# Frequency effects on the processing of Dutch regular and irregular past tense verbs

## Investigating whole-word representations of regular verbs

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lexical retrieval
past tense inflection

ABSTRACT
Previous research has found that irregular verbs are stored and retrieved from declarative memory as whole-word representations, unlike regularly inflected verbs, whose morphological complexity require them to be rule-processed in the procedural memory before being retrieved from declarative memory. In our study, however, we aimed to investigate whether frequency has a stronger facilitatory effect on regulars compared to irregulars. In other words, we examined whether highly frequent regular past tense verbs are retrieved directly from the declarative memory, like irregular past tense verbs, instead of first being decomposed in the procedural memory. We therefore hypothesized an interaction between frequency effects and verb type. However, the findings did not support this hypothesis. Despite the expected facilitatory effect of frequency in the overall processing of verbs, the results show that regularly inflected verbs are responded to faster than irregular verbs, thus being opposed to findings of previous research. Therefore, no interaction between frequency and verb type was found in our study. Nevertheless, further research is required to determine whether other variables, such as stem-cluster frequency and age of acquisition, affected the results, therefore leading to a better understanding of the way in which words are stored and retrieved from the lexicon.

### 1. Introduction

Over the past thirty years, researchers have shown an increased interest in the way morphologically complex forms are represented as well as how these representations are accessed in the human mind. The present study aims to contribute to this growing area of research by exploring how Dutch regularly and irregularly inflected past tense verbs are processed, focusing on the effects of frequency on these computations. The issue of regular and irregular form processing has been a controversial and much disputed subject within the field of psycholinguistics, which has led to the emergence of two distinct theories. On the one hand, Rumelhart and McClelland (1986) proposed a single-system model, according to which both regular and irregular past tense verbs are computed by the same mechanism. They suggested that there are distinct entries in the mental lexicon for each

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past tense form, regardless of its morphological status. They also argued that the retrieval of its stems results from its phonological similarity with their respective present tense forms.

Challenging this view, Pinker (1991, 1999) and Ullman (2004) proposed the dual-system model, highlighting the necessity of postulating different mechanisms for the processing of regular and irregular forms. More specifically, they argued that regularly inflected verbs (e.g. walked) are processed in a rule-based manner, whereas irregularly inflected verbs (e.g. *went*) are handled by the declarative memory. The storage and retrieval of regular forms is a two-phase process, as it includes the concatenation of the past tense suffix (*-ed*) with the verb stem. Therefore, they are first processed by the procedural memory, which is responsible for the application of the rule and the decomposition of the verb into its parts (stem + *ed*), before being retrieved by the declarative memory (Ullman, 2004). In contrast, irregular forms are stored and retrieved as whole-word representations from the declarative memory, as they cannot be decomposed. Their morphological difference from their verb stems therefore allows them to occupy separate entries in the mental lexicon.

Prasada and Pinker (1993) proposed two versions of the dual-system model. The strong version suggests that regularly inflected forms are never stored as whole words in memory, whereas the weak version allows for storage of regular forms as whole-word representations. Nevertheless, unlike irregulars, regularly inflected forms are not dependent on these whole-word representations, because they are generalized on the basis of abstract rules. However, according to the weak version, this does not exclude the existence of separate entries for certain regularly inflected forms.

Multiple studies that followed provided support for the dual-system model, often using lexical decision tasks. Silva and Clahsen (2008) did a masked-priming lexical decision task with regular verb stems that were primed by their past tense inflected form, their identical form or a non-related form. The results of the task showed that the decomposition of the regular past tense verbs enables the stem to prime the target verb similarly to its identical form. Using a cross-modal priming paradigm in a lexical decision task, Sonnenstuhl, Eisenbeiss and Clahsen (1999) investigated German participles. They reported activation of the same entry in the mental lexicon for both inflected and uninflected forms of the regular verbs, but not for the respective forms of the irregular verbs. Furthermore, Pliatsikas and Marinis (2013), whose research focused on L2 learners' processing of English regular and irregular past tense verbs at the sentence level has also supported the dual-system model, reporting slower processing time for regular than irregular verbs. This delay was explained by the application of the rule for regular verbs, which leads to the decomposition of the inflected form. EEG studies have also contributed to the strengthening of the dual-system approach. Allen, Badecker and Osterhout (2003) examined whether verbs that vary in grammaticality (grammatical vs. ungrammatical), morphological status (regular vs. irregular) and frequency (high vs. low) differ in the delay of elicitation of the P600 component. Their data showed slower elicitation of P600 for gram-

matical violations with regular than irregular verbs. This suggests that the former are rule-processed and decomposed on-line, unlike the irregularly inflected verbs, which are processed as whole words.

Frequency is an essential factor that affects the way in which words are stored and processed (Pinker, 1999; Prado & Ullman, 2009). Studies have shown that a higher word frequency facilitates retrieval, leading to faster responses to highly frequent words in various tasks (e.g. Hudson & Bergman, 1985; Schilling, Rayner & Chumbley, 1998). However, according to the dual-system model, frequency is not expected to equally affect the processing of regularly and irregularly inflected verbs, because they are retrieved differently (Pinker, 1991; 1999). In fact, whole-word frequency effects have been found for representations of irregular forms, which are stored in the lexicon. However, such effects were not attested in regularly inflected forms, as they are assumed to be processed by applying a rule (Clahsen, Eisenbeiss & Sonnenstuhl-Henning, 1997).

Other studies have challenged this view. For example, Alegre and Gordon (1999) used lexical decision tasks to investigate frequency effects for regularly inflected nouns and verbs. Whole-word frequency varied from high to low, while simultaneously stem-cluster frequency (i.e. the frequency of the stem and its inflected forms combined) was kept constant. The results showed a frequency effect for regular forms, although it only emerged above a threshold of appearing about 6 times per million words.[2] This suggests that regularly inflected forms with a frequency above that value can be stored and retrieved as whole-word representations. On the other hand, those found below this threshold "require compositional representations based on morphological structure" (Alegre & Gordon, 1999, p. 56). Although their study provided an overall support for the dual-system model, their findings that regularly inflected forms can also be stored as whole-word representations in the memory was not in line with Prasada and Pinker's (1993) strong version of the model. The weaker version, thus, seems to be a better fit for their research outcome. Moreover, research by Baayen, McQueen, Dijkstra, and Schreuder (2003) broadened the empirical support for frequency effects on regular forms. They conducted visual and auditory lexical decision tasks in order to examine the recognition of inflected Dutch nouns and verbs. Their findings showed effects of whole-word frequency for regular plural forms of nouns and verbs in both modalities. This suggests that there are independent representations of plural forms for nouns and verbs across modalities, even for regularly inflected forms. The results of this study are in line with Alegre and Gordon's (1999) theory, arguing against the idea that only irregular complex words are stored in the declarative memory (Prasada & Pinker, 1993).

2 This corresponds to a log word frequency of 2.42 based on the SUBTLEX-NL database (Keuleers et al., 2010). As will be explained later, in the current study we aimed to use verbs from the full frequency range regular verbs occur in, which was between 0.30 to 3.90 log word frequency. Thus, we both use stimuli with a frequency below as well as above the frequency threshold found by Alegre and Gorden (1999).

The weak version of the dual-system model allows for separate word entries for regularly inflected verbs (Prasada & Pinker, 1993). We posit that this is due to reasons of economy. Regulars are retrieved slower than irregulars (e.g. Silva & Clahsen, 2008), because of the decompositional process, which delays retrieval. This suggests that separate word entries are more economical than rule application. This leads to our research question: *Can regular past tense verbs, under certain conditions, be directly retrieved from the Declarative Memory?* If that is the case, we suggest that this would be under the condition that the verb is used so frequently that it is more economical to store it as a whole-word representation and retrieve it directly than to go through an in-between step of decomposing the verb. Therefore, more frequent regular past tense verbs should be more likely to be stored in the declarative memory than less frequent regular past tense verbs. Thus, the processing of highly frequent regular past tense verbs will be more similar to that of irregulars, which are also directly retrieved from declarative memory. Thus, even though regulars are responded to slower than irregulars, whole-word frequency is predicted to have a stronger facilitatory effect on regulars compared to irregulars. That would lead to an interaction between verb type and frequency. Although we believe that this effect applies to both production and comprehension, the focus of the current paper will be on the retrieval of regular and irregular forms in language comprehension. We therefore tested our expectations using a visual lexical decision task (cf. Alegre & Gordon, 1999; Baayen et al., 2003).

## 2. Method

### 2.1 Participants

Twenty-nine adult native speakers of Dutch (23 females) participated in the study. They were recruited from the social network of the authors. None of them reported any language-related impairment (e.g. dyslexia) and all had normal or corrected-to-normal vision. The participants were on average 26;10 years old, ranging from 19;6 to 56;6. Four of them had learnt another language besides Dutch as a child, but all confirmed that Dutch was their dominant language. The study was approved by the UiL-OTS Ethical Committee.

### 2.2 Materials

The materials consisted of 480 items (240 words and 240 non-words) in total. All items had different stems to prevent priming effects. Thus, verb stems that were used in one condition (e.g. regular verbs) were not used in any other conditions (e.g. fillers). In addition, compound verbs and homographs were excluded.

#### *2.2.1. Experimental items*

The experimental items consisted of 70 regular (e.g. *werkte* ‘worked’) and 70 irregular (e.g. *sprak*, ‘spoke’) past tense verbs. Only singular verbs were chosen to prevent any (additional) inflection in the past tense forms from confounding the results. The whole-word frequency data for the experimental items were obtained from the SUBTLEX-NL database (Keuleers et al., 2010). As the relation between

processing speed and word frequency is non-linear, the log base 10 transformed data was used (cf. Keuleers et al., 2010). The items were evenly distributed on a frequency continuum from 0.30 to 3.90 log word frequency, which corresponds to an occurrence of respectively 0.02 to 180 times per million words.

As regular past tense forms in Dutch are inherently longer than irregular forms due to their *–de* or *–te* ending, it was only possible to partially control for length. In addition, the suffix in regulars might be processed faster than additional letters in irregulars. The irregulars (length in letters: *M*=5, min=4, max=9) were therefore slightly shorter than the regular (*M*=6.57, min=5, max=8) verbs. Since highly frequent words tend to be shorter than low frequent words, we also ensured that in each condition, length was distributed evenly across the frequency continuum.

### *2.2.2. Filler items*

100 present tense verbs were used as filler items.[3] Since all experimental items were past tense, the use of present tense verbs aimed to prevent the participants from finding out the purposes of the experiment. In addition, including present tense verbs forced participants to process the past tense. Half of the present tense verbs (n=50) were non-inflected 1st person forms (e.g. *loop* 'walk') and the other half were inflected 2nd/3rd person forms (e.g. *loopt* 'walks'), to balance the number of items with and without suffix. Present tense forms whose stems end in –t (e.g. *praat* 'talk(s)') were decided not to be included as they are ambiguous for 1st/2nd/3rd person singular.[4] Since frequency was manipulated for the target items, the filler items were also equally distributed on a frequency continuum. The whole-word frequency data of the fillers were also collected from the SUBTLEX-NL database (Keuleers et al., 2010).

### *2.2.3. Non-words*

Half of the total number of all items were non-words (n=240). The pseudo-word generator Wuggy (Brysbaert, 2010) was used to create non-words out of the existing experimental and filler items. The pseudowords were matched to the existing items on length. Some modifications were made if one of the following conditions applied:

1. The 'stem' was an existing Dutch noun (e.g. **pet-te*, noun: pet 'cap');
2. The suggested non-word was a regularized irregular verb (e.g. **loop-te* 'walked');
3. The suggested non-word did not adhere to phonological constraints in Dutch (e.g. if the suffix had to be *–de* instead of *–te*).

The manual modifications mentioned above led to changing one phoneme of the word suggested by Wuggy. The 120 non-words that were created based on the

3 Although the number of filler items (n=100) was lower than the number of experimental items (n=140), none of the participants reported in the debriefing that they had noticed this.

4 Due to a mistake the final stimuli set contained one such verb: verlaat 'leave'.

regular past tense (e,g, *beveerde*) and 2nd/3rd person present tense verbs (e.g. *spielt*) resembled inflected items. This was not the case for the words extracted from irregular past (e.g. *kield*) and 1st person present (e.g. *spaag*), as these forms do not have any inflection.

### 2.3. Procedure

All items were presented to all participants. All items were pseudo-randomized to prevent any order effects. The pseudo-randomization was constrained in such a way that the same condition appeared at most in four consecutive trials. In this way, we prevented the display of many inflected verbs consecutively which might lead the participant to press the button rhythmically, or read the words faster without processing the inflection. Positive responses (stimulus was an existing word) were made with the dominant hand. The experiment was run on a computer in a soundproof booth at a university building or on a laptop in a quiet room at the participants' or experimenters' home. The experiment lasted approximately twenty minutes.

After the participants received instructions, they completed a practice block, in which feedback was provided. The practice block consisted of 10 items (5 words and 5 non-words). The items consisted of plural present tense verbs (e.g. *koken* 'cook'). None of the stems of these verbs appeared in the experimental trials. Participants were allowed to ask questions before and after the practice block, but not during the experimental block. No feedback was provided in the experimental block, which consisted of 480 items. At the start of each trial, a fixation cross appeared for 1000 ms, after which the item was presented. If one of the two buttons was pressed, the visual stimulus disappeared and the next trial started. If participants did not press the button within 2000 ms after the start of the visual presentation, the word disappeared and the next trial started.

### 2.4 Analysis

A linear mixed effects analysis was performed using the lme4 package (Bates, Maechler, Bolker & Walker, 2014) in R (R Core Team, 2017) to investigate whether verb type and frequency significantly affected the response time on trials that were identified correctly. A step-up approach was used to determine which model fitted the data best, including a fixed factor only if a likelihood ratio test showed that the model with the effect in question significantly improved the model compared to the same model without that effect.[5] This approach showed that both factors of interest, verb type and frequency, significantly improved the model, as well as trial number. The interaction between type and frequency, however, did not explain significantly more variance. The confound variables length (as well as its interaction with type), age and gender did not significantly improve the model.

5 If two models were compared using the likelihood ratio test, they always had the same random effect structure to make sure that any obtained effect could only be due to the inclusion of the fixed effect. Still, the model with the more maximal random effect structure, namely including the random slope for type, became the new baseline model to minimize the chance of type I errors.

The fixed effect structure of the final model therefore consisted of verb type, frequency and trial number. The random effect structure was kept as maximal as possible, but was reduced in case of a convergence or overfitting error, following Barr, Levy, and Scheepers (2013). The final model contained random intercepts of subjects and items, as well as a random slope for type per participant.[6]

## 3. Results

### 3.1. Accuracy

The accuracy score in this study is 91.5% (SD = 27.8%). As shown in Figure 1, there seems to be a non-linear relation between accuracy and frequency. To examine whether this was the case, an additional binomial mixed model logistic regression analysis was performed. The model contained a log transformation of word frequency as a fixed factor and random intercepts for participants and items.[7] There was a significant main effect of log word frequency, with higher word frequency leading to more accurate responses [β=1.80, SE=0.22, z(4039)=8.31; p < .01].

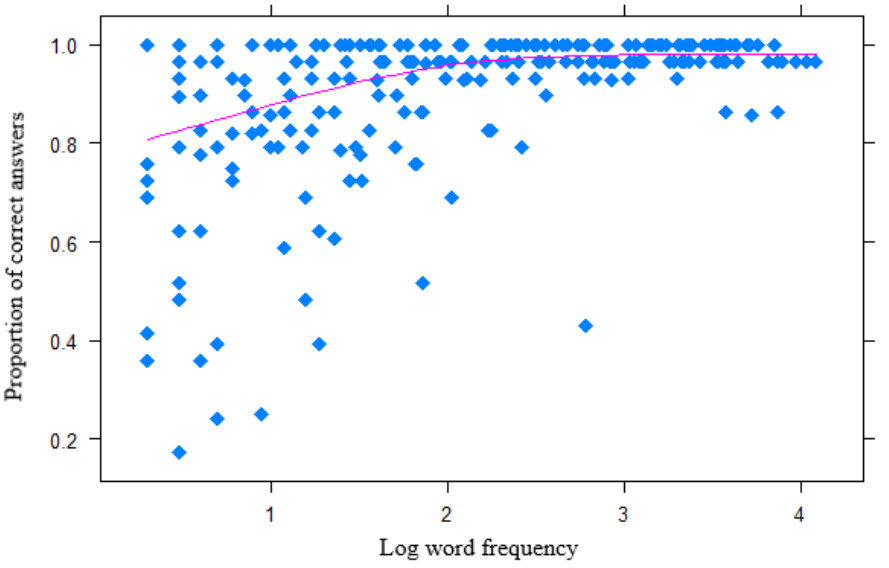


*Figure 1.* Proportion of correct answer for each word by frequency

### 3.2. Response times

On average, regular verbs yielded faster responses (M = 686 ms, SD = 213 ms) than irregular verbs (M = 721 ms, SD = 230 ms). The main effect of type on response time was significant [t(69) = -3.58; p < .01]. According to the model, irregular verbs were responded to 38.51 ms (± 10.76 standard error) slower than regular verbs. Moreover, there was a negative relation between word frequency and response time, as is illustrated in Figure 2. This effect proved to be significant [t(137) = -11.74; p <

6 responsetime_model ← lmer(rt ~ type + frequency + trialnumber + (1+type|subject) + (1|item) )

7 accuracy_model ← glmer((response==correct) ~ log(frequency) + (1|subject) + (1|item) )

.01]. Response time decreased by 56.74 ms (± 4.83 SE) when the word frequency was 1 log word frequency higher. Finally, trial number positively affected response time [β=0.11, SE=0.02, t(3612) = -4.64; p < .01]. The interaction between type and frequency did not affect response time, since adding this interaction did not improve the model, as indicated earlier.

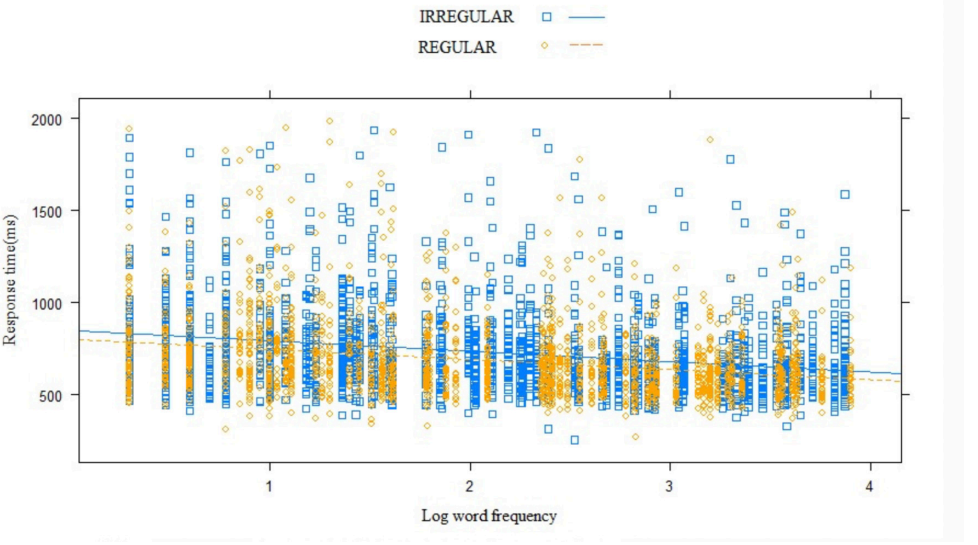


*Figure 2.* Response time for each verb type by frequency

## 4. Discussion

### 4.1 Interpretations and implications of the results

To sum up, the results show that frequency had a negative effect on response time and accuracy, that is, lower frequency led to longer response times and lower accuracy. The response times to regular verbs were shorter than those to irregular verbs, with a facilitating effect of frequency which did not differ between verb types. Compared to previous research (e.g. Alegre & Gordon, 1999) the accuracy score in this study was quite low. This might be due to the use of verbs with a very low frequency. Indeed, the mixed model binary logistic regression analysis showed that frequency negatively affects accuracy, an effect that became stronger as frequency decreased. Not all participants might have known these words or they might have been too slow in responding to them, leading to a lower number of correct answers for these verbs. In addition, some participants remarked that they found this task much harder than previous lexical decision tasks they had participated in. This might be because this task only contained verbs and verbs are typically more abstract than nouns. However, since only the latency of the correct answers was included in the response time analysis, this is not an issue for the findings on the response times.

Earlier studies on the processing of regular and irregular forms have often shown that irregulars are processed faster than regulars (e.g. Silva & Clahsen, 2008). This has been argued, according to the dual-system model, to be due to the

decomposition of regular verbs in the procedural memory (e.g. Pinker, 1991). The regular past tense forms were therefore also expected to be responded to slower than to the irregular past tense verbs. However, the results suggest that the opposite is true, although the significance of this difference depends on the model used in the analysis. The finding that frequency positively affects response time is directly in line with our predictions and with much previous research on the effects of frequency on word retrieval (e.g. Hudson & Bergman, 1985; Schilling et al., 1998). The finding that participants speed up during the experiment might be because they became increasingly familiar with the task. However, it might also be caused by a priming effect as the participants saw many past tense forms.

We predicted that there would be an interaction between frequency and verb type in such a way that frequency would have a stronger effect on regular than on irregular forms. Since more frequent regular verbs were hypothesized to often be retrieved as whole-word representations, we expected the processing difference between more frequent regular vs. irregular verbs to be smaller. No such interaction was present in the results and the hypothesis can therefore not be confirmed. Note that since the main effect of verb type was opposite to what has been found in the literature, caution is required in interpreting this finding. Decomposition is assumed to take longer than the retrieval of a whole-word representation. Thus, if it is the case that all regular verbs are decomposed, regardless of their frequency, it is surprising that they were responded to faster than the irregular verbs. Possible explanations for this finding will be discussed in more detail below.

## 4.2 Limitations and suggestions for further research

Although many potential confounding variables have been controlled for, other factors might have influenced the obtained results. The experimental items might have primed subsequent items, because they are all past tense verbs. Priming is especially relevant for regular forms, as seeing the *-de* or *-te* ending in previous items will morphologically prime other regularly inflected verbs, thus facilitating their retrieval (cf. Silva & Clahsen, 2008). More specifically, this may have confounded our results, because the delay caused by the decomposition of the word is reduced. This might be the reason why regular verbs are responded to faster than irregulars in this study. It could also explain why no interaction between type and frequency was found, because the priming of the past tense morpheme makes it less beneficial to access the whole-word representation of highly frequent regularly inflected forms.

An alternative explanation could be that if a regular form is decomposed, then it will not be the word form frequency, but the stem-cluster frequency, that predicts response time (Pinker, 1991). Stem-cluster frequency effects suggest that words are retrieved through the activation of decomposed representations, whereas whole-word frequency effects reflect lexical access via the activation of full-form representations. As we assumed a weak version of the dual-system model (Prasada & Pinker, 1993), hypothesizing that highly frequent regular past tense verbs

are more likely to have a separate whole-word representation, we chose to use the whole-word frequency of the verbs. However, we did not take into account the stem-cluster frequency, which might affect the response time of regular verbs, especially of less frequent verbs. Therefore, a post-hoc analysis[8] was performed on the responses to the regular verbs. It showed that the base 10 log frequency of the lemma (SUBTLEX-NL, Keuleers, et al., 2010) predicted response time independently of whole-word frequency [$\beta$ = -38.55, SE= 15.74, t(64) = -2.45, p = .017], but not for irregular verbs (p > .05). This suggests that lemma frequency should also be taken into account in the future, when comparing the processing of regular and irregular verbs.

Furthermore, the formation of some irregular verbs might be rule-like in Dutch, which might lead them to also be processed by the procedural memory, like regular verbs. For example, many Dutch verbs with *-ij-* in the stem, turn into *-ee-* in the past tense (e.g. *lijken* → *leken*, 'appear(ed)'). These forms were marked as irregular in this study, but the rule might be productive according to the Tolerance Principle (Yang, 2016). This could have affected the results in the current study as these irregular forms are retrieved slower than 'real' irregular forms. However, the Elsewhere Condition, in which an exceptional rule is applied before the more general rule, suggests that these forms are still processed faster than regular verbs with a *-de* or *-te* ending. Further research on the productivity of irregular verbs in Dutch is therefore needed to see whether these forms are processed differently.

Future work could also investigate how age of acquisition affects the processing of regular and irregular forms. This factor has a strong correlation with frequency, but it has also been shown to predict response time regardless of frequency (Morrison & Ellis, 1995). However, it would be particularly interesting for words that are either formed by rules or not, since children tend to make overgeneralization errors at a certain age, showing that they have acquired rule formation (Pinker, 1991). Words that are acquired before this age might be represented differently in the mind, as they have not been decomposed when they were heard for the first time. It is therefore possible that age of acquisition exerts a stronger effect than frequency on how a word is stored and retrieved.

## 5. Conclusion

The current study set out to investigate whether highly frequent regular forms are stored in the declarative memory, instead of first being decomposed in the procedural memory. Previous studies have shown that regular verbs are processed slower than irregulars, which suggests that decomposition is less economical. Regular verbs that are highly frequent were therefore expected to not be decomposed. Thus, it was hypothesized that there would be an interaction between the facilitatory effect of word/verb frequency and regularity of verbal inflection. However, the findings do not confirm this hypothesis. Although frequency facilitated processing

8 lemma_model <- lmer(rt ~ loglemma + logWF + trialnum + (1 | ppid) + (1 | word) )

as expected, regular verbs yielded faster responses than irregular verbs in the present study. This is opposite to the findings in earlier research. Also, there was no interaction between verb type and frequency. Further research needs to be done to investigate how other variables, such as age of acquisition and stem-cluster frequency, could have affected the results. This might lead to new insights in how words are stored in and retrieved from the lexicon.

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## References

Alegre, M. & Gordon, P. (1999). Frequency effects and the representational status of regular inflections. Journal of Memory and Language, 40(1), 41-61.

Allen, M., Badecker, W., & Osterhout, L. (2003). Morphological analysis in sentence processing: An ERP study. Language and Cognitive Processes, 18(4), 405–430.

Baayen, R. H., McQueen, J. M., Dijkstra, T. & Schreuder, R. (2003). Frequency effects in regular inflectional morphology: Revisiting Dutch plurals. Morphological structure in language processing, 151, 355-390.

Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. Journal of memory and language, 68(3), 255-278.

Bates, D., Maechler, M., Bolker, B. & Walker, S. (2014). Fitting Linear Mixed-Effects Models Using lme4. Journal of Statistical Software, 67, 1-48.

Clahsen, H., Eisenbeiss, S., & Sonnenstuhl-Henning, I. (1997). Morphological Structure and the Processing of Inflected Words. Theoretical Linguistics, 23(3), 201–250.

Hudson, P. T., & Bergman, M. W. (1985). Lexical knowledge in word recognition: Word length and word frequency in naming and lexical decision tasks. Journal of Memory and Language, 24(1), 46-58.

Keuleers, E., Brysbaert, M., & New, B. (2010). SUBTLEX-NL: A new measure for Dutch word frequency based on film subtitles. Behavior research methods, 42(3), 643-650.

Morrison, C. M., & Ellis, A. W. (1995). Roles of word frequency and age of acquisition in word naming and lexical decision. Journal of Experimental Psychology: Learning, Memory, and Cognition, 21(1), 116-133.

Pinker, S. (1991). Rules of language. Science, 253(5019), 530-535.

Pinker, S. (1999). Words and rules: The ingredients of grammar. London: Weidenfield and Nicolson.

Pliatsikas, C., & Marinis., T. (2013). Processing of regular and irregular past tense morphology in highly proficient second language learners of English: A self-paced reading study. Applied Psycholinguistics, 34(5), 943-970.

Prado, E. L., & Ullman, M. T. (2009). Can imageability help us draw the line between storage and composition? Journal of Experimental Psychology: Learning, Memory, and Cogni-

tion, 35(4), 849.
Prasada, S. & Pinker, S. (1993). Generalization of regular and irregular morphological patterns. Language and Cognitive Processes, 8(1), 1-56.
R Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.
Rumelhart, D. E., & McClelland, J. L. (1986). On learning the past tense of English verbs. In J. L. McClelland & D. E. Rumelhart (Eds.), Parallel distributed processing: Explorations in the microstructures of cognition, 2, (pp. 216–271). Cambridge, MA: MIT Press.
Schilling, H. E., Rayner, K., & Chumbley, J. I. (1998). Comparing naming, lexical decision, and eye fixation times: Word frequency effects and individual difference. Memory & Cognition, 26(6), 1270-81.
Silva, R., & Clahsen, H. (2008). Morphologically complex words in L1 and L2 processing: Evidence from masked priming experiments in English. Bilingualism: Language and Cognition, 11(2), 245–260.
Sonnenstuhl, I., Eisenbeiss, S., & Clahsen, H. (1999). Morphological priming in the German mental lexicon. Cognition, 72(3), 203–236.
Ullman, M. T. (2004). Contributions of memory circuits to language: The declarative/procedural model. Cognition, 92(1-2), 231-270.
Yang, C. (2016). The price of linguistic productivity: How children learn to break the rules of language. MIT Press.