Noun imageability facilitates the acquisition of plurals: survival analysis of plural emergence in children

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Abstract

Some research in child language suggests that semantically general verbs appear in grammatical structures earlier than semantically complex, specific ones. The present study examines whether this was the case in nouns, using imageability as a proxy measure of semantic generality. Longitudinal corpus data from 12 children from the Manchester corpus in CHILDES were used to obtain information on the first occurrence of plurals. A total of 3560 uninflected nouns were identified in the corpora, of which 1202 were observed in the plural. Survival analyses indicated that the chance of observing a plural form increases with the imageability rating of the noun, even after accounting for the age of acquisition of the uninflected noun, maternal input frequency, and word length. Noun imageability thus facilitates the acquisition of plural forms. This finding contradicts the observations from verbs, and indicates that the acquisition of grammar is facilitated by high imageability rather than semantic generality.

Introduction

One of the basic questions in language acquisition research concerns the factors that determine the timing and the order of acquisition of grammatical morphemes, such as inflectional endings (plural *-s*, past tense *-ed*), copulas and auxiliary verbs, or prepositions. Brown's (1973) influential analysis of the acquisition of 14 grammatical morphemes revealed that children acquire grammatical morphemes in a relatively constant order. However, no consensus has been reached concerning the causal factors responsible for this acquisition order. Most accounts that have been proposed focus on the properties of the grammatical morphemes themselves: their frequency, meanings they encode, or their grammatical function. The present study takes a different approach, testing whether the timing of morpheme acquisition is affected by the semantic properties of the words with which the morphemes combine. Although the study of semantic effects in morphological acquisition has a long tradition, the present study is, to the author's knowledge, the first to demonstrate an effect of a specific semantic dimension, imageability, on the emergence of plural forms in nouns.

The present study is inspired by the observation that the acquisition of a morpheme is not a sudden change affecting all words in a category at once, but rather a piecemeal process of using the morpheme with more and more content words. For example, the acquisition of the English plural morpheme *-s* does not occur for all regularly inflected nouns at once; some nouns will be used in plural earlier, some later. Whether a particular content word is used with a grammatical morpheme may thus depend on the properties of this content word, not just on the properties of the morpheme. Using this perspective, the present paper provides a novel insight in the relationship between semantic properties of nouns and the acquisition of the English plural morpheme with these nouns.

The assumption that semantics plays a role in morphological acquisition is not new. An influential view was proposed by R. Brown (1973), who argued that grammatical morphemes are acquired according to their semantic and syntactic complexity. These terms refer to the number of semantic or syntactic features that are encoded by a given grammatical morpheme. Brown found a considerable overlap between his estimates of semantic and syntactic complexity and the observed acquisition order of 14 grammatical morphemes (see also Villiers & Villiers, 1973). The reason to suggest semantic and syntactic factors in morphological acquisition was that the acquisition order of grammatical morphemes cannot be fully explained by their frequency in the language children hear. Frequency effects probably exist, but they cannot explain some important observations, such as why articles in English are acquired relatively late (R. Brown, 1973; Goodman, Dale, & Li, 2008).

Intuitively, the notions of semantic and syntactic complexity are appealing because they suggest that the language elements with more elaborate structure are more difficult to acquire, i.e. that structural complexity comes at a cost. However, R. Brown (1973) pointed out that syntactic and semantic complexity make very similar predictions with regard to the acquisition order, it is thus very difficult to distinguish their effects (Villiers & Villiers, 1973, made a similar point). Another problem is the definition of complexity, both in the syntactic and in the semantic domain. This depends on the theory used for evaluating the complexity metric, and there is no universally accepted theory in either domain. Finally, the complexity of grammatical morphemes may explain the relative acquisition timing of grammatical morphemes, but it cannot explain the gradual onset of these morphemes.

Grammatical morpheme acquisition and the properties of content words

There is a rich tradition of discussing the acquisition of various grammatical categories and morphemes in relationships with the properties of words that are used with these

morphemes, especially their semantic properties. An example of this phenomenon is the semantic bias in children's use of verb morphology. English-learning children use the progressive marker *-ing* mostly with verbs with durative aspect, such as walk, ride, or write, while the past tense (regular or irregular) is typically used with verbs that have the completive aspect, such as find or break (Bloom, Lifter & Hafitz, 1980). The association between verb semantics and the acquisition of tense and aspect morphology has been demonstrated in other languages as well, such as in Chinese and Greek (Li & Bowerman, 1998; Stephany, 1981; see Shirai, 2010 for a review).

The semantic bias in verbs essentially means that the semantics of time in verbs affects the use of tense with these verbs. Thus, the phenomenon connects two notions that are closely related to one aspect of meaning, namely the time properties of events. In other domains, semantics and the acquisition of grammar appear to be connected through complexity or difficulty, rather than through meaningful content relations. So, in the domain of spatial language, it has been argued that children acquire semantically less complex prepositions and inflections before those with more complex meanings (Slobin, 1973; Gentner & Bowerman, 2009). For example, prepositions *in* or *on* that encode the relationship of two things are acquired before prepositions such as *below* or *beside* which additionally require representing some orientation of the spatial coordinate system (Parisi & Antinucci, 1970). The notion of semantic complexity or generality is especially prevalent in the research on the acquisition of verbs and their grammar.

Clark (1978) was among the first to propose that children initially rely on semantically general, light verbs. These are verbs such as *get*, *go*, or *be* that have general meanings and can be used in a broad range of contexts. A similar notion has been advanced by Ninio (1999), who identified a group of *pathbreaking* verbs that are among the first to be used in newly

acquired syntactic constructions. Ninio identified these verbs in early English and Hebrew and noted that they tend to be semantically general according to Clark's criteria. Also, Pinker (1984) proposed that the first verbs used in word combinations are semantically general (see also Rice & Bode, 1993). Further evidence for this semantically driven view of acquisition was provided by Bloom, Merkin, and Wootten (1982). They argued that the acquisition of wh-words in children depends on the semantic complexity of the wh-words, and on the semantic properties of verbs with which the wh-words combine. Combinations of wh-words with semantically general verbs, such as the copula (*who is*), should thus appear earlier than combinations with semantically more complex verbs (such as *who walks*). Bloom et al. (1982) found evidence that this is indeed the case, and similar findings were reported for sentences containing connectives (Bloom, Lahey, Hood, Lifter, & Fiess, 1980).

The evidence about the role of semantic generality and its opposite, semantic specificity, is mixed. A number of proposals suggest that generality of the verb meaning affects the acquisition of grammatical structures. The usual interpretation of verb generality is that general verbs have a small number of semantic features, and the assumption is that semantically general verbs are also semantically less complex. In contrast, semantically specific verbs have more detailed meaning specifications, which results in increased information-processing cost, i.e. higher cognitive complexity. However, there are some suggestions to the contrary. Rowland, Pine, Lieven, and Theakston (2003) and Theakston, Lieven, Pine, and Rowland (2004) found no effect of semantic generality on the acquisition of grammatical structures, over and above the effect of input frequency, suggesting that the first verbs to occur in grammatical structures are simply the most frequent ones. Also, there is good evidence that semantic specificity, rather than generality, facilitates the acquisition of lexical items, especially nouns. Children's first words tend to be specific, concrete (Morrison,

Chappell, & Ellis, 1997; McFalls, Schwanenflugel, & Stahl, 1996; Cameirão & Vicente, 2010). Early use of specific verbs, including some syntactic consequences of this fact, was also reported by P. Brown (2008). She observed that early verbs in children acquiring Tzeltal, a Mayan language, are semantically rather specific (e.g. verb with the meaning *eating something tortilla-like*), and that children omit objects of these verbs more often than objects of more general verbs. The role of semantic generality and semantic specificity in language acquisition is thus an open issue. Proposals dealing with verbs suggest that general verbs are early to occur in grammatical structures, but lexical acquisition is faster in more specific words. The effect of generality on grammatical acquisition may thus be limited, perhaps to verbs or to verbs in some particular languages. On the other hand, it is possible that the acquisition of lexical items is facilitated by semantic specificity, but the acquisition of their use in grammatical structures is subject to the opposite effect. In that case, semantically general nouns and other categories should occur with grammatical morphemes earlier than specific ones, just like it is the case with verbs. The present study addressed this question.

One problem with the notion of semantic generality vs. specificity is that there is no widely accepted way of classifying words as general or specific. Some studies used a rather crude measure for semantic generality, making only a two-level distinction between a small class semantically general, light verbs, such as *go* and *get*, and all the remaining verbs, which were viewed as semantically specific (Rowland et al., 2003; Theakston et al., 2004). This measure may not be sensitive enough for a statistically reliable identification of the effects of semantic generality in acquisition. Recently, Maouene, Laakso, and Smith (2011) proposed a more fine-grained approach to the ratings of verb specificity, noting that some verbs may appear with many different objects (*get, have*), while others appear with only a few typical ones, such as *read* or *sing*. The number and diversity of objects associated with a verb can

thus provide a continuous and relatively fine-grained metrics of semantic generality or specificity, but this approach cannot be used with words from other categories. Interestingly, Maouene et al. (2011) also showed that the number of associated objects is correlated with a metrics that is available for words from diverse categories, namely imageability. Imageability has been used in a number of other psycholinguistic studies (e.g. Toglia & Battig, 1978; Groot, 1989; Strain, Patterson, & Seidenberg, 1995), and recent research suggests that it is related to the acquisition and processing of grammatical categories (Prado & Ullman, 2009; Ma, Golinkoff, Hirsh-Pasek, McDonough, & Tardif, 2009). It is thus a promising candidate for evaluating specificity.

Imageability in language processing and acquisition

Imageability is the property of a word that describes how easy it is for that word to elicit mental images of its referent. Highly imageable words are words that, for most people, easily elicit a mental image of sensory experiences (Paivio, Yuille, & Madigan, 1968), such as *banana*. On the other hand, words with low imageability (e.g. *would*) do not elicit mental images. Highly imageable words are recognized more easily in lexical decision tasks (Kroll & Merves, 1986), named faster (Groot, 1989; Strain et al., 1995), and acquired earlier (Morrison et al., 1997) and more reliably (Masterson, Druks, & Gallienne, 2008) than words with lower imageability. Imageability is highly correlated with concreteness, and it follows from the definition that the most imageable words are semantically specific rather than general or abstract. Hence imageability might serve as a proxy measure of semantic specificity. It is reasonable to expect that imageability could affect the appearance of words in combinations with grammatical morphemes. If imageability affects lexical processing, it may also affect the processing of stems while grammatical combinations are being formed.

Prado and Ullman (2009) recently found a link between imageability and inflected

forms. They found that accessibility and acceptability of irregular English past tense forms are correlated with imageability, so that the past forms of highly imageable verbs are easier to process and more acceptable than those of less imageable verbs. Presumably, the past forms of irregular verbs are stored in memory as undivided units, and the more imageable words are easier to retrieve from memory. For this reason, the effect was not present in regular verbs whose past forms are created online using morphological rules. In any case, the result indicates that imageability can affect the use of inflected forms, even though it is not a property of the inflection but of the content word which is being inflected. Prado and Ullman (2009) demonstrated the importance of word imageability for morphological processing in adults, it is a question whether similar effects can be observed in children. The present study provides the first examination of this type of semantic effect in acquisition.

Current research provides an additional reason to focus on the role of imageability in acquisition, namely its role in some crosslinguistic differences in acquiring different grammatical classes. Ma et al. (2009) found that imageability predicts the age of acquisition for Chinese verbs, and argued that imageability is responsible for the differences between early English and Chinese. Chinese verbs tend to be more imageable than verbs in English, and Chinese children have an advantage when acquiring the verb vocabulary. This observation is true even for verbs matched on length and maternal frequency. The difference between the proportion of verbs in early English and Chinese vocabularies, according to Ma et al. (2009), does not stem from grammatical differences between the languages but from the differences in verb semantics.

To summarize, recent findings on imageability suggest that it may affect not only the processing and acquisition of lexical units, but also their grammatical behavior. It is also correlated with the dimension of semantic generality and specificity, which has long been

implicated in the acquisition of grammatical structures. Together, these facts suggest that imageability might serve as a proxy measure of semantic generality or specificity. Therefore, it could be used to address the issue of the effects of semantic generality in acquisition. Some existing research suggests that semantically general verbs are first to appear in grammatical structures, perhaps because specific verbs are cognitively more complex (Clark, 1978; Ninio, 1989; Bloom et al., 1980, 1982). On the other hand, there is evidence that semantically specific words are acquired earlier than others (e. g. Morisson et al., 1997, Maouene et al., 2011; Ma et al., 2009), and it is possible that these effects generalize to the acquisition of grammatical structures containing these words. The current theories and research thus contain conflicting predictions, a situation that warrants further empirical research. The present study addresses this issue using imageability as a metrics of semantic specificity, and testing the hypothesis that imageability affects the timing of emergence of stem-morpheme combinations.

The study extends the existing work in two respects. Firstly, it examines nouns rather than verbs. Secondly, the focus is not on free grammatical morphemes or syntactic structures, but on inflectional morphology, namely on plurals. One reason to focus on nouns is that they have less complex properties than verbs. Verbs are complex in multiple respects: they have complex meanings (cf. Gillette, Gleitman, Gleitman, & Lederer, 1999), they carry the argument structure of sentences, and they tend to appear in morphologically or syntactically complex forms and structures. These complexities may mask the potential effect of semantic variables. Another reason to focus on nouns is to test whether the effects of semantic specificity or generality are limited to verbs or whether they extend to other categories.

The second main difference between the present study and previous research is the focus on plurals, i.e. bound inflectional morphemes. Bound morphemes appear in children’s

language only as parts of words, in combination with stems. It is thus reasonable to expect that various properties of stems will influence the readiness with which these stems combine with bound morphemes. While there are a number of studies that implicated semantic properties of verbs and nouns in the acquisition and use of inflectional morphology (e.g. Li & Bowerman, 1998; Ramscar, 2002), semantic generality or imageability have not been studied in this context. The present study thus extends the study of this aspect of word semantics towards bound morphology.

Method

The study examines the onset of use of noun plurals in the Manchester corpus (Theakston, Lieven, Pine, & Rowland, 2001) available via CHILDES (MacWhinney, 2000). The study uses the methods of event history analysis, also known as survival analysis, to examine the effects of various properties of words on the acquisition of plurals with these words. The Manchester corpus was chosen because it provides a rich set of data sampled with relatively high frequency over a long period. The sample of the corpus consists of 12 children, and each of these children was recorded over a period of about one year. All children experienced pronounced growth of language skills during the period (see Table 1). The corpus thus covers a period of rapid grammatical development. This is also apparent from the number of studies that used the corpus to test or examine claims about grammatical development (e.g. Theakston et al., 2001; Rowland et al., 2003; Serratrice, Joseph, & Conti-Ramsden, 2003, to mention just a few).

The present study uses the first occurrence of an inflected form as evidence of its acquisition. The first occurrence is not the only possible criterion; one can argue that it does not provide sufficient evidence that the form has been acquired. It is possible that a child uses an inflected form while imitating an adult, or that a form is transcribed by mistake, either due

to intelligibility limitations or typographic errors. Different studies have used different criteria to avoid random errors in determining the acquisition age. For instance, R. Brown (1973) only considered as acquired the morphemes that were used correctly in 90% of obligatory contexts. This approach is good for controlling children's omissions of grammatical morphemes but it requires that enough obligatory contexts are present. Using Brown's criterion for evaluating the acquisition of a morphological form of a particular word would mean that only the most frequent words would have sufficient number of observations. It would also be difficult to assess the obligatory contexts reliably.

The possibility that a form is coded as acquired due to random imitations or transcription errors may also be reduced by requiring more than one occurrence of a form as evidence for its acquisition. Bloom et al. (1982) used the third use criterion; the age of acquisition in their study was the age at which the third use of a morpheme was attested. The same approach was used by Rowland et al. (2003), who also performed a comparison of the criteria of first and third use. They discovered that the results using the two criteria were very similar. For this reason, the first use criterion is used in the present study as the main measure of acquisition. However, it should be pointed out that the measure may better be viewed as a measure of emergence, rather than full acquisition of the plural morpheme with a particular noun. But this is in line with the goal of the present study because the first emergence of the morpheme is an important step in the acquisition process.

Participants and transcripts

The analyses uses the Manchester corpus of child language which contains longitudinal transcripts of 12 typically developing children acquiring British English as their native language. The procedure for selection of the children and further details about the data collection procedure have been reported by Theakston et al. (2001).

The data set for each child consists of 34 pairs of files collected at approximately equal intervals of ca. 10 days. The two transcripts in each pair were collected on the same day during free play but they differ in the toys used during the play session (a standardized set of toys vs. the child's own toys). Transcripts were transcribed using the CHAT conventions used in CHILDES (MacWhinney, 2000). The analyses were based on morphological codings on the %mor: tier of the transcripts. According to the online documentation of the CHILDES database, these codings were generated automatically using the MOR utility of CLAN (MacWhinney, n.d.). The transcripts used in the present analysis were retrieved from the database in January 2010.

Data preparation

The data used in the present analyses were obtained by processing the transcripts using custom routines written in Perl, and subsequent processing of the data in R. The first step was the identification of all word types in each transcript, and of all forms in which each type occurred. For each transcript, the frequencies for all word forms were obtained. This database was then used to identify the first occurrence of each noun form, separately for each child. The age of acquisition for a form, then, was the age at the time of the corresponding recording. The age was calculated in days.

In order to obtain estimates of the input frequency for individual words and forms, maternal language data from the transcripts were used. However, using the same transcripts for determining the age of acquisition and estimating the maternal frequency could artificially inflate the observed relationship between these variables. In order to avoid this, one transcript was used to provide data either about the child or the mother, but not both. The input frequency estimates were obtained from samples taken at different times during the observation period, using every fifth recording beginning with recording number 5. Hence, six

recordings were used to obtain data on maternal frequency, and 28 recordings data on child frequency and age of acquisition.

The sample of nouns that were a part of the analysis was different for each child. All nouns produced by a child at least once in the uninflected form became a part of the sample. The numbers of nouns included in the analysis are summarized in Table 1, along with the Mean Length of Utterance (MLU) data on individual children and the number of observed plural forms.

The imageability ratings used in the analysis were obtained from the online version of the MRC psycholinguistic database (Wilson, 1988). The database contains mean ratings of imageability elicited from adults on a large set of words. The database combines ratings from three sources, expanded version of Paivio's norms (Paivio et al., 1968), and the norms by Toglia and Battig (1978) and Gilhooly and Logie (1980). The norming studies generally asked adult participants to rate how easy it is to form a mental sensory image of the word's referent, and mark their rating on a scale from 1 (hard to imagine) to 7 (easy to imagine). The imageability ratings in the database are scaled with minimum possible value of 100 and maximum of 700. Only nouns with available imageability ratings were included in the analyses.

Analyses

The appearance of a particular morphological form is a developmental event. The statistical method designed for the analysis of event data is the survival analysis, also known as event-history analysis. This method is used to estimate the baseline hazard function, which describes probability of the event at a particular time. The hazard function is used to construct the survivor function that shows the proportion of observed units for which the event has occurred at a given time. Cox regression can be used to examine the influence of various

variables on the survival function. This analysis estimates the average increase or decrease of event likelihood that is associated with unit change in the predictor variable.

In this study, Cox regression was used to examine if the likelihood of the first occurrence of the plural form is affected by the imageability of the word in question. However, such an analysis would be misleading. Words that are acquired early are also likely to appear early in inflected forms. Because imageability is correlated with age of acquisition, any effect of imageability on the acquisition of inflected forms can be due to the effect of imageability on the acquisition of the words, whether in an inflected or in an uninflected form. To control for this possibility, the age of the first occurrence of the uninflected forms was included in the Cox regression as a predictor along with imageability. The third predictor in the analyses was maternal frequency: the frequency of the inflected form in maternal speech is very likely to influence its acquisition, and it also reflects the extent to which there is an opportunity to use the inflected form in mother-child interactions. Including maternal frequency as a predictor should account for a substantial part of the variability in the acquisition timing, which in turn can increase the sensitivity to the possible effects of imageability. All analyses thus included three predictors: the age of the first occurrence of the uninflected form, the logarithm of maternal frequency, and the imageability rating for the given word.

An assumption in standard Cox regression is that the observations are independent. This is not the case with the present analysis because observations coming from one child are dependent, and the data thus contains 12 distinct clusters of dependent observations. In order to correct for this dependence, all statistical tests relied on robust standard errors (Therneau & Lumley, 2009; Therneau & Grambsch, 2000).

Survival analysis is well suited for the study of word acquisition, but it has been used

relatively rarely in acquisition research (Tamis-LeMonda, Bornstein, Kahana-Kalman, Baumwell, & Cyphers, 1998; Tamis-LeMonda, Bornstein, & Baumwell, 2001). Regression-type techniques have been used for similar purposes in some influential studies, with quantitative predictors as independent variables and the age of acquisition as the dependent variable. For instance, Rowland et al. (2003) examined the relationships between various measures of semantic complexity and the acquisition of wh-words and their combinations with verbs. Unlike survival analysis, this approach cannot use information from words that are not acquired during the observed period. On the other hand, it may be easier to interpret for readers familiar with linear regression methods. It also excludes the possibility that findings made using survival analysis are due to some special properties of units for which the event was not observed, i.e. nouns with no plural observed. For these reasons, the current analysis also included a mixed-model analysis with the age of acquisition for the inflected forms modeled as a function of the three predictors discussed above. All analyses included persons as the grouping factor, the statistical tests were based on MCMC simulations (Baayen, Davidson, & Bates, 2008).

Results

Descriptive data.

The preliminary data processing identified 1833 different nouns produced by at least one child. Of these nouns, 472 were observed in plural form at least once. The imageability ratings were available for 530 nouns, of which 332 were observed in plural form. The set of 530 nouns was the primary sample for the analysis. Each word could be used by multiple children in the sample. The total number of observational units is thus higher than the number of different nouns in the data set. The numbers of nouns observed in each child in an

uninflected form is summarized in Table 1, along with the number of these nouns for which plural forms were observed. The table only includes nouns for which the imageability ratings were available in the MRC database.

The mean imageability value for the 530 nouns in the final sample was 542.31 (SD = 77.27, median = 568, min = 284, max = 667). Nouns for which plurals were observed had mean imageability rating of 561.56 (SD = 70.47, median = 584, min = 284, max = 655). Most of the imageability ratings are in the upper range, since the maximum possible value was 700. This is expected as children are likely to use rather specific nouns that are usually highly imageable. Yet the distribution of the imageability values is not uniform and there are clear differences between less and more imageable nouns, as the range and standard deviation of scores suggest. The use of the variable as a quantitative predictor is thus meaningful.

Cox regression.

Cox regression revealed a significant effect of all three predictors on the timing of the first plural use: the age of acquisition of the uninflected form, logarithm of maternal frequency, and imageability were significantly related to the dependent variable. However, the diagnostic evaluation of the regression model suggested that the proportional hazard assumption of Cox regression has been violated, which could result in invalid inferences. Thus, it was necessary modify the analysis. The violations typically result from non-uniform effects of the predictors which may be different at different times. It might be possible to account for this fact by including an interaction between the predictors and time into the model. However, such an analysis would be difficult to interpret, as there were three predictors already. Instead, the observations were split in groups according to the age of acquisition for the uninflected noun, and analyzed separately in each time band. The bands were determined by narrowing down the time ranges so that the analyses no longer violated

the proportional hazard assumption.

The results are summarized in Table 2. The odds ratio reported corresponds to the change in probability of the inflected form occurrence associated with unit change of the predictor. For instance, an odds ratio of 2.73 for log-frequency means that for a pair of words that differ in frequency by one log-unit, the more frequent word will be 2.73 times more likely to occur in an inflected form at any given time. For ease of interpretation, the imageability scores were divided by 100, so that the odds ratio corresponds to the 100-point change of imageability according to the MRC norms. The odds ratios for the age of occurrence of the uninflected forms correspond to months.

The analyses of individual time bands showed significant effects of all three predictors for nouns whose uninflected forms occurred before 1000 days of age (ca. 32 months). As expected, when the age of occurrence for the uninflected form was higher, the odds of the inflected form emergence decreased. The odds also increased with higher maternal frequency of the plural form. Importantly, the odds increased with increasing imageability of the relevant word. Noun imageability thus affects the acquisition of plurals so that plurals of highly imageable nouns appear earlier than plurals of less imageable nouns. This is the case even for nouns that are acquired at the same time, and whose plurals are equally frequent in the input language. Figure 1 shows the estimated survivor function for plurals, with separate curves for words with high and low imageability.

Mixed-model analysis was performed to cross-examine the event history models. A mixed model analyzed 1202 observations with participants as a random factor, and revealed a significant effect of all three fixed predictors (age of uninflected form acquisition: $t = 8.19, p_{MCMC} < 0.001$; log input frequency: $t = 9.93, p_{MCMC} < 0.001$; imageability: $t = 4.03, p_{MCMC} < 0.001$). Higher imageability was associated with earlier age of acquisition, ca.

19 days for a 100-point difference in imageability. These results clearly support the findings from the event history analyses, and confirm that high imageability of noun stems contributes to the early acquisition of plural morphology. The effect is thus not due to low imageability of the nouns for which no plurals were observed.

Controlling for formal properties.

Reilly and Kean (2007) examined the formal properties of words differing in imageability and found that highly imageable words tend to be shorter than their less imageable counterparts and show other formal differences, e. g. in their phonological neighborhood density or prosodic properties. It might be argued that the above results are due to the relationship between imageability and word length: children may acquire inflections more easily for shorter words, and these happen to be those with high imageability. In order to test this interpretation, the models used in the original analyses were fit again with word length in phonemes (according to the MRC database) as an additional predictor. The results are summarized in Table 3. The effect of word length was significant in some analyses, but imageability remained a significant predictor even if there was some effect of word length. The estimated odds ratios did not substantially change. The effect of imageability on acquisition is thus not due to a spurious relationship mediated by word length.

Excluding low-imageability extremes and semantic anomalies.

Some of the words with low imageability might raise suspicion that the observed effects are due to a small number of words with low imageability which have no plural form, such as the mass nouns, or whose plural is semantically special and not generally used. In part, this objection was addressed by using the linear mixed model analysis that only included words with observed plural forms. However, it is still possible that the sample contains a few words

with low imageability that do have plural forms that are nevertheless rare and acquired late. This small group of words could be responsible for the observed effect. In order to address this possibility, the analysis was repeated with a subsample that excluded all words with imageability below 500 points, 145 words in total (see Appendix). This group corresponded to 27% of the word types examined, and constituted 13% of the observed units: the words with low imageability usually occurred only in some of the children examined.

Another fact that could cast doubts over the validity of the finings is that the sample contains a number of low-imageability words that are rarely used as nouns, e.g. *fall*. Plurals of these words may be semantically anomalous or might result from adult imitations; it is also possible that the automatic morphological tagging software used in CHILDES coded some of them incorrectly as nouns. To ensure that the anomalous words did not cause spurious effects, all words were examined manually and a group of suspicious words was excluded. The analysis was then repeated. The excluded words were ones that are typically used as adjectives and verbs (see Appendix). Also excluded were some nouns that are usually not used in singular (e.g. *pea*).

Results of the two additional analyses are summarized in Table 4. It is obvious that for most words, the significant results hold even after excluding low-imageability extremes or suspicious words, and that the exclusions sometimes even strengthen the estimated imageability effects. Surprisingly, the results from the last age band show no significant effect in the original analysis, but show an inhibitory effect of imageability when the low-imageability words were excluded. The effect of imageability on plural acquisition may thus differ according to the age of the stem acquisition. The positive effect of imageability on plural acquisition, however, is clearly present in the initial stages, and it is not due to any extreme observations.

Discussion

The effects of imageability on morphological acquisition documented in this paper indicate that semantic specificity plays a role in the acquisition of grammatical morphology. This idea is not new, but the present findings provide a new and surprising perspective. First of all, the timing of bound morpheme acquisition has not been previously linked to the notion of semantic generality or specificity. Secondly, the proposals that implicated semantic generality in acquisition suggested the acquisition of grammar is facilitated in semantically general words (Clark, 1978; Bloom et al., 1980, 1982). The present results suggest almost the opposite, namely, that grammatical acquisition is faster in semantically specific, highly imageable nouns, at least in the earliest stages of acquisition. Even though imageability is not commonly viewed as the opposite of semantic generality, it follows from the accepted definitions that the two semantic dimensions are negatively correlated (see also Maouene et al., 2011, for empirical evidence about such negative correlation). To the author's knowledge, it is the first finding showing a relationship between high imageability and the acquisition of grammatical morphology.

In principle, imageability could exert two types of effects to facilitate the acquisition of inflected forms. One possibility is that it saves processing resources in highly-imageable words. Adults recognize and name highly imageable words faster than words with lower imageability (Kroll & Merves, 1986; Groot, 1989; Strain et al., 1995), and highly imageable words also appear earlier in language acquisition (Morrison et al., 1997; Ma et al., 2009). These observations suggest that imageable words are easier to process for children as well as adults. Fewer processing resources are needed for activating the stems of highly imageable words, and the free resources can be used to access the derived morphological form. According to this view, the use of an inflected form incurs processing cost that may prevent

children from using it. The processing cost may be due to the cost of assembling the morphological form, if online decomposition is assumed (cf. Pinker, 1984), or it could result from the syntactic and semantic requirements of the form: using an inflected form typically means that other parts of a sentence, such as articles or subjects, have to be in the right places, and that more information must be integrated to use the inflection correctly.

Alternatively, the effect may be due to the effects of imageability on memory retrieval. Prado and Ullman (2009) recently showed that adults retrieve the irregular past tense forms of verbs more easily if the verbs are highly imageable. This suggests that high imageability improves retrieval not only for uninflected stems but also for the inflected forms. Unlike in Prado's and Ullman's study, the present findings are not limited to irregular forms; in fact, most of the forms examined in the present study were regular. But children may initially access all inflected forms the way adult access irregulars, i.e. by retrieval from memory and not by morphological composition. Children's overregularizations provide independent evidence for this view. Children initially use correct irregular forms but later start regularizing them (e.g. Marcus et al., 1992), which indicates that they initially recall inflected forms from memory, and only later start applying morphological rules. The developmental process is visible in irregular forms because the correct form is different from that provided by morphological rules. However, there is no reason why children should initially rely on memory only in irregular words.

It is also possible that the effects are semantic in nature. The more imageable nouns may be ones for which the concept of plurality and multiple instances is easier to encode and retrieve. Note, however, that the analyses controlled for the inflected form input frequency, so that the effects are not due to higher frequency of plural use in highly imageable nouns in the input. The two proposed mechanisms of imageability effects are not mutually exclusive. It is

quite possible that high imageability facilitates online processing of words, and at the same time aids their retrieval from long-term memory. Discovering the contribution of each mechanism will require further research with more detailed developmental data and experimental evidence.

The proposed mechanisms share the assumption that imageable words are in some way easier to deal with, either during processing or in memory retrieval. This may also link the current findings with the proposals suggesting that semantic generality, especially in verbs, aids the acquisition of grammatical structures (Clark, 1978; Bloom et al., 1982; Ninio, 1999). These accounts considered semantically general words as less complex and easier to process, presumably because their use requires specifying less semantic information. However, there is not much independent evidence supporting this view. The reason why the early verbs in English are semantically general is that the most frequent and productive English verbs are general (Rowland et al., 2003; Theakston et al., 2004). This does not seem to be the case in all languages, as the results from Chinese and Tzeltal suggest (Ma et al., 2009; P. Brown, 2008). The present results do not support the notion that semantically general words provide a pathway to grammar, showing that this is not the case for nouns. However, they do support the idea that grammatical morphology first appears with words that are in some way easy to process.

One question raised by the present findings is whether these effects should be attributed specifically to imageability or whether other similar or related notions are the actual factor behind the effects. In particular, concreteness is correlated with imageability, and it might be questioned which of these two related but distinct dimensions is the true factor influencing the results. The present study cannot answer this question. During the analyses, concreteness and imageability were tested separately and both were significantly related to the acquisition of

inflections. Imageability was chosen as the target variable because it the literature suggested its effects on acquisition (esp. Prado & Ullman, 2009), and because it seems likely that children are affected by imageability rather than by concreteness, as this depends on the hierarchical relationships within the conceptual system, which may not be developed enough at this early age. The true locus of imageability effects remains an open research topic.

It is important to note that previous work on semantic generality is concerned exclusively with verbs. It might be objected that the present findings on nouns are thus irrelevant. However, it seems unlikely that semantic factors have opposite effects in nouns and verbs. The present findings provide a hint suggesting that the effects of imageability may differ in words that are acquired at different times. One of the present analyses (see Table 4) suggested that imageability facilitates plural acquisition in nouns that are acquired early, but it may have the opposite effect in nouns that are acquired somewhat later, around the age of three. It is thus possible that imageability facilitates grammatical acquisition in words that are relatively easy to acquire, but for the more advanced vocabulary, it is semantic generality that helps in grammatical acquisition. Since verbs are generally acquired later than nouns in English and are considered more difficult, the previously observed effects of semantic generality may be similar to the negative imageability effect on plurals of late-acquired nouns.

Overall, the present findings provide evidence against a uniform role of semantic generality. While it is well established that the first verbs in English-speaking children's grammatical constructions are semantically general, the priority of this type of verbs does not appear to generalize across languages, and the present findings show that it does not generalize across word classes. This paper demonstrates that acquisition of inflections is facilitated in highly imageable nouns, at least during the initial stages of plural acquisition. This complements some recent findings that showed imageability to affect grammatical

processing and lexical acquisition (especially Prado & Ullman, 2009; Ma et al., 2009), and also argues against the broadly accepted idea that semantic generality facilitates acquisition. However, contrary to some claims (e.g. Rowland et al., 2003), it also shows that semantic variables are relevant for the acquisition of grammatical elements, even after accounting for input frequency.

References

Baayen, R. H., Davidson, D., & Bates, D. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language, 59,* 390–412.

Bloom, L., Lahey, M., Hood, L., Lifter, K., & Fiess, K. (1980). Complex sentences: Acquisition of syntactic connectives and the semantic relations they encode. *Journal of Child Language*, *7*, 235–261.

Bloom, L., Lifter, K. & Hafitz, J. (1980). Semantics of verbs and the development of verb inflection in child language. *Language,* 56, 386–412.

Bloom, L., Merkin, S., & Wootten, J. (1982). Wh-questions: Linguistic factors that contribute to the sequence of acquisition. *Child Development, 53,* 1084–1092.

Brown, P. (2008). Verb specificity and argument realization in tzeltal child language. In M. Bowerman & P. Brown (Eds.), *Crosslinguistic perspectives on argument structure: Implications for learnability* (pp. 167–189). Mahwah, NJ: Erlbaum.

Brown, R. (1973). *A first language: The early stages*. Cambridge, Mass.: Harvard University Press.

Cameirão, M. L., & Vicente, S. G. (2010). Age-of-acquisition norms for a set of 1,749 portuguese words. *Behavior Research Methods, 42,* 474–480.

Clark, E. V. (1978). Discovering what words can do. In D. Farkas, W. M. Jacobsen, & K. W. Todrys (Eds.), *Papers from the parasession on the lexicon* (pp. 34–57). Chicago, IL: Chicago Linguistic Society.

Gentner, D., & Bowerman, M. (2009). Why some spatial semantic categories are harder to learn than others: The typological prevalence hypothesis. In J. Guo, E. Lieven, N. Budwig, S. Ervin-Tripp, K. Nakamura, & S. Ozcaliskannm (Eds.), *Crosslinguistic approaches to the psychology of language: Research in the tradition of Dan Isaac*

Slobin (pp. 465–480). New York: Psychology Press.

Gilhooly, K., & Logie, R. (1980). Age of acquisition, imagery, concreteness, familiarity and ambiguity measures for 1944 words. *Behavior Research Methods and Instrumentation, 12*, 395–427.

Gillette, J., Gleitman, H., Gleitman, L., & Lederer, A. (1999). Human simulations of vocabulary learning. *Cognition, 73*, 135–176.

Goodman, J. C., Dale, P. S., & Li, P. (2008). Does frequency count? parental input and the acquisition of vocabulary. *Journal of Child Language, 35*, 515–531.

Groot, A. M. de. (1989). Representational aspects of word imageability and word frequency as assessed through word association. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15*, 824–845.

Kroll, J. F., & Merves, J. S. (1986). Lexical access for concrete and abstract words. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 12*, 92–107.

Li, P., & Bowerman, M. (1998). The acquisition of lexical and grammatical aspect in chinese. *First Language, 18*, 311–350.

Ma, W., Golinkoff, R. M., Hirsh-Pasek, K., McDonough, C., & Tardif, T. (2009). Imageability predicts the age of acquisition of verbs in chinese children. *Journal of Child Language, 36*, 405–423.

MacWhinney, B. (2008). *Enriching CHILDES for morphosyntactic analysis*. In H. Behrens (Ed.). Corpora in language acquisition research: history, methods, perspectives. New York: Benjamins.

MacWhinney, B. (2000). *The CHILDES project: Tools for analyzing talk.* Mahwah, NJ: Lawrence Erlbaum.

Maouene, J., Laakso, A., & Smith, L. B. (2011). Object associations of early-learned light

and heavy English verbs. *First Language, 31*, 109–132.

Marcus, G. F., Pinker, S., Ullman, M., Hollander, M., Rosen, T. J., & Xu, F. (1992). Overregularization in language acquisition. *Monogrraphs of the Society for Research in Child Development, 57*, 1–182.

Masterson, J., Druks, J., & Gallienne, D. (2008). Object and action picture naming in three- and five-year-old children. *Journal of Child Language*, *35*, 373–402.

McFalls, E. L., Schwanenflugel, P. J., & Stahl, S. A. (1996). Influence of word meaning on the acquisition of a reading vocabulary in second-grade children. *Reading and Writing, 8*, 235-250.

Morrison, C. M., Chappell, T. D., & Ellis, A. W. (1997). Age of acquisition norms for a large set of object names and their relation to adult estimates and other variables. *The Quarterly Journal of Experimental Psychology (Section A): Human Experimental Psychology, 50*, 528–559.

Ninio, A. (1999). Pathbreaking verbs in syntactic development and the question of prototypical transitivity. *Journal Of Child Language*, *26*, 619–653.

Paivio, A., Yuille, J. C., & Madigan, S. A. (1968). Concreteness, imagery, and meaningfulness values for 925 nouns. *Journal of Experimental Psychology, 76(1, Pt. 2)*, 1–25.

Parisi, D., & Antinucci, F. (1970). Lexical competence. In G. B. F. d'Arcais & W. J. M. Levelt (Eds.), *Advances in psycholinguistics* (pp. 197–210). Amsterdam: North Holland.

Pinker, S. (1984). *Language learnability and language development*. Cambridge, Mass.: Harvard University Press.

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 Cognition, 35,* 849–866.

Ramscar, M. (2002, Aug). The role of meaning in inflection: why the past tense does not require a rule. *Cognitive Psychology, 45*(1), 45–94.

Reilly, J., & Kean, J. (2007). Formal distinctiveness of high- and low-imageability nouns: Analyses and theoretical implications. *Cognitive Science, 31,* 157–168.

Rice, M. L., & Bode, J. V. (1993). GAPS in the verb lexicons of children with specific language impairment. *First Language, 13,* 113–131.

Rowland, C. F., Pine, J. M., Lieven, E. V. M., & Theakston, A. L. (2003). Determinants of acquisition order in wh-questions: Re-evaluating the role of caregiver speech. *Journal of Child Language, 30,* 609–635.

Serratrice, L., Joseph, K. L., & Conti-Ramsden, G. (2003). The acquisition of past tense in preschool children with specific language impairment and unaffected controls: Regular and irregular forms. *Linguistics, 41,* 321–349.

Shirai, Y. (2010). Semantic bias and morphological regularity in the acquisition of tense-aspect morphology: what is the relation? *Linguistics, 48,* 171–194.

Slobin, D. I. (1973). Cognitive prerequisites for the development of grammar. In C. A. Ferguson & D. I. Slobin (Eds.), *Studies of child language development* (pp. 175–208). New York: Holt, Rinehart & Winston.

Stephany, U. (1981). Verbal grammar in modern Greek early child language. In P. S. Dale & D. Ingram (Eds.), *Child language: An international perspective* (pp. 45–57). Baltimore, MD: University Park Press.

Strain, E., Patterson, K., & Seidenberg, M. S. (1995). Semantic effects in single-word naming. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,*

1140–1154.

Tamis-LeMonda, C. S., Bornstein, M. H., & Baumwell, L. (2001). Maternal responsiveness and children's achievement of language milestones. *Child Development, 72*, 748–767.

Tamis-LeMonda, C. S., Bornstein, M. H., Kahana-Kalman, R., Baumwell, L., & Cyphers, L. (1998). Predicting variation in the timing of language milestones in the second year: an events history approach. *Journal of Child Language, 25*, 675–700.

Theakston, A. L., Lieven, E. V. M., Pine, J. M., & Rowland, C. F. (2001). The role of performance limitations in the acquisition of verb-argument structure: an alternative account. *Journal of Child Language, 28*, 127–152.

Theakston, A. L., Lieven, E. V. M., Pine, J. M., & Rowland, C. F. (2004). Semantic generality, input frequency and the acquisition of syntax. *Journal of Child Language, 31*, 61–99.

Therneau, T. M., & Grambsch, P. M. (2000). *Modeling survival data: Extending the cox model*. New York: Springer.

Therneau, T. M., & Lumley, T. (2009). survival: Survival analysis, including penalised likelihood. [Computer software manual]. (Available from: http://CRAN.R-project.org/package=survival)

Toglia, M., & Battig, W. (1978). *Handbook of semantic word norms*. New York: Erlbaum.

Villiers, J. G. de, & Villiers, P. A. de. (1973). A cross-sectional study of the acquisition of grammatical morphemes in child speech. *Journal of Psycholinguistic Research, 2*, 267–278.

Wilson, M. (1988). The MRC psycholinguistic database: Machine readable dictionary, version 2. *Behavioural Research Methods, Instruments and Computers, 20*, 6–11.

Appendix

A. List of top 21 words in imageability in the analyzed sample (imageability > 632): apple, banana, beach, bed, beetle, car, dog, father, fire, girl, gorilla, ice, kitten, milk, pickle, pig, puppy, skin, squirrel, sun, telephone.

B. List of words with imageability < 500 (excluded in the first reanalysis from Table 4): age, answer, back, balance, bang, belt, bit, block, blow, bottom, brave, break, build, bump, buy, care, clean, cool, count, course, cover, crawl, creature, crumb, crush, cry, cut, cymbal, damage, die, dip, down, dream, drop, end, escape, fault, feel, find, finish, front, germ, give, guess, help, hide, hold, hurt, idea, inch, job, keep, last, lead, lie, life, lift, line, load, look, lorry, manner, march, mark, match, matter, mean, measure, mind, minute, miss, move, name, need, number, open, pass, pat, pattern, peck, peel, peep, piece, place, play, present, pull, push, race, reach, repair, rescue, rest, ride, roll, rush, shape, shoot, shout, show, side, slide, slip, smell, snap, sound, squeak, squirt, stand, stay, step, still, stop, story, stroke, surprise, sweet, take, talk, taste, thing, throw, till, time, tip, top, touch, tow, track, trick, trouble, try, tumble, turn, vacuum, wait, way, wear, week, whack, win, wish, work, wrong, year.

C. List of the semantically or categorically suspicious words excluded in second reanalysis from Table 4: blue, boat, care, cook, down, drink, end, fall, find, fire, fly, give, green, jump, keep, kiss, light, look, love, move, need, open, paint, post, rain, slide, stay, step, stick, stop, sweet, take, top, turn, walk, wear, whistle, white, work, yellow, drill, hurt, idea, pan, pea, pin, bubble, squeak, pump, try, puzzle, cover, matter, clock.

Table 1: Descriptive information about each child's data, including total number of nouns and nouns with plurals observed.

Name	Total uninflected	With plurals	Min. MLU	Max. MLU	Min. age (mo.)	Max. age
Anne	298	120	1.72	3.36	22	33
Aran	336	102	1.25	4.37	23	34
Becky	306	117	1.34	3.39	24	35
Carl	282	92	1.8	4.01	20	32
Domin	258	86	1.23	3.51	22	34
Gail	307	112	1.43	3.68	23	35
Joel	325	110	1.54	3.57	22	34
John	299	102	1.78	3.47	23	34
Liz	320	118	1.35	4.24	23	34
Nic	267	77	1.11	3.09	24	36
Ruth	244	48	1.12	3.37	23	35
Warr	318	118	1.71	4.41	22	33
Sum	3560	1202				

Table 2: Cox regression results for the analysis with the complete sample and three predictors. Age refers to the age of acquisition for the uninflected (singular) form (OR... odds ratio).

		Uninflected age		Log-frq		Imageability		
Age range (days)	N	OR	p	OR	p	OR	p	Proportionality
all (627 to 1105)	3560	0.90	<0.001	2.70	<0.001	1.52	<0.001	violated
627 to 690	304	0.79	<0.001	2.39	<0.001	1.81	<0.001	OK
691 to 800	1544	0.89	0.004	2.73	<0.001	1.52	<0.001	OK
801 to 1000	1412	0.93	0.005	2.68	<0.001	1.50	<0.001	OK
1001 to 1105	300	0.81	n.s.	2.54	<0.001	1.18	n.s.	OK

Table 3: Cox regression results with word length included in the models (OR... odds ratio).

Age range (days)	N	Age OR	Log-frq OR	Imag. OR	Length OR
627–690	303	**0.79	**2.36	**1.86	**0.87
691–800	1522	*0.88	**2.73	**1.53	1.01
801–1000	1378	*0.92	**2.71	**1.49	†1.07
1001–1105	287	†0.81	***2.54	1.18	n.s.

Note: ***p < 0.001, **p < 0.01, †p < 0.1.

Table 4 Cox regression results using samples without the low-imageability or questionable words (OR ... odds ratio).

Age range (days)	N	Uninflected age OR	p	Log-frequency OR	p	Imageability OR	p
Excluding words with imageability < 500							
627 to 690	261	0.76	<0.001	2.41	<0.001	1.48	0.016
691 to 800	1245	0.88	0.005	2.69	<0.001	1.53	<0.001
801 to 1000	1039	0.92	0.023	2.58	<0.001	1.46	0.043
1001 to 1105	203	0.74	0.027	2.58	<0.001	0.47	0.032
Excluding questionable and suspicious words							
627 to 690	259	0.80	<0.001	2.53	<0.001	1.83	0.012
691 to 800	1347	0.88	0.004	2.76	<0.001	1.65	<0.001
801 to 1000	1247	0.93	0.015	2.70	<0.001	1.55	<0.001
1001 to 1105	260	0.69	0.001	2.88	<0.001	1.21	n.s.

Figure Captions

Figure 1. Estimated proportion of nouns for which the inflection has not yet occurred in nouns with high and low imageability. Remaining predictors were set to the mean values. Uninflected form age of acquisition: 24 months, maternal frequency of plural: 1. Solid line: 90th percentile on imageability. Dotted line: 10th percentile on imageability.