

RUNNING HEAD: Imageability and the acquisition of inflections

The power of imageability: the acquisition of inflected forms is facilitated in highly imageable  
verbs and nouns in Czech children

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## Abstract

Imageability is the ability of words to elicit mental sensory images of their referents. Recent research suggested that imageability facilitates the processing and acquisition of inflected word forms. The present study examined whether inflected word forms are acquired earlier in highly imageable words in Czech children. Parents of 317 children (mean age 28 months) were asked whether their child used specific forms of 63 nouns and 35 verbs. For nouns, the forms were nominative singular and plural; for verbs, third person singular present, second person singular present, and the past participle. Plural nouns, and second person and past participle verbs were considered the marked, inflected forms. Analyses revealed that imageability is positively related to the use of the inflected form, even when controlling for the use of the unmarked form in each child, and the inflected form frequency. Two main explanations are suggested: facilitation of form retrieval from long-term memory, or facilitation of inflected form processing, especially by supporting the representations in working memory.

## Grammatical morphemes in language acquisition

Acquisition of grammatical morphemes has been one of the important topics in language acquisition research from the earliest modern studies (e. g. Berko, 1958). Early research showed that the order in which English-learning children acquire grammatical morphemes is relatively stable, and that it cannot be explained by surface factors such as frequency (Brown, 1973; Villiers & Villiers, 1973; see xxx). Brown suggested that the timing of morpheme acquisition is determined by semantic and syntactic complexity of the morphemes. It is clear that various properties of grammatical morphemes, such as frequency or semantic and syntactic complexity, influence when they will be acquired, but the morpheme properties may not be the only influence. Grammatical morphemes are always used with lexical morphemes, i. e. words, either as their affixes or as parts of phrases, clauses, and sentences. Usage or acquisition of grammatical morphemes is likely to be affected by properties of content words that are used along with the grammatical morphemes. The present study focuses on this aspect of acquisition; it examines the relation between the emergence of inflectional affixes and the semantic properties of words that combine with these affixes. We demonstrate, confirming some previous findings, that words with higher imageability appear in inflected forms earlier than their less imageable but otherwise similar counterparts.

The idea that the acquisition of grammatical morphemes is related to the properties of content words used with these morphemes has been put forward in various lines of research. Bloom, Lahey, Hood, Lifter, and Fiess (1980), and Bloom, Merkin, and Wooten (1982) studied the acquisition of connectives and wh-words and hypothesized that children first use these words in sentences with semantically general verbs. According to this view, semantically general verbs have a limited set of semantic features, which leaves more free resources for their grammatical processing in multi-word constructions. Similar ideas have been proposed by different researchers (Rice & Bode, 1993; Pinker, 1984, 1989). However,

the role of semantic generality has been questioned in newer research. Rowland, Pine, Lieven, & Theakston (2003) examined similar structures as Bloom et al. (1980, 1982) and concluded that semantic factors in content words did not account for the use of function words after removing the effects of input frequency. The role of semantic generality is thus unclear, but it is one example of how the semantics of content words could be related to the acquisition of morphology. Recent research suggested another semantic factor that might have some effect on grammatical morpheme acquisition, namely imageability.

#### Imageability and language acquisition

Imageability of a word reflects how easily and fast the word elicits a mental image of its referent. It was first studied as a factor influencing verbal memory, with high imageability of words related to their better recall in paired associate learning tasks (e.g. Paivio, Yuille, & Madigan, 1968). Subsequent research showed that imageability affects processing as well as acquisition of content words. Highly imageable content words are processed faster and more accurately in lexical decision and naming tasks across languages (Groot, 1989; Kauschke & Frankenberg, 2007; Kroll & Merves, 1986; Luke, Liu, Wai, Wan, & Tan, 2002; Strain, Patterson, & Seidenberg, 1995). They are also acquired earlier than less imageable ones, which has been first shown using adult estimates of the age of acquisition (Ferrand et al, 2008; Gilhooly, & Logie, 1980; Masterson & Druks, 1998; Wilson, Cuetos, Davies & Burani, 2013), but it was more recently confirmed using parent report data on children's vocabulary (Ma, Golinkoff, Hirsh-Pasek, McDonough, & Tardif, 2009; McDonough, Song, Hirsh-Pasek, Golinkoff, & Lannon, 2011), as well as child language corpus data (Smolík, under review).

Word imageability is a subjective characteristic that cannot be measured directly; it is estimated using adult ratings of words. These ratings, collected from a larger number of people and averaged, define the level of imageability for individual words. Because imageability ratings depend on subjective evaluations, it is possible that the content of these

rating varies across individuals, and that it may show cross-linguistics differences. However, imageability ratings are reported to have high level of internal consistency and test-retest reliability (xxx), which points out that they reflect a well-defined and reasonably stable dimension. Also the fact that relations between imageability and word processing or acquisition are consistently found across various languages, including English, German, French, Spanish, or Chinese (see references above), suggests that the measure reflects a real aspect of word meaning. This is further supported by studies that show relations between imageability and objective properties of words related to their semantics (Kambanaros, Grohmann, & Michaelides, 2013; Maouene, Laakso, & Smith, 2010; Maouene, Sethuraman, Laakso, & Maouene, 2011). At the same time, there is currently no widely accepted theory-based definition of imageability. The current knowledge allows us to assume that it is a measurable property of words related to their semantics, but its exact cognitive underpinnings are not known. New findings on the role of imageability may initiate the development of semantic theories that will address this issue directly. Meanwhile, imageability may be viewed as a useful empirically motivated construct.

The effects of imageability on content words are only indirectly relevant for the present study. The main issue is the relation between grammatical morphemes and word imageability. This has been suggested by the theoretical reasoning along the lines of Bloom et al. (1980, 1982) and others, who examined the effects of semantic generality on grammatical acquisition, and by some recent empirical studies of the effects of imageability (e. g. Dye, Walenski, Prado, Mostofsky, & Ullman, 2013; Prado & Ullman, 2009).

Prado and Ullman (2009) reported that English-speaking adults produce past tense forms of irregular verbs faster if the verbs are highly imageable; also acceptability judgments of the inflected forms were better in highly imageable words. The effect was limited to irregular verbs, presumably because their inflected forms are not constructed during processing but

retrieved from memory. Further research, however, found a similar effect for regular verbs as well (Cohen-Shikora, Balota, Kapuria, & Yap, 2013). These studies show that semantic properties of word stems may affect the processing of inflected forms in these words. If this is so, it is also possible that the inflected forms are acquired earlier in words with high imageability. If inflected forms are processed faster and more easily in some words, children may have more cognitive resources left while processing these inflected forms, which may in turn facilitate the acquisition of forms.

This hypothesis was addressed by Smolík (2014), who examined the emergence of plural forms of nouns in English-speaking children from the Manchester corpus (Theakston, Lieven, Pine, & Rowland, 2001). The study examined the predictors of whether and at which age the children first used the plural form of nouns. The predictors under consideration included the age of first usage of the uninflected form, frequency of the plural form, and word imageability. Plural forms were acquired faster in highly imageable nouns even when the frequency of the plural form and the age of acquisition of the singular form were statistically controlled. This strongly suggested that imageability facilitates the acquisition of inflections. However, the study was limited in a number of ways. First, it was limited to nouns and noun plurals. It is possible that highly imageable nouns are more likely to appear in plural for conceptual reasons. Such nouns are likely to be names of common objects, which may be used in plural more often than some less imageable words. Another limitation was that the ages of acquisition for the plural and singular forms were estimated from their first occurrence in a longitudinal corpus. This approach is biased as the forms that are used more frequently are likely to appear earlier compared to forms that were acquired at the same time but are less frequent. Finally, English morphology may not be the most typical example of inflection. It is possible that in languages with richer inflectional system, imageability plays a different role than in English. These considerations motivated the present study.

The goal was to examine the relations between imageability and the acquisition of inflectional morphemes using a different method and a different language than the existing research. If effects of imageability on acquisition of inflectional morphemes are confirmed under these conditions, it would provide important convergent evidence about the role of imageability in inflectional acquisition.

### Inflectional morphology in Czech

Czech is a West Slavic language with rich verb and noun morphology. Nouns are inflected for number (singular or plural) and seven cases. Nouns carry arbitrary gender that surfaces in agreement between the noun and adjectives or some determiners, such as demonstrative pronouns. The standard grammar distinguishes 14 main different inflectional classes, but some of these further split to different subtypes. The system is highly syncretic, the same inflectional ending typically encodes multiple case forms. At the same time, identical endings may play a different role in nouns of different inflectional classes. For example, the ending *-e* may reflect the nominative singular or plural of the feminine class *růže*, as well as the accusative singular of the masculine animate class *muž*, as in the form *muže*. Czech verb morphology is complex as well, the language inflects verb forms for person, number, tense and mood. There is also a complex and irregular system of aspect marking. There are 14 main conjugation paradigms in 5 classes defined by different forms in the third person singular and other forms.

Previous research on effects on imageability on grammatical forms used exclusively English. Czech is different in important respects. First, as the morphology is substantially richer. For instance, a noun typically has two forms in English, in singular or plural (*castle* vs. *castles*); in Czech, the number of distinct noun forms depends on the declination class but it is usually between 6 and 10 (e. g. for the noun *hrad* “castle”, there are additional forms *hradu/ě*, *hrade*, *hradem*, *hrady*, *hradů*, *hradům*, *hradech*). For verbs, English typically has two distinct

forms in the present tense (*wait, waits*); most Czech verbs have distinct form for each number/person combination (for the verb *čekat* “wait”, the forms are *čekám, čekáš, čeká, čekáme, čekáte, čekají*), sometimes with homophonous 3rd person sg. and pl. forms. In addition to being more complex, the Czech system differs from English in that very few forms may be considered morphologically unmarked or zero-marked. Even word forms seen as basic or citation forms (nominative singular in nouns and infinitive or third person singular in verbs) are typically marked with inflectional morphemes. So, the ending *-a* marks nominative singular in one class of feminine nouns (*žen-a*); the verbs used in the present study have the endings *-á* (*čeká* „waits“) or *-í* (*brečí* „cries“) in 3rd person singular, or *-at* (*čekat*) and *-et* (*brečet*) in infinitive. Zero marked forms that are used include nominative singular forms of most masculine nouns, and of a small subset of feminine nouns. The present study used only a small subset of Czech nouns and verbs, limited to two morphological subtypes for each form class (see Table 1). Only one of the noun classes used here has the nominative singular form without morphological marking. The difference between Czech and English morphology means that the present study may show whether the effects of imageability observed in English generalize to a language with a different morphological system.

#### Parent report questionnaires and grammatical development

The present study used parent report as the source of information about children's usage of words and forms. Parent report methods have been widely adopted in language acquisition, especially when the MacArthur-Bates Communicative Development Inventories (CDI; Fenson et al., 1993, 2007) became widely available. Even though the largest section of the CDI is concerned with the development of vocabulary knowledge, the toddler versions of the tool (such as the original CDI: Words and Sentences) contain one or more sections examining grammatical development. The grammatical sections of CDI have been used to argue for specific hypotheses about the relation between vocabulary and grammar development



(Andonova, 2015; Caselli, Casadio, & Bates, 1999). Parent report measures of grammatical skills were used e. g. to examine the relations between grammatical development and social understanding (Markova & Smolik, 2014) or to assess the grammatical markers of language impairment (Hadley, 2006). It could be argued that parents may not be reliable sources of information on children's grammatical development. It may be relatively easy to remember if a child uses a particular word; but it is disputable if parents, especially non-linguists, remember particular word forms or grammatical morphemes children use. Also, the methods potentially confounds language of children with the memory performance of adults. Words or forms may be absent from parent reports because children do not use them, or because parents may fail to recall their use in children. Similar criticisms could be applied to all grammatical parent report measures, including the grammatical sections of CDI that are viewed as valid (see Fenson et al., 1993, 1994, 2007; Feldman et al., 2005; Marchman, Martinez-Sussmann, 2002). More importantly, using parental report can provide convergent evidence to the previously reported findings that used different methods, such as corpus analysis. For example, the first usage of a word form in a longitudinal corpus depends on its frequency, frequent forms are much more likely to be sampled early. It is thus desirable to validate the corpus findings using different methods. Because children spend most of their time with parents, parents are likely to witness the usage of less frequent forms that are unlikely to appear in corpora. Parent report measures may thus overcome some limitations of corpus-based studies. However, it is important to keep in mind the potential shortcomings of parent reports.

The present study

The goal of the present study was to extend and cross-examine the previous findings on the relation between imageability and inflectional acquisition using a different data collection method, and a language with substantially richer morphology than English. A list of nouns

and verbs was compiled and parents of young children were asked whether children used specific inflected forms of these words. For nouns, the inflected form of interest was the nominative plural form. For verbs, two forms were examined, the past participle and the second person present form. The analyses examined whether imageability increased the likelihood that the inflected form is used. Such a relation needs to be controlled for the effects of imageability on the acquisition of words in general.

Highly imageable words are acquired earlier than words with lower imageability. Showing a relation between the emergence of inflected forms and imageability would thus likely reflect the imageability effects on words, rather than on inflected forms. These effects can be controlled by assessing for each inflected form whether the child uses its uninflected counterpart. However, there are really no uninflected words in Czech. Most words carry some morphological marking, and it is thus a question what should serve as the analogue of the uninflected form in English (as used e. g. in Smolík, 2014). We decided to use the nominative singular form for nouns and the third person singular for verbs. Nominative singular is the standard citation form of nouns that is used in dictionaries and lists, and adults generally consider it the basic form of a noun. Also, some noun classes, e. g. masculine nouns, carry no overt inflectional affix in nominative singular, and may thus be viewed as uninflected. For verbs, the citation form is usually the infinitive. However, the infinitives are not always present in children's language. We decided to use the third person singular because it is likely the most frequent form in the language of children (Smolík, 2002) and the one of the most frequent form in adults (Jelínek, Bečka, Těšitelová, 1961), and it is also the form that represents the inflectional paradigm of the given morphological class.

The key research questions in the present study thus were:

1. Is there a positive relation between children's production of inflected forms of words and their imageability, even after accounting for its effects on the acquisition of

lexical units? Given the previous findings, the working hypothesis is that this would be the case.

2. Is there a difference between verbs and nouns in the effects of imageability? The most direct precursor of the present study (Smolik, 2014) only examined nouns. In contrast, the existing studies on imageability and inflectional processing (e. g. Cohen-Shikora et al., 2013; Prado, Ullman, 2009) only studied the effects of imageability in verbs. The present study aimed to examine both classes of words together, using a common analysis. Given the semantic differences between nouns and verb, it is possible that the relation between imageability and inflectional acquisition will differ between the word classes, and the present study tested this possibility.

## Method

### Materials

The study used parent report as the source of data on children's morphological acquisition. Two stages of preparation were necessary, first creating the list of words of interest and collecting imageability norms, and subsequently creating the parent report questionnaire.

*Word selection.* The initial step was selecting the type of words that would be used. The selection of words was limited to two morphological classes for nouns and two morphological types of verbs defined by the differences of stem vowel in the infinitive, past participle and third person present singular. This was done to limit the possibility of confounding the age of inflection acquisition with the morphological class: it is possible that some classes are more difficult than others. A summary of the forms examined in this study and citation forms of words in these inflectional classes is provided in Table 1. We also limited the length of nouns to 4 to 7 phonemes in nominative singular, and the length of verbs to 5 to 8 phonemes in the

infinitive. Based on these formal criteria, an initial list of 290 words was created. The words were selected so that they could be expected to appear in the vocabulary of young children but their expected age of acquisition were different. As a rough guide for this first selection, three sources of data were used: the pilot data for the Czech adaptation of MacArthur-Bates CDI, the Weslalex database of word frequencies in children's books (Garabík et al., 2007; Kessler, Caravolas, 2011), and translation equivalents of some words in the imageability norms for English (Stadthagen-Gonzales & Davis, 2006). For the initial list of 290 words, the age-of-acquisition estimates by Czech adults were collected. Overall, 166 adults completed online questionnaires asking for their estimate of the age when they learned each word. Age-of-acquisition ratings from adults are a problematic method, even though they are commonly used as a variable in psycholinguistic research (xxx citation). However, their use in the present study had only a minor role. This step served to get a rough estimate of the relative acquisition age of the words, so that the final word list contained words with variable expected age of acquisition. The final list that was used contained 98 words. There were 63 nouns and 35 verbs in the list, reflecting the larger proportion of nouns in children's early vocabularies.

*Imageability norms.* Imageability ratings were collected for the final list of 98 words. The list was presented to a group of 64 students (35 males) of three secondary schools in Prague, Czech Republic, aged 18-20, who were asked to mark for each word how easily and fast the word elicited a sensory image of its referent. The instruction was translated and adopted from Paivio et al. (1968). The responses were recorded on a 7-point scale. The instruction and stimulus words were printed in a short booklet that was completed by each participant. In addition to the printed instruction, the examiner read the instruction before the participants started responding. To exclude the possible effects of presentation order on

imageability ratings, the forms were created in 10 block-randomized versions. The final imageability estimate for each word was its mean imageability rating across all respondents.

*Parent report questionnaires.* The questionnaires included 98 words of interest. In order to keep the questionnaire length in reasonable limits, the list of words was split in two parts, each used to create one version of the questionnaire. The descriptive statistics of spoken frequencies and imageability for the words and forms included in the final lists is reported in Table 2, for each sublist separately as well as merged together.

Each parent responded to 49 words of interest. The lists were block-randomized so that words from any of the four classes/types did not accumulate in a particular position during the rating session. The questionnaires were presented and distributed electronically via internet. The introductory page contained information about the study and the informed consent statement. The following page asked background information about the child and the family. Following that, the questionnaire proper was presented. For each noun, parents saw two forms, nominative singular and nominative plural; for verbs, the questionnaire contained three forms, the third person singular present, the second person singular present, and the past participle. The two or three forms of each word were presented next to each other under a common heading, which was the nominative singular form in nouns and the infinitive in verbs. Parents were asked to mark each form they heard from their child.

*Frequency data.* Inflected forms that are more frequent in input language are likely to be acquired earlier. At the same time, imageability is correlated with frequency. To control confounding between these two variables, an estimate of input frequency was used as a control predictor in the analyses. Because Czech has no corpora of child-directed speech available, we used the frequency data from a corpus of adult spoken Czech, ORAL 2008 (Czech National Corpus - ORAL2008). This corpus contains approximately one million words.

## Participants

Participants were recruited using social networks, emails and announcements in various online media. Readers were asked to refer mothers of children in the appropriate age to the webpages of the study and the online questionnaires. This way, a total of 361 (version A: 174; version B: 187) responses was obtained. From this total number of responses, 44 were excluded (version A: 19; version B: 25) because the questionnaire was not completed by the child's mother, the information on the child's age was contradictory or incomplete, or the child did not meet the age criteria. The final sample of 317 responses included 155 responses to version A of the questionnaire, and 162 responses to version B. Summary information on participating children and families, separately for each form of the questionnaire, is reported in Table 3. Only children whose mothers were native speakers of Czech and used it in communication with the child were included in the analyses xxx?

## Analysis

The analyses examined the relation between imageability of a word and the presence of inflected forms of this word in children's productions, as reported by parents. Doing this, it must be taken into account that the presence of inflected forms is influenced by many other factors, including the mastery of the whole lexical unit and the child's age. The analyses thus included a number of control predictors in order to avoid confounding imageability with other factors related to the acquisition of words and inflections.

The analyses used binomial mixed models, a form of regression analysis with dichotomous dependent variable and with random terms accounting for the variability between persons and words. The dependent variable was the presence of the inflected form of interest. The key predictor of interest was imageability. All three forms, plurals, past participles and second person singular forms were analyzed within a single analysis, with one

categorical predictor specifying the form. The presence of the unmarked form of the word, i. e. nominative singular in nouns or third person singular present in verbs, was included as a categorical control predictor. Children's age and the log-frequency of the inflected form in the corpus of spoken Czech (Czech National Corpus - ORAL2008) were included as continuous control predictors. Interactions between the inflected form type (plural vs. past vs. second person) and all remaining predictors (presence of the uninflected form, age, imageability, and log-frequency of the inflected form) were included as well to examine whether the effects of different predictors differ depending on the type of the inflected form. Also included was the interaction between imageability and word frequency because some existing work suggested that the effects of imageability may be different for words with different frequency (Smolík, under review; Snedeker, Zeitlin, Crawford, 2013). The models included random effects for persons and items.

## Results

Table 4 provides descriptive statistics about the use of unmarked and inflected forms in children of different age. It collapses responses from all children in the given age band and all words of the given category and shows the number of words for which the unmarked and marked forms were acquired or not. It also shows the contingency between acquiring the unmarked form and the marked forms: it is clear that only very few words appeared first in the inflected forms, while most words initially appeared in the unmarked form, and only later in an inflected form.

The main analysis of imageability effects is summarized in Table 5. Because plural was coded as the baseline category, the main effects correspond to the effects of predictors in plurals. All predictors had significant main effects. The presence of the unmarked form increased the odds of observing the inflected form by the factor of 11.2. Increases in imageability, inflected form frequency, and the child's age also increased the likelihood of

observing the inflected form. The increase in imageability by one unit increased the odds of reporting the inflected form by 1.65.

There were significant negative interactions between forms, both past and second person, and the occurrence of the uninflected form. This means that the presence of the unmarked form is a weaker predictor of the inflected form use in verbs, compared to nouns. The use of inflected forms without using the unmarked form was more frequent in verbs compared to nouns. However, even in verbs, there is a clear contingency, as shown e. g. in Table 4. Another significant interaction was found between the past tense verb form and spoken frequency. This was negative, suggesting that input frequency is a somewhat weaker predictor of past participle forms than plural or second person singular present forms. Finally, there was a positive interaction between second person verb form and imageability. This suggests that imageability was a stronger predictor of the second person form use than of past participle and plural use.

The effects of imageability for each form category are illustrated in Figure 1. The graphs show the estimated effect of imageability when other predictors are held equal on their average values, and demonstrate the interaction between frequency and imageability, as well as the differences between the effects of imageability and frequency in different forms.

Some previous reports of imageability effects in language processing suggested that the effects may differ between genders (e. g. Dye et al., 2013). We tested this in models that included gender as an additional predictor but found no such effects.

## Discussion

The present study adds to the growing body of evidence suggesting that imageability of words affects the acquisition and processing of inflections in these words, even though the inflections have no transparent semantic relation to imageability. It has been established



previously that English past tense forms are retrieved by adults faster and more reliably in highly imageable verbs, even though it is not clear whether this is true for all verbs (Cohen-Shikora et al., 2013) or for irregular verbs only (Prado & Ullman, 2009); the effect has been partially replicated with children (Dye et al., 2013). The present paper indicates that the effects of imageability are not limited to morphological processing but also to the acquisition of morphology. At least one previous report found facilitative effects of imageability on the acquisition of plural forms in nouns (Smolík, 2014). However, it might be argued that in highly imageable nouns, plurals are more easily available because it is easier to conceptualize multiple instances of highly imageable objects. Highly imageable words are more likely to refer to objects that are countable, and such objects may also be more likely to appear in multiple instances in everyday life (we are more likely to talk about multiple *apples* compared to *competitions*). The findings on nouns may thus be viewed as inconclusive, but the present study indicates that the effect of imageability can be observed in verbs as well as nouns, and that it extends to a highly inflected language such as Czech. The present study thus provides converging evidence that imageability of words affects the acquisition of inflectional morphology in these words, at least the initial stages of acquisition. Such an effect has some implications for our understanding of how inflectional morphology is acquired in children.

The notion that semantics of words may affect the acquisition of morphology is not new. However, the previous suggestions typically included morphemes that modulate semantics of words in ways that are somehow related to their core meaning. For example, the semantic bias in acquiring English verb morphology means that children acquire the progressive marker *-ing* earlier in verbs with durative semantic aspect, while past tense appears earlier with completive verbs (Shirai, 2010). The semantic effects described in the present study are different in that the semantics of content words affects the acquisition of inflected forms regardless of the meaning modulation carried by the inflections. In this respect, the effects

observed here are somewhat similar to the the idea that semantic generality of verbs facilitates the acquisition of grammatical words with these verbs (Bloom et al., 1980, 1982). Like the current findings, this approach also suggested that a semantic variable associated with content words, namely semantic generality, affects how early some grammatical morphemes appear with these words. However, the effects of semantic generality were not confirmed after frequency was taken into account (Rowland et al., 2003). The present results provide an interesting perspective on the old suggestion. Semantic generality is likely to be negatively correlated with imageability: highly imageable words tend to be rather specific in meaning (McDonough et al., 2011; Spreen & Schulz, 1966). It is thus possible that the actual effect of semantics is in fact the opposite of what Bloom et al. (1980) suggested. According to the present results, semantically specific, not general words have advantage at combining with grammatical morphemes. The present analyses also suggest that the previous conflicting findings, as well as the contrasts between the present and previous findings, might be in part due to the complex relations between the effects of imageability and frequency. Forms with high frequency were not affected by high imageability in the current study, or perhaps even affected in a negative manner. Perhaps previous analyses (Bloom et al., 1980, 1982) were restricted to frequent words which, according to the current results, might have negative relation with imageability. The null results reported by Rowland et al. (2003) could result from sampling words with somewhat lower frequency. Of course, these previous analyses examined free grammatical morphemes and semantic properties of verbs only, so they are not directly comparable to the present results. The current analyses pose the question of what it is about imageability that facilitates the emergence and acquisition of inflected forms, and whether it is related to the general effect of imageability in acquiring words.

Imageability or concreteness have long been viewed as factors in the acquisition of lexical units (Gilhooly & Logie, 1980, Morrison, Chappel, & Ellis, 1997). Highly imageable

words tend to be acquired earlier than words with lower imageability, even after accounting for differences in frequency and other variables. This is not surprising, as highly imageable words are likely to label concepts with more straightforward conceptual representations, and also words whose referents are easier to identify (Gillette, Gleitman, Gleitman, & Lederer, 1999). However, it is not clear why imageability should affect the acquisition of inflected forms, above and beyond the effect it has on the acquisition of stems or unmarked forms. Some suggestions come from research that showed relations between imageability and the processing of inflected forms in adults. The most important suggestion was formulated by Prado and Ullman (2009), who linked it to the discussion between single-mechanism and dual-mechanism models of morphology.

The distinction between these two types of representation reflects two views of how inflected forms are represented in the language system. In the single mechanism models, all forms are represented in a system of distributed associative memory (e. g. McClelland & Patterson, 2002). The alternative, dual-mechanism models, suggest that some inflected forms are retrieved from memory, while others are constructed on the fly based on morphological rules. Some dual mechanism models propose that only irregular inflected forms are stored in memory, while regular forms are rule-based (Taft, 1979). Other such models suggest a more complex view, with regular forms sometimes being represented in memory, especially when highly frequent (e. g. Baayen, Dijkstra, & Schreuder, 1997). Prado and Ullman (2009) suggested that imageability only plays role in the associative memory route, showing that imageability only affects the processing of irregular inflections. Cohen-Shikora et al. (2013) found effects of imageability even in regularly inflected verbs, which may indicate that at least some regular words also use the associative memory representation of inflections, or that imageability affects other aspects of word processing than just memory retrieval. The current results also suggest that regular inflections in children are related to imageability. The

question is to what extent the effects of imageability in processing, such as those documented by Prado and Ullman (2009) or Cohen-Shikora et al. (2013), are responsible for the effects in acquisition observed here and in Smolík (2014). It is a parsimonious working hypothesis that the effects in processing and acquisition are related, and it is not difficult to see how the mechanisms proposed for processing effects might affect acquisition.

The first possible mechanism is the effect on memory. Prado and Ullman (2009) argued that past tense forms of irregular verbs must be retrieved from memory, and memory retrieval is facilitated by increased imageability of the verbs. Such mechanism should also affect acquisition: easier retrieval of the inflected forms for highly imageable words should lead to the earlier use of such forms in children. At the same time, the effect of imageability could also affect memory encoding, thus facilitating the process by which children acquire their knowledge of the inflected form. Such effect on encoding would be consistent with the positive effects of imageability in paired associate learning that were discovered in early imageability research (e. g. Paivio, Yuille, & Smythe, 1966). One limitation is that the proposal by Prado and Ullman (2009) suggests that imageability should only affect inflected forms that are stored in memory as wholes, i. e. the irregular forms. This is at odds with the fact that the words in the present study were inflected regularly, even though the system in Czech is substantially more complex than regular past tense inflections in English. On the other hand, other evidence suggests that the processing of inflected forms is related to imageability in regular verbs as well, both in adults and in children (Cohen-Shikora, 2013; Dye et al., 2013). From the theoretical point of view, the effects of imageability in regular words might lend support to single-mechanism models of morphology, but they are also consistent with those dual-mechanism models that envisage use of stored representations at least in some regular words.

An alternative explanation is that the processing of highly imageable words is less demanding than that of less imageable ones. The process of lexical selection may be faster and more robust in highly imageable words, which would leave more cognitive resources available for performing the morphological operation, i. e. adding the inflectional morpheme or finding the corresponding irregular form. However, the efficiency of access to the stem cannot be the only source of imageability effects. High imageability of a word facilitates access to its inflected forms even when the uninflected word was presented immediately before (Prado & Ullman, 2009; Cohen-Shikora, 2013). Such recent activation of a lexical unit should be sufficient to activate it for subsequent use in generating the inflected form, and imageability should thus play no additional role. But because imageability does have an effect, it must affect more than the retrieval of the base lexical unit. One possibility is that the representation of highly imageable words in working memory is more robust or efficient. To provide the inflected form given the uninflected form, the language processing system must retrieve the inflection and combine it with the stem, or retrieve the inflected form as a whole. In both cases, the uninflected form must stay activated in some sort of working memory, either to be combined with the inflectional morpheme, or to be compared with the retrieved inflected form to ensure it is the inflected form of the right word. It is possible that the storage in the working memory and access to this temporary representation is aided by high imageability (cf. Nishiyama, 2013). At the same time, such facilitation of processing by imageability is likely to be even more pronounced in children, whose working memory is more limited than that of adults.

The effects of imageability on inflected forms might thus be due to two kinds of mechanisms: facilitation of long-term memory access, or facilitation morphological processing, perhaps via effects on working memory. In fact, the memory-based and processing-based explanations are not mutually exclusive. It is possible that the access to

inflected forms in highly imageable words is facilitated because they are processed faster and more efficiently, and at the same time, that high imageability facilitates their retrieval from memory. The ultimate explanation of imageability effects will require adopting a detailed model of lexical access. In particular, this model should specify how inflected forms are accessed, and whether accessing the inflected form always requires new access to the stem or uninflected form.

It is important to keep in mind that the effects of imageability may change in development. Even if it were the case that imageability only affects irregular words in adults, as suggested by Prado and Ullman (2009), it could be that the effects are different in children. There is evidence that children initially process morphologically complex forms as unanalyzed wholes (Cazden, 1968; MacWhinney, 1976), and it is thus likely that the first occurrences of inflected forms are based on stored representations. To the extent that imageability affects retrieval or processing of forms stored in associative memory, it should play a stronger and more prominent role in children compared to adults, and the available evidence suggests that this is the case (cf. Dye et al., 2013). This could also explain the fact that effects of imageability in the present study were observed for regularly inflected words.

An interesting aspect of the current findings is the interaction between imageability and frequency indicating that high-frequency inflected forms are affected by imageability to a lesser extent than low frequency forms, or even in the opposite manner. According to some dual-mechanism models, high-frequency forms are more likely to be stored as wholes (Baayen, Dijkstra, & Schreuder, 1997; Lehtonen, Niska, Wand, Niemi, & Laine, 2006). If imageability affects retrieval of full forms stored in memory, the effects of imageability should thus be stronger in high-frequency forms, not weaker. This aspect of the present results thus indicates that the effects of imageability in acquisition are at least partially different from its effects in processing. The present findings suggest that high-frequency forms are acquired

regardless of imageability, while lower-frequency forms must be supported by semantics to appear in children's productions. One way to interpret this is that all inflected forms in children are stored, but only learning of low-frequency ones benefits from the effects of imageability, while the high-frequency forms receive sufficient input due to their frequent occurrence, and imageability does not bring additional benefits.

The study of imageability effects in language acquisition is confronted with a potential paradox because the ratings of imageability are collected from adults. Consequently, the question arises whether adult estimates of imageability are relevant for the language system of children. There are at least two reasons to assume that they are. First, the sole fact that imageability rated by adults predicts various aspect of children's language knowledge or performance indicates that the measure reflects some properties of child language. Second, it is a parsimonious assumption that children's semantic system is fundamentally similar to that of adults. If imageability affects language processing in adults and children, and also language acquisition in children, these effects should be viewed as sharing common mechanisms, unless there is evidence to the contrary. However, while the notion of imageability in children and adults likely rests on a similar representational system, the actual values of imageability may differ depending on age in which they are collected, and imageability can have distinct impact at different ages. After all, children are generally less likely to have words with low imageability in their vocabularies. To our knowledge, no existing imageability estimates attempted to use children's ratings. This will be an important step in establishing how exactly imageability affects children's language system.

### Conclusions

The present findings indicate that imageability plays a role in the acquisition of inflectional morphemes. This supports the view that semantic properties of words may affect how grammatical phenomena involving these words are acquired. Word semantics is thus a

factor that should be taken into account when studying morphological acquisition. It is likely that the effects of imageability in acquisition are related to the effects of imageability in the processing of inflected words in adults and children. This opens the possibility of using the effects of imageability to study the nature of children's inflectional morphology and lexical processing.

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Table 1

Overview of forms examined in the study

NOUNS			VERBS		
Nom. sg.	<i>žena woman</i>	<i>hrad castle</i>	Inf.	<i>čekat wait</i>	<i>brečet cry</i>
Nom., Acc., Voc. pl.	<i>ženy</i>	<i>hrady</i>	2 sg. pres.	<i>čekáš</i>	<i>brečíš</i>
			3 sg. pres.	<i>čeká</i>	<i>brečí</i>
			PP sg. m./f./n.	<i>čekal/a/o</i>	<i>brečel/a/o</i>
			PP pl. m., f./n.	<i>čekali(y)/a</i>	<i>brečeli(y)/a</i>

Table 2

## Word characteristics in the final selection

	Log frequency	Imageability
<b>Nouns (N=63)</b>		
All forms	2.884 (1.304)	6.164 (0.769)
Nom sg.	1.802 (1.275)	
Nom pl.	1.448 (1.263)	
<b>Verbs (N=35)</b>		
All forms	3.172 (1.492)	4.776 (0.906)
3 sg. pres.	1.778 (1.5)	
2 sg. pres.	0.414 (0.726)	
Past participle	2.183 (1.394)	
<b>All words (N=98)</b>	2.987 (1.374)	5.668 (1.055)



Table 3

Participant characteristics for each inventory and the total sample.

	<b>Total</b>	<b>Inventory A</b>	<b>Inventory B</b>
N (N of girls)	317 (140)	155 (64)	162 (76)
N without older siblings	186	85	101
Mean (SD) age in months	28.52 (6.42)	28.61 (6.71)	28.44 (6.15)
Mean (SD) age of 1st word	10.41 (3.04)	10.62 (3.07)	10.21 (3.01)
Mean (SD) hours in day care	3.881 (8.11)	4.26 (8.43)	3.519 (7.8)

Note: Each parent received one of the two forms of the questionnaire, each containing half of the words.

Table 4

Relations between the presence of the marked form and the unmarked form for different age bands (total numbers of words reported)

Age	Unmarked form	Marked form					
		Plural		Past		Second person	
		Absent	Present	Absent	Present	Absent	Present
18-23	Absent	1956	13	1387	23	1381	29
	Present	373	107	215	75	227	63
24-29	Absent	1846	40	1317	126	1395	48
	Present	1015	354	454	354	534	274
30-35	Absent	1067	33	800	99	838	61
	Present	910	749	310	706	392	624
36-42	Absent	297	12	259	58	283	34
	Present	433	622	132	497	201	428

Table 5

Parameter estimates and odds ratios for the final model

Term	Estimate	OR	p
Intercept	-5.147	0.006	< 0.001
Uninflected form present	2.42	11.245	< 0.001
Age (months)	0.259	1.295	< 0.001
Imageability	0.503	1.653	0.02
Log frequency (spoken)	0.881	2.414	< 0.001
Form:past participle	2.717	15.134	< 0.001
Form:2nd person sg.	2.043	7.711	< 0.001
Uninflected form present $\times$ past	-0.579	0.561	0.001
Uninflected form present $\times$ 2sg	-0.492	0.611	0.01
Age (month) $\times$ past	0.015	1.015	0.19
Age (month) $\times$ 2sg	0.017	1.017	0.14
Imageability $\times$ past	1.336	3.805	< 0.001
Imageability $\times$ 2sg	0.437	1.548	0.16
Log frequency $\times$ past	-0.830	0.436	< 0.001
Log frequency $\times$ 2sg	-0.708	0.493	< 0.001
Imageability $\times$ log frequency	-0.342	0.711	< 0.001

Figure 1

Model predictions of the likelihood of observing the inflected form

