological substitution errors.

Meaning-based substitution errors

Semantic substitution errors were analyzed for word frequency, word length, age of acquisition (AoA), target-error cooccurrence strength, and word association norms.

Based on the types of conceptual-semantic relationships between the target and its substitute, the target-error pairs of nouns were classified as either "cohyponyms" (e. g. *saucer → plate*) or "antonyms" (e. g. *descendants → ancestors*) or "associatively related" (e. g. *carpets → floors*) by 20 undergraduate students of linguistics from St Petersburg State University and by 4 professional linguists. The resulting error corpus under study comprised 724 cohyponym, 187 antonym, and 467 "associatively related" target-error pairs.

Examples

1. Cohyponyms

Ja tebe ***bljudce****, meždu pročim, xoču dostat' →* … ***tarelku***
Incidentally, I want to get you a ***saucer →*** … *a* ***plate***

2. Antonyms

A potom, predstavljaete, naši ***potomki*** *obnaružat etu knigu →* ... ***predki*** ...
And then, can you imagine, our ***descendants*** *will discover this book →* ... ***ancestors*** ...

3. "Associatively related"

Koška vse vremja deret ***kovry →*** …***poly***
The cat keeps tearing the ***carpets →*** … ***floors***

Word frequency The results indicate that error word frequencies tend to exceed target word frequencies in cohyponym (t(723)=2.49, p<0.01) and "associatively related" (t(466)=3.91, p<0.0001) semantic substitutions but not in antonym substitutions (figs. 2, 3, and 4).

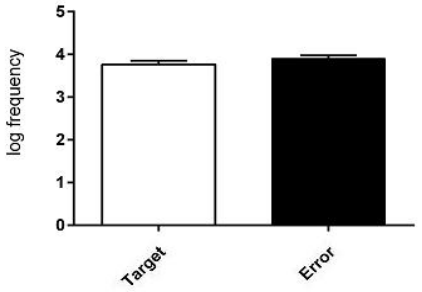

Figure 2: Target vs. error log-transformed frequencies (Mean and SEM): Cohyponym substitution errors.

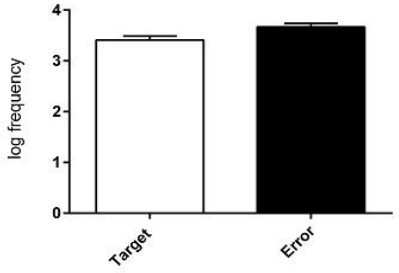

Figure 3: Target vs. error log-transformed frequencies (Mean and SEM): "Associatively related" substitution errors.

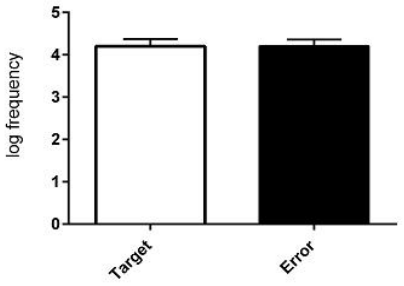

Figure 4: Target vs. error log-transformed frequencies (Mean and SEM): Antonym substitution errors.

Besides, there is a very significant positive correlation between target and error frequency values in cohyponym (r=0.74, p<0.0001) and "associatively related" (r=0.60, p<0.0001) error types (figs. 5 and 6).

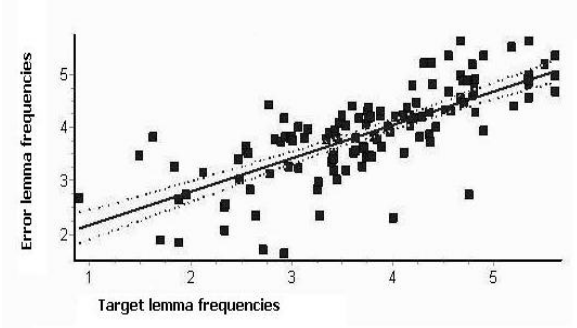

Figure 5: Correlation of target and error word frequencies: Cohyponym substitution errors.

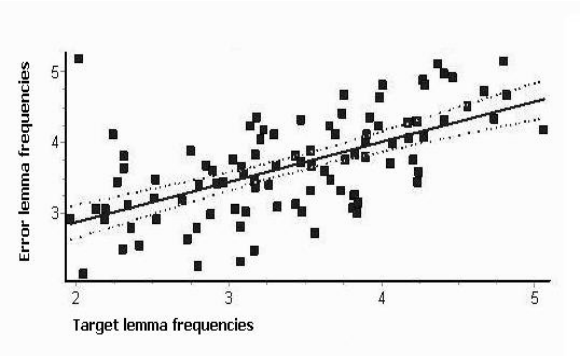

Figure 6: Correlation of target and error word frequencies: "Associatively related" substitution errors.

Age of acquisition AoA ratings for target and error words were obtained using the experimental procedure described in Kuperman, Stadthagen-Gonzales, & Brysbaert, 2012. The target and error words were distributed over lists of 250 words each. For every word, participants were asked to enter the age (in years) at which they thought they had learned the word, i.e. the age at which they would have understood the word even if they did not use it actively at the time.

The lists were initially presented to 20 participants each. If a word got less than 18 valid observations after this phase because of some values missing in the completed lists, it was included in a new, comparable list at the end of the data collection and presented to new participants until the required number of observations was reached. The ratings were collected from 256 respondents, who were all native speakers of Russian with college education aged between 21 and 76.

The results suggest that error words tend to be acquired earlier than target words in cohyponym ($t(717)=2.94$, $p<0.01$) and "associatively related" ($t(446)=2.79$, $p<0.01$) but not in antonym substitutions (figs. 7, 8, and 9).

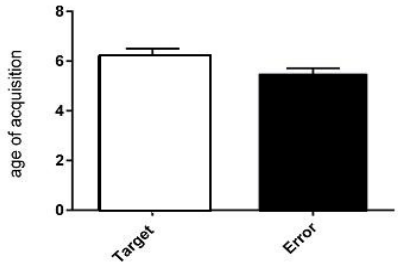

Figure 7: Target vs. error age of acquisition (Mean and SEM): Cohyponym substitution errors.

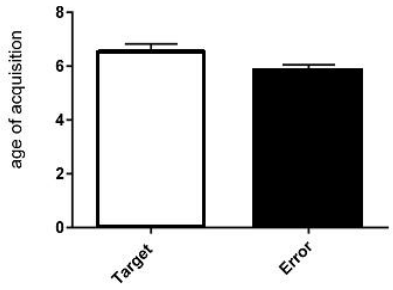

Figure 8: Target vs. error age of acquisition (Mean and SEM): "Associatively related" substitution errors.

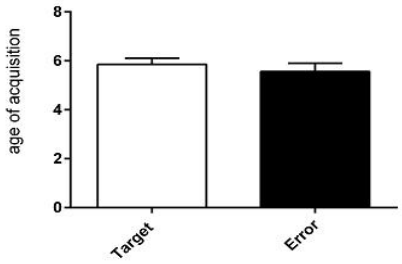

Figure 9: Target vs. error age of acquisition (Mean and SEM): Antonym substitution errors

Word length Word length measured in syllables, while not affecting cohyponym and antonym errors, may still be predictive of the outcome of "associatively related" semantic substitutions, in which target words were found to be significantly longer than error words ($t(466)=2.49$, $p<0.01$) (fig. 10).

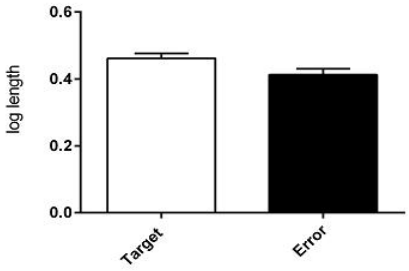

Figure 10: Target vs. error log-transformed word length (syllables) (Mean and SEM): "Associatively related" substitution errors.

Target-error associative relatedness Target-error pairs were analyzed in terms of word association norms from the Russian Word Association Thesaurus. For the purpose of this study, a target word was taken to be a stimulus word, and the substitute word, to be its associative response.

The results indicate that both antonym and cohyponym errors tend to have much higher measures of target-error associative relatedness compared to "associatively related"

errors while antonym target-error pairs are more closely related than cohyponyms ($F(2, 1336)=17.71$, $p<0.0001$) (fig. 11).

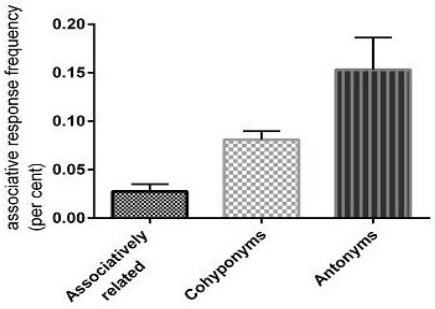

Figure 11: Target-error associative relatedness (Mean and SEM): "Associatively related" vs. cohyponym vs. antonym substitution errors.

Target-error cooccurrence strength The Russian National Corpus was used to estimate the mutual informativeness, or co-occurrence strength, of the target and its substitute. Since Mutual Information (MI) score is known to overestimate low-frequency words, T-score was used in addition to MI because it highlights the word pairs whose co-occurrence frequency is high enough to be reliable. MI and T-scores were computed for each target-error pair with a context window of ± 10 (the average length of a Russian language sentence).

Both antonym and cohyponym errors appear to have much higher measures of target-error cooccurrence strength compared to "associatively related" errors ($F(2, 1372)=9.85$, $p<0.0001$) (fig. 12).

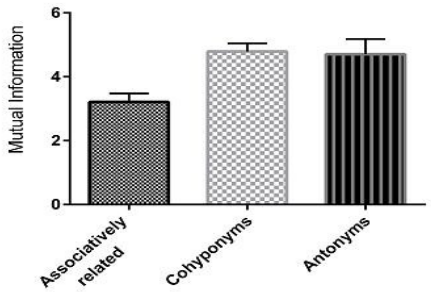

Figure 12: Target-error cooccurrence strength (Mutual Information score) (Mean and SEM): "Associatively related" vs. cohyponym vs. antonym substitution errors

The findings are in line with the view that lexical retrieval is affected by word frequency (Brysbaert et al., 2000; Navarrete et al., 2006) and AoA (Catling et al., 2010; Meschyan & Hernandez, 2002) and provide support for the hypothesis that various determinants of entrenchment may play a role throughout the process of lexical selection including its earlier stages such as the stage of lemma retrieval.

Substitutions of inflected word forms

The analyses, based on the frequency data from the spoken part of the Russian National Corpus, involved context-free substitutions of inflected word forms that resulted in the selection of a wrong inflectional variant of a noun, pronoun, verb, or adjective.

Examples

1. Case (DAT → GEN)

Ty otvezi ix v Moskvu k ***RODSTVENNIK-AM***
you take them to Moscow to relative-PL.**DAT**
→ … *k* ***RODSTVENNIK-OV***
to relative-PL.**GEN**
Why don't you take them to your relatives in Moscow.

2. Person (2d → 3d)

Poslezavtra ***BUD-EŠ '*** *otdoxnuvšij*
day after tomorrow be-**2**SG.FUT well-rested
→… ***BUD-ET*** …
be-**3**SG.FUT
You'll feel well-rested tomorrow.

3. Tense (FUT → PST)

Ja vynuždena ***BUDU*** *vyslušat' plamennuju tiradu*
I have to be:3SG.**FUT** listen to fiery tirade
→ … ***BYLA*** …
be:3SG.**PST**
I'll have to listen to a fiery tirade.

The results indicate, firstly, that **token frequency** is relevant to the selection of inflected word forms. A comparison between the frequencies of the target and error inflected word forms in the corpus reveals that the general tendency is for a higher-frequency inflectional variant of a word to substitute for a lower-frequency variant ($t(241)=3.78$, $p<0.001$) (fig. 13).

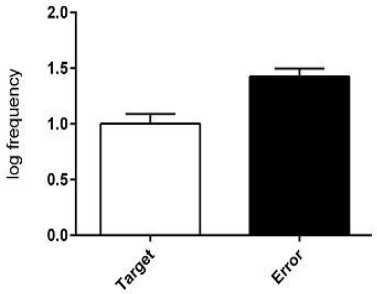

Figure 13: Target vs. error log-transformed frequencies (Mean and SEM): Substitutions of inflected word forms.

Thus, Russian speech error data corroborate the claim that the production of inflected forms may be influenced by word form frequency (Baayen et al., 2003; Clahsen, Hadler, & Weyerts, 2004; Fleischhauer & Clahsen, 2012).

Furthermore, it appears that the selection of inflected forms is sensitive to **type frequency**. A comparison between the relative frequencies of the target and error inflectional variants within the word's declension paradigm suggests that the case forms of nouns and personal pronouns that occur most frequently in spoken Russian (nominative, genitive, and accusative) tend to substitute for the less

frequent oblique case forms such as the dative whereas the higher-frequency nominative and accusative forms tend to replace the genitive ($t(86)=4.03$, $p<0.001$) (fig. 14).

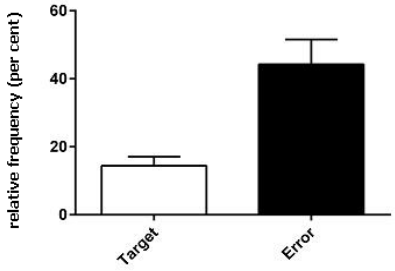

Figure 14: Target vs. error relative frequencies (per cent) (Mean and SEM):
Substitutions of noun/personal pronoun case forms.

The results are evident in favor of usage-based models of mental grammar suggesting that the degree of entrenchment, regarded as a mental correlate of usage frequency, may influence the selection of a word's inflectional variants. Furthermore, the data provide support for the claim that the frequency of use of grammatical constructions at different levels of schematicity is an important determinant of linguistic structure and language use (see Bybee, 2006; Croft & Cruse, 2004; Diessel, 2007).

Errors of agreement in modifier-head constructions

The analysis involved "reversed agreement" errors in modifier-head [Adj/Part/Pron/Num+N] constructions, when a speaker selects an irrelevant noun case form based on the case-ambiguous pre-modifier adjective form instead of computing the adjective case form based on the head noun form.

Examples

1. PL.LOC → PL.GEN

*na et-IX forum-**AX***
*at this-PL.GEN/LOC forum-**PL.LOC***
→
*na et-IX forum-**OV***
*at this-PL.GEN /LOC forum-**PL.GEN***
(I visited different Internet forums and) at these forums…

2. SG.F.GEN → SG.F.DAT

*mil-**OJ*** *ženščin-**Y***
nice-SG.F.GEN/DAT/INS/LOC woman-SG.F.**GEN**
→
*mil-**OJ*** *ženščin-**E***
nice-SG.F.GEN/DAT/INS/LOC woman-SG.F.**DAT**
(I visited a presentation made by a) nice woman…

The errors were analyzed using frequency data from the disambiguated part of the Russian National Corpus. The comparison reveals the tendency for speakers to substitute more frequent constructions for less frequent constructions ($t(236)=3.49$, $p<0.001$) (fig. 15). To ascertain that the result was not due to higher frequencies of error head nouns, a statistical test was run to compare target and error head noun frequencies, which did not produce a significant frequency difference; so it seems plausible to conclude that it is the higher frequencies of error modifier-head constructions that account for the result.

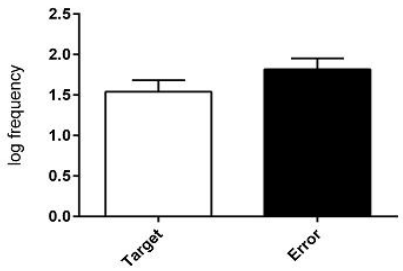

Figure 15: Target vs. error construction log-transformed frequencies (Mean and SEM): Agreement errors in modifier-head [Adj/Part/Pron/Num+N] constructions

Evidence from agreement errors in modifier-head constructions indicates that the production mechanism makes use of distributional patterns of relevant constructions stored in long-term memory. This finding is in line with some recent studies that suggest that number agreement may be computed based on the speaker's linguistic experience (Haskell, Thornton, & MacDonald, 2010; Thornton & MacDonald, 2003). The error construction seems to be a well-entrenched recurrent pattern, which a speaker, based on their linguistic experience, tends to use as a default schema instead of using more generalized constructional schemas.

Conclusion

Speech error data provide supportive evidence for the claim that properties of linguistic units regarded as entrenchment determinants are important throughout the process of spoken language production. Furthermore, the results suggest that the degree of entrenchment of words and lexico-grammatical structures may be a factor involved in the occurrence of speech errors. At the same time, more research is needed to investigate the effects of other variables such as imageability on the word's susceptibility to errors in normal speech.

Acknowledgments

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