

*Helping a crocodile to learn German plurals: children's online judgment of actual, potential and illegal plural forms*

**Katharina Korecky-Kröll, Gary Libben,  
Nicole Stempfer, Julia Wiesinger, Eva  
Reinisch, Johannes Bertl & Wolfgang  
U. Dressler**

**Morphology**

ISSN 1871-5621

Volume 22

Number 1

Morphology (2012) 22:35-65

DOI 10.1007/s11525-011-9191-8



**Your article is protected by copyright and all rights are held exclusively by Springer Science+Business Media B.V.. This e-offprint is for personal use only and shall not be self-archived in electronic repositories. If you wish to self-archive your work, please use the accepted author's version for posting to your own website or your institution's repository. You may further deposit the accepted author's version on a funder's repository at a funder's request, provided it is not made publicly available until 12 months after publication.**

## Helping a crocodile to learn German plurals: children's online judgment of actual, potential and illegal plural forms

Katharina Korecky-Kröll · Gary Libben · Nicole Stempfer ·  
Julia Wiesinger · Eva Reinisch · Johannes Bertl · Wolfgang U. Dressler

Received: 12 December 2010 / Accepted: 12 December 2010 / Published online: 24 February 2012  
© Springer Science+Business Media B.V. 2012

**Abstract** A substantial tradition of linguistic inquiry has framed the knowledge of native speakers in terms of their ability to determine the grammatical acceptability of language forms that they encounter for the first time. In the domain of morphology, the productivity framework of Dressler (CLASNET Working papers 7, 1997) has emphasized the importance of this ability in terms of the graded potentiality of non-existing multimorphemic forms. The goal of this study was to investigate what role the notion of potentiality plays in online lexical well-formedness judgment among children who are native speakers of Austrian German. A total of 114 children between the ages of six and ten and a total of 40 adults between the ages of 18 and 30 (as a comparison group) participated in an online well-formedness judgment task which focused on pluralized German nouns. Concrete, picturable, high frequency German nouns were presented in three pluralized forms: (a) actual existing plural form, (b) morphologically illegal plural form, (c) potential (but not existing) plural form. Participants were shown pictures of the nouns (as a set of three identical items) and simultaneously heard one of three pluralized forms for each noun. Response latency and judgment type served as dependent variables. Results indicate that both children and adults are sensitive to the distinction between illegal and potential forms (neither of which they would

K. Korecky-Kröll (✉) · J. Bertl · J. Wiesinger · W. U. Dressler  
Department of Linguistics and Communication Research, Austrian Academy of Sciences,  
Kegelgasse 27, 1030 Vienna, Austria  
e-mail: katharina.korecky-kroell@oeaw.ac.at

G. Libben  
Brock University, 500 Glenridge Ave., St. Catharines, Ontario L2S3AI, Canada

N. Stempfer · J. Wiesinger · W. U. Dressler  
Department of Linguistics, University of Vienna, Sensengasse 3a, 1090 Vienna, Austria

E. Reinisch  
Max Planck Institute for Psycholinguistics, Wundtlaan 1, 6525XD Nijmegen, The Netherlands

have encountered). For all participants, plural frequency (rather than frequency of the singular form) affected responses for both existing and non-existing words. Other factors increasing acceptability were the presence of supplementary umlaut in addition to suffixation and homophony with existing words or word forms.

**Keywords** German · Plural · Acquisition · Processing · Potentiality · Acceptability judgment.

## 1 Introduction

The majority of psycholinguistic research which has contrasted the processing of existing and non-existing word forms has focused on actual grammatically well-formed word forms on the one hand and on non-existing and ungrammatical word forms on the other (some recent examples of such contrasts include Cunnings and Clahsen 2008 and Berent and Pinker 2008).

Our focus in this study is a third domain—potential word forms that are not existing, but are also not in violation of morphological patterns of the language. It has long been appreciated that such potential forms can play a key role in advancing the understanding of language systems and language processing. Thus, potential words have played an important role in both the structuralist and generative traditions. Saussurean *langue* is a system of potentialities (particularly as developed in Coseriu 1975). More explicitly, Chomsky (1986) insisted on the contrast between grammatical (both actual and potential) and ungrammatical sentences and, analogically, on phonologically potential versus illegal words (e.g., non-existing English potential *blik* versus illegal *\*bnik*). In usage-based models (Bybee 2001; Tomasello 2003; Croft and Cruse 2005), however, potentiality of non-existing but conceivable linguistic items is more of a continuum of the probability of the extension of patterns of existing items.

The domain of morphology, in which possible morphological structures are typically fully interpretable, provides a particularly fruitful domain within which to investigate the role of potentiality. Here, Marchand (1960) distinguished the traditional stock of accepted word formations, called word-formedness (German *Wortgebildetheit*) and focussed any synchronic study on productive word formation (G. *Wortbildung*) which yields potential words. In this way, Marchand was a direct forerunner of Schultink (1961) and Aronoff (1976), who focus on potential words that can be generated by productive word-formation rules. A similar approach to inflection within the model of Natural Morphology can be found in Dressler (2003), with the difference that productivity and thus also potentiality is graded (see Sect. 2.2).

A graded concept of potentiality can also be found in Köpcke's (1988, 1993) schema model, where morphological patterns of German plurals (so-called schemas) are graded according to the extent to which they are typical plural forms. Thus different degrees of cue strength are assumed for German plural markers: *-(e)n* and

-s suffixes have the highest cue strength, pure umlaut a small to medium degree, and zero has the least.

Our investigation of morphological potentiality focused on German plural nouns. These forms provide a rich testing ground for the potentiality as a structural and processing construct because they have a variety of subpatterns which show variable degrees of suffix productivity and therefore whole word potentiality. The study report is based on a tripartite stimulus distinction among *actual*, *potential*, and *illegal* forms. *Actual* forms are the existing German plural nouns. *Illegal* forms are those that do not exist in the language and, moreover, contain patterns that are not attested in the language. Finally, the stimuli that are the core of our investigation, the *potential* forms, are those that do not exist in the language but contain a pattern that is attested in the language.

We investigated the manner in which German plural nouns are perceived by probing the performance of children in an on-line acceptability task in which actual existing plural word forms were contrasted to both potential and illegal non-existing ones. The study was also carried out with a comparison group of adult native speakers of German. By focusing on children, our goal was to tap into the heightened sensitivity to potentiality that might be evident in the course of acquisition. The acquisition domain has also been the one in which the dispute between rule-based and usage-based models has been most intense (cf. Tomasello 2003; Behrens 2009; Eisenbeiß 2009).

## 2 Background to the study: German noun plurals

German plurals (excluding Latinate ones) are formed by the suffixes *-e*, zero, *-er*, *-(e)n*, and *-s*, the first three occurring with and without umlaut:

Plural marker	Singular (example)	Plural (example)	Gloss
-e-plurals	der Bus	die Buss- <b>e</b>	the buses
-e+umlaut-plurals	der Ball	die Bäll- <b>e</b>	the balls
zero plurals	der Koffer ['kɔfɐ]	die Koffer ['kɔfɐ]	the suitcases
pure umlaut plurals	der Apfel	die Äpfel	the apples
-er-plurals	das Kind	die Kind- <b>er</b>	the children
-er+umlaut-plurals	das Rad	die Räd- <b>er</b>	the wheels
-(e)n-plurals	die Katze	die Katze- <b>n</b>	the cats
-s-plurals	das Auto	die Auto- <b>s</b>	the cars

The assignment of these plural markers is bound to gender, lexical, phonological and (sometimes also) semantic characteristics of the nouns (Köpcke 1993; Wurzel 1994; Wegener 1999). This complexity has made their acquisition and processing a focus of both empirical investigation and theoretical debate. Key aspects of these are discussed in the following section.

## 2.1 Previous studies

The acquisition and processing of German noun plurals has been a hotly debated issue during the last two decades. Supporters of dual route models (e.g., Clahsen et al. 1992; Clahsen et al. 1996; Clahsen 1999; Pinker 1998; Marcus et al. 1995; Bartke et al. 1995; Bartke 1998; Marcus 2000; Clahsen 2006) claim that there are two separate systems: a computational system which is responsible for generating regular forms according to rules, and a lexical system where irregular forms are stored.

On the other hand, connectionists, constructivists and supporters of usage-based or schema-oriented models favour single-route models of processing and acquiring inflectional morphology (e.g., Rumelhart and McClelland 1986; Dorffner 1991; Plunkett and Marchman 1991, 1993; Daugherty and Seidenberg 1994; Hahn and Nakisa 2000; Köpcke 1998; Bybee 2001; Tomasello 2003).

German plural morphology provides a good testing ground for these two models, because—in contrast to, e.g., the English past tense, where the ‘regular’ suffix *-ed* has also the highest frequency (as is also the case in the German and Dutch past tense)—regularity, frequency and similar properties do not converge in German plurals. Supporters of dual-route models claim that the *-s* plural is the only regular default plural (cf. Marcus et al. 1995; Bartke et al. 1995; Clahsen 1999; Marcus 2000), although weaker versions of the model admit that *-en* plurals of feminines ending in *schwa* are also regular (Sonnenstuhl-Henning 2003; Clahsen 2006; Ković et al. 2008).

A large number of longitudinal and transversal spontaneous and elicited studies on children’s acquisition of noun plurals (e.g. Behrens 2001; Bittner and Köpcke 2001; Klampfer and Korecky-Kröll 2002; Korecky-Kröll and Dressler 2009; Klampfer et al. 2001; Laaha et al. 2006; Schaner-Wolles 2001; Szagun 2001, 2004; Vollmann et al. 1997; Sedlak et al. 1998) demonstrate that children overgeneralize many (if not all) plural markers and that they do not show any preference of overgeneralizing *-s* plurals (which would be predicted by the dual-route model).

On the other hand, several online processing studies (Penke and Krause 2002; Clahsen et al. 1997; Sonnenstuhl and Huth 2002; Sonnenstuhl-Henning 2003), ERP studies (Weyerts et al. 1997; Bartke et al. 2005), and fMRI studies (Beretta et al. 2003) have found that reaction times and brain activation between different plural markers differ from each other: (rule-based) *-s* plurals have shorter reaction times and lower brain activation levels than (stored) *-er* plurals, but *-en* and *-e* plurals have intermediate levels. These results point to several subregularities which are compatible with a refined dual-route model or with a processing difference that emerges through a learning process in an initial single route (Feldman 2005, p. 26; Plaut 1995; Elman et al. 1996).

## 2.2 The potentiality framework: The role of productivity and potentiality in German noun plurals

Without denying the importance of both type and token frequency of plural forms for the processing and acquisition of plurals, we consider degree of productivity and of potentiality an additional important factor. The investigation that we report was

developed within the framework initiated by Dressler (1997). This approach does not derive morphological productivity from frequency, but rather considers morphological productivity as the ability to form new potential words, i.e. plural forms of new words and potential variants of existing plural forms. Thus, the degree of potentiality is a function of the degree of productivity. In predicting potential plural forms, a rule is more productive, the more predictable the plural outputs are of singular outputs which fit the structural description of the plural formation rule or pattern. The framework further assumes a two-level approach to productivity of rules of inflectional morphology (Dressler 2003; Laaha et al. 2006, for word formation cf. Dressler and Ladányi 2000; Libben et al. 2002). In the sections below, we refer to this framework as the *Potentiality Framework*.

In the first step the degree of productivity is established according to the number of obstacles that a rule or pattern has to overcome in order to create a new plural form. The greatest challenge for the application of a productive rule is represented by loan words with unfitting properties, which have to be fitted (accommodated) to the system of the loaning language, the first obstacle being foreignness, the second unfitting properties. No such examples (e.g., *die Gruppe* < Fr. *le groupe* with accommodation of gender from masculine to feminine) were used in our tests.

A lower criterion of productivity is present in plural formation rules which apply to loan words with already fitting properties, because only one obstacle, foreignness, has to be overcome. Examples are:

- (1) English *laser* → *der Laser*, Pl. *die Laser-(s)*; E. *quiz* → *das/der Quiz*, Pl. *die Quizz-e*; E. *fax* → *das Fax*, *die Fax-e*; E. *miss* ('beauty queen') → *die Miss*, Pl. *die Miss-en*

Also abbreviations of all sorts are partially strange to the grammatical system of morphology, because abbreviatory devices are extragrammatical (cf. Dressler 2001), as in:

- (2) *Autobus* → *der Bus*, Pl. *die Buss-e*, *Lokomotive* → *die Lok*, Pl. *die Lok-s*.

Among still lower criteria we want to cite recent diachronic change from one plural pattern to another one. The new pattern must be sufficiently productive in order to overcome blocking (of stored morphology) of actual forms of the previous pattern. A case in point is the expansion of umlaut in masculine *-e* plurals in the nineteenth and twentieth century, as in:

- (3) *Mops-e* > *Möps-e* 'pugs', *General-s* > *General-e* > *Generäl-e* 'generals'

In a second step, productivity is related to predictability of plural forms as depending on the presence or absence of rule competition. If a productive rule is the only one which may apply to a given set of nouns, then it is, within this domain, more productive than a productive rule which competes with another productive rule for the same input in the same domain, since rule competition diminishes predictability. If a productive rule competes with an unproductive rule, predictability is

only diminished for the restricted set of words to which an unproductive rule is applied. But in both cases of rule competition we must assume a precedence of stored plural forms over forms not stored.

Thus the resultant scale of productivity differentiates between full productivity in case of non-competing productive rules, medium productivity if two productive rules compete with each other for the same input, low productivity if three or more productive rules compete with each other. The scaling of productivity on the preceding first level of our approach allows for a finer scaling within these three ranks of productivity.

Irrespective of these differences in productivity, we may summarise the relation between productivity and potentiality as follows: all productive plural rules predict potential plurals, be they actually existing or only conceivable forms, whereas rules accounted for by unproductive rules comprise only actual plural forms.

So far we have dealt with potentiality and degrees of productivity of plural patterns of native adult speakers of German. But as has been shown in Laaha et al. (2006) and Klampfer et al. (2001, cf. also Korecky-Kröll and Dressler 2009), productivity and potentiality also play a significant role in the acquisition of German noun plurals, at least in longitudinal corpora and classical off-line plural formation tests. Therefore we decided to run online tests with both children and adults.

But clearly potentiality and productivity are not the only premises for predicting the outcomes of our tests. Thus we integrated them into the following hierarchically ordered principles:

1. If there is certainty about the existing plural, which should be the case particularly for adults, alternatives are less acceptable. This is a primary fact about learning plurals and is expected to be a key factor in the determination of participants' acceptability judgment patterns. But all actual plural forms used in the test have potential alternatives (with the exception of the type *Änker*, see Sect. 3.4)
2. The more productive a plural pattern is, the more it is acceptable.
3. If a form contains an umlaut in addition to a suffix, it sounds like a better plural, because it includes a usefully redundant anticipatory co-signal of the plural suffix (Dressler 1985). For example, if one hears before the plural suffix the stem variant *Füchs-* [fyks] of *Fuchs-* 'fox', then this form may be only completed as either the plural *Füchs-e* or the derived feminine Sg. *Füchs-in* or the derived adjective *füchs-isch*. The test design disambiguates and allows to predict the plural form.
4. If a non-existing form is homophonous with an existing word form, then it is more acceptable than if it is not.

### 3 Materials

We selected 58 German umlautable noun plurals (see Appendix A) belonging to five different plural classes (plural markers: *-e*, *-e* + U feminine, *-e* + U masculine, zero, pure U). Fifty-one of these nouns were taken from Ravid et al. 2008's longitudinal

study of child input data. For each stimulus we recorded Wortschatz (<http://wortschatz.uni-leipzig.de>) token frequency as well as lexical statistics from the CELEX database (Baayen et al. 1993). These included the overall, written and spoken lemma frequencies, as well as the word form frequencies of the uninflected form and of the plural form.

Our goal was to target items of low to middle frequency that are easily picturable. We avoided words with high frequency plural forms, which might have obscured participants' abilities to distinguish among competing non-existing forms.

Due to the small amount of cases within some umlautable plural classes (especially depictable ones), we had to add seven items not contained in the Ravid et al. (2008) longitudinal child input data set. This created the total number of 58 stimuli. As this was the input to younger children (aged 1;3–6;0), one can assume that children participating in the present study (aged 6–10) knew at least all items taken from the input study and probably also the seven supplementary items. Finally each class comprised between nine and fourteen items. For each actual (i.e., existing and correct) plural form, we established two alternative variants: a potential and an illegal plural form (according to our potentiality approach). Test items were balanced for potentiality and plural class. As is explained in our description below of the experimental procedure, each child heard only one of the three plural possibilities (actual, potential, or illegal).

### 3.1 Set 1 stimuli: Set1.M.e.U-e.U-en (e.g., Bus → Buss-e)

Our first stimulus set (Set1.M.e.U-e.U-en) consists of the productive class of masculine nouns (e.g., *Bus*) that are pluralized through the addition of *-e* (e.g., *Buss-e* 'bus-es'). Nouns of this class can have potential non-existing plurals in *-e* with umlaut (e.g., *Büss-e*, a non-existing form that some children produce as an overgeneralisation of umlaut in various age brackets; these plurals correspond to the actual productive class 3). Although principle 3 predicts that these potential plurals are better plurals than the actual forms, principle 1, which favours actual forms (particularly with adults), has priority over principle 5. As a result the difference between correct responses and responses accepting the potential forms should be relatively small. An illegal pluralisation of these nouns involves the combination of umlaut and *-(e)n* plural suffixation (e.g., *Büss-en*), a combination which never occurs in German. Children produce such erroneous forms rarely and in our longitudinal corpora only at an early age.

As is the case for all five stimulus sets in this study, the set label indicates the stimulus characteristics in abbreviated form. Sections of the label are punctuated by dots (.). The first section indicates the Set number (in this case, "Set1"). The second section indicates the grammatical gender of the stimuli (in this case, "M."). The third section indicates the form of the actual plural (in this case, suffixation with "e". The fourth section indicates the potential form (in this case, umlaut with *-e* suffixation "U-e."). Finally, the fifth section indicates the illegal form (in this case, umlaut with *-en* suffixation "U-en.").

In terms of productivity, both the actual and potential forms of Set 1 have medium productivity, but the actual form is more productive because it applies

currently to new loan-words and abbreviations, as in examples (3, 4) whereas umlaut forms show a lower degree of productivity as shown by pattern change in example (5).

### 3.2 Set 2 stimuli: Set2.F.U-e.en.e (e.g., Braut → Bräut-e)

The actual forms of the second stimulus set (Set2.F.U-e.en.e) consist of the unproductive class of feminine nouns that are pluralized via addition of an *-e* suffix plus supplementary umlaut (e.g., *Bräut-e* ‘brides’). Set 2 nouns have potential non-existing plurals without umlaut and with the productive feminine *-en* suffix (e.g., *Braut-en*: medium productivity). Thus the potential form is better than the actual one, because it is productive, but worse because it does not contain an additional umlaut. An illegal plural of these nouns is an *-e* plural without umlaut which does not occur with feminines (e.g., *Braut-e*) other than the loan-word *Ananas* ‘pineapple’.

### 3.3 Set 3 stimuli: Set3.M.U-e.e.en (e.g., Baum → Bäum-e)

The third stimulus set (Set3.M.U-e.e.en) resembles Set 2, but its actual forms consist of masculine (instead of feminine) nouns that are also pluralized through the *-e* suffix plus supplementary umlaut (e.g., *Bäum-e* ‘trees’), but in a productive way. Potential plurals of this set are masculine nouns with *-e* suffixation, but without supplementary umlaut (e.g., *Baum-e*). Therefore Sets 1 and 3 show a complementary distribution: Potential Set 3 plurals correspond to actual Class 1 plurals, whereas potential Set 1 plurals correspond to actual Class 3 plurals. Both concurring plural classes (Classes 1 and 3) are of medium productivity (see Class 1 above) and also compete with *-s* plurals (which are productive especially with nouns ending in full vowels but cannot be applied to nouns ending in sibilants). They are found in overgeneralizations by children of various age groups. Illegal plurals of Class 3 are unproductive *-en* plurals (e.g. *Baum-en*), but less illegal than illegal Set 1 forms because there exist unproductive masculine *-en* plurals without umlaut (e.g., *Staat-en* ‘state-s’) These illegal plurals are rarely found in spontaneous speech data of very young children.

### 3.4 Set 4 stimuli: Set4.M.sing.U.U-s (e.g., Anker → Anker)

The fourth stimulus set (Set4.M.sing.U.U-s) has actual plurals which are homophonous to the singulars and are thus called ‘zero plurals’ (e.g., Sg *der Anker* – Pl *die Anker* ‘the anchors’). They are productive and compete only with productive *-s* plurals (but these are very rare in bisyllabic masculine nouns in Austrian German). We chose as potential plurals unproductive pure umlaut plurals (e.g., *Änker*) which contain several nouns with middle token frequency, in order to compare them better with set 5. Thus similar to sets 1 and 3, sets 4 and 5 are complementary. The truly potential rival of the actual zero plurals of set 4 would have been *-s* plurals, which are homophonous with genitive singulars (e.g., *des Apfel-s*). We preferred to have complementarity between sets 4 and 5. Illegal plurals of this set combine an umlaut

with an *-s* suffix (e.g., *Änker-s*) which is impossible in German. Nevertheless, Set 4 must be regarded as different from the other sets and therefore considered with caution for two reasons: (1) actual plurals are identical to the singulars, (2) it is the only set where the potential plurals belong to an unproductive class.

### 3.5 Set 5 stimuli: Set5.M.U.sing.U-s (e.g., Apfel → Äpfel)

The last set (Set5.M.U.sing.U-s) shows a complementary distribution to Set 4: Actual plurals (e.g., *Äpfel* ‘apple-s’) are formed via unproductive pure umlaut. They compete with productive and frequent Class 4 stimuli, which have been chosen to be the potential forms of set 5 (e.g., *Apfel*). These potential forms are homophonous with the existing corresponding singulars and thus should increase their acceptability in the tests. Illegal plurals also contain an *-s* combined with an umlaut (e.g., *Äpfel-s*, as in Set 4). Although these plurals are highly illegal, they may become more acceptable in rapid reactions due to being the only illegal plurals which include the actual form (*Äpfel* as part of *\*Äpfels*).

## 4 Experiment 1: children ages six to ten

### 4.1 Participants

Participants were 114 children attending elementary school in Vienna. All children had native speaker competence in Austrian German. As can be seen in Table 1, roughly equal numbers of boys and girls participated in the study across the five age groups (6–10).

**Table 1** Distribution of age and gender among child participants in the study

Participant gender			
Age	Female	Male	Total
6	11	7	18
7	11	15	26
8	10	13	23
9	17	14	31
10	9	7	16
Total	58	56	114

### 4.2 Procedure

The experimental paradigm was an online well-formedness judgment task in which participants were presented with oral stimuli accompanied by a pictorial representation of the object. Participants were asked to judge whether the auditorily

presented word was a 'correct' plural form by pressing either a button labeled "Yes" or a button labeled "No" (German: "Ja", "Nein", respectively).

Conducting this experiment with children as young as six required the presentation of an appropriate context for the elicitation of well-formedness judgments. This was done by presenting a cartoon character at the outset of the experiment who was portrayed as a young, likeable, female crocodile, called Susi. In an oral introduction presented on the computer through an audio file, the little crocodile girl complains that other children laugh at her because she often uses wrong noun plurals. She asks the participant to help her by (presumably) giving her the appropriate feedback on whether her plural productions are correct in the following manner:

*Take a look at the buttons in front of you. There is a red one and a green one. If I say the right word, press the green button as quickly as possible. But if I say something that is wrong, please press the red button as quickly as possible. Don't worry about the exact fit of word and picture, but only if I am saying the correct word, OK?*

Test items were simultaneously presented auditorily (by the crocodile's voice) and visually (by pictures on the screen). In order to indicate the plural, each noun was auditorily preceded by the numeral "three" and accompanied by three similar drawings of the item.

The experimental trials were preceded by a training trial to acquaint the participants with the apparatus and a practice session consisting of one correct stimulus and one incorrect stimulus. The main experiment was conducted in three blocks of trials (Block 1: 20 trials, Block 2: 20 trials, Block 3: 18 trials). Between sections of the experimental protocol and between trial blocks, the crocodile cartoon character re-appeared to offer encouragement and to create a more enjoyable testing atmosphere for the children (See Appendix B for the cartoon character's script).

In each trial, participants heard an auditory stimulus consisting of the phrase "three x", where x was either an actual plural form, a potential plural form (by our analysis) or an illegal plural form (by our analysis). The auditory stimulus was accompanied by three identical pictures of the stimulus noun. Each picture was presented within a 7 × 7 centimeter frame, and the three pictures were arranged in a triangular manner with one picture in the upper portion of the computer screen and the other two in the lower portion. The pictures remained on the screen until a response was made. Although it was not expected that latency measures would be meaningful for this age group, response times were recorded. The median response time for all trials and all participants was 1,615 mss. The experiment took about 30 minutes per participant. The experiment was carried out on a Macintosh laptop computer and was controlled by a script implemented in PsyScope 1.1 (Cohen et al. 1993). Before finalizing the test design, a series of pilot tests was carried out with children across the age range of the child participants. The purpose of the pilot testing was to ensure that that procedure was comprehensible to even the youngest children and, at the same time, acceptable to the oldest children.

### 4.3 Results

The yes/no responses of 114 participants comprised the dataset. This yielded a total of 6,612 observations. Of these, 260 (3.9%) showed response latencies of over 5 s, which we had established as the response timeout value. Responses that occurred beyond the timeout value were not analyzed.

#### 4.3.1 Acceptance rates

Acceptance rates were calculated for all participants. In Fig. 1 below, the acceptance scores for children at the five age groups are shown. As can be seen in this figure, acceptance rates for actual words were all at the 80% level and above, whereas acceptance rates for potential and illegal words were all below 50%. For all age groups, actual plural forms were significantly more often accepted than potential and illegal forms. Potential plural forms were accepted significantly more often than illegal plural forms. The acceptance of actual forms ranges from 80 to 90%, and generally rises with age. This effect was found to be significant ( $p = 0.0008$ , see Table 2, below). In the analysis of potential and illegal forms (detailed in Table 3 below), the effect of age is also significant ( $p = 0.0014$ ). In this case, though, increasing age is associated with decreased acceptance of the potential and illegal forms. This is what would be expected as children come to distinguish between the actual plurals, on the one hand, and the potential and illegal forms (which are both non-existing) on the other hand.

Figure 1, therefore provides us with an initial perspective of the data that indicate the expected acceptance patterns. We therefore turn our attention to differences among the stimulus categories.

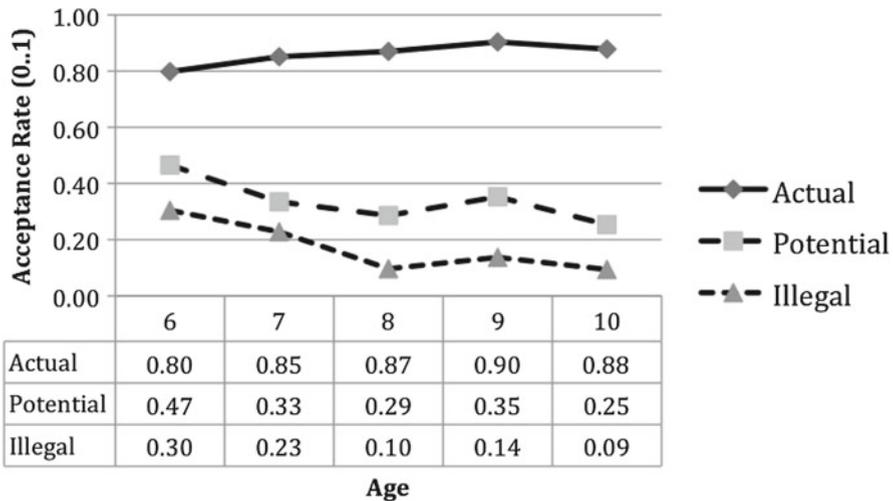


Fig. 1 Acceptance rates for actual, potential, and illegal plural forms across the five age groups

**Table 2** Effects of age, log plural frequency, and stimulus type on children's judgments of actual plural forms

	Estimate	Std. Error	z value	Pr(> z )
(Intercept)	-1.11	0.66	-1.673	0.0943
Plural frequency	0.94	0.31	3.012	0.0026**
Age	0.23	0.07	3.336	0.0008***
Set2.F.U-e.en.e	1.73	0.51	3.376	0.0007***
Set3.M.U-e.e.en	2.25	0.52	4.310	0.0000****
Set4.M.sing.U.U-s	1.11	0.48	2.311	0.0208*
Set5.M.U.sing.U-s	0.53	0.46	1.158	0.2470

*Note:* Set 1 forms are on the intercept. The standard deviation for the by-participant random intercepts was 0.59 and that for the by-item random intercepts was 0.94. The asterisks indicate the following significant levels (\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ , \*\*\*\*  $p < 0.0001$ )

**Table 3** Effects of age, log plural frequency, stimulus type, and potentiality on children's judgments of potential and illegal plural forms

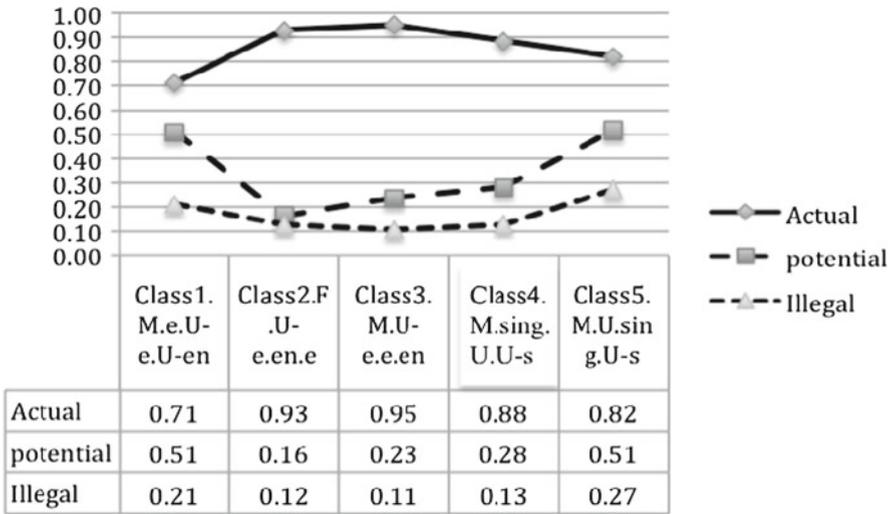
	Estimate	Std. Error	z value	Pr(> z )
(Intercept)	1.28	0.79	1.62	0.1054
Log plural frequency	-0.90	0.22	-4.07	0.0000***
Age	-0.29	0.09	-3.20	0.0014**
Set2.F.U-e.en.e	-1.47	0.38	-3.92	0.0001***
Set3.M.U-e.e.en	-1.33	0.36	-3.65	0.0003***
Set4.M.sing.U.U-s	-0.90	0.36	-2.51	0.0121*
Set5.M.U.sing.U-s	0.50	0.35	1.44	0.1496
PluralStimStatuspotential	1.34	0.09	14.64	0.0000****

*Note:* Set 1 forms are on the intercept. The standard deviation for the by-participant random intercepts was 1.16 and that for the by-item random intercepts was 0.73. The asterisks indicate the following significant levels (\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ , \*\*\*\*  $p < 0.0001$ )

In Fig. 2, acceptance rates are shown for each of the five stimulus categories. This perspective indicates that there is an overall tendency across the categories for the actual plurals to be accepted over either the potential or illegal ones, and for the potential forms to be more acceptable than the illegal forms. But, this is not uniformly the case. As can be seen in this figure, there is a relationship between the acceptability of the actual forms and the acceptability of the potential and illegal forms. Specifically, for categories in which the actual forms are judged less acceptable, the potential forms in particular, are judged to be more acceptable (significantly more than illegal forms in set 1 and 5, see Tables 2 and 3). This trend appears to also be present for the illegal forms.

#### 4.3.2 The roles of stimulus type (group) for actual plural forms

Our key analysis for accuracy scores for actual plural forms (real words) concerns the role of group membership. To analyze this, we employed a logistic regression in



**Fig. 2** Acceptance rates for actual, potential, and illegal plural forms across the five stimulus sets. Note that the label for each set provides information on the actual, potential, and illegal forms of the stimuli. The labels can be parsed in the following manner: SETNUMBER.GENDER. ACTUALFORM. POTENTIALFORM. ILLEGALFORM

which participants and items were treated as random factors. The three independent variables investigated were plural frequency, age and Stimulus Category in the mixed effects model (Note: The frequency of the singular form was not a significant predictor in the model. Gender was not significant and did not interact with age).

The results of the logistic regression analysis are presented in Table 2. The first column of this table shows the intercept, the two continuous variables (plural frequency and age), and four levels of the variable Stimulus Set. Set 1 stimuli are considered to be on the intercept, and the other levels, Sets 2–5, are compared to it. The second column provides an indication of how independent variable values affect dependent variable values. In this case, because all values under the Estimate column are positive, we interpret that column to indicate that higher levels of plural frequency are associated with more “yes” judgments for actual plural forms ( $z = 3.012, p = 0.003$ ). The same is true of age ( $z = 3.3, p = 0.0008$ ), and all stimulus sets, as compared to Set 1, are associated with more “yes” judgments for actual plural forms. In the case of Set 5, this increase is not significant. The significance levels associated with the  $z$  values are provided in the fourth column of the table. These levels indicate a pattern that accords with the pattern (unadjusted for other factors) that is shown in Fig. 2.

#### 4.3.3 The roles of stimulus type (group) and the role of potential versus illegal plurals

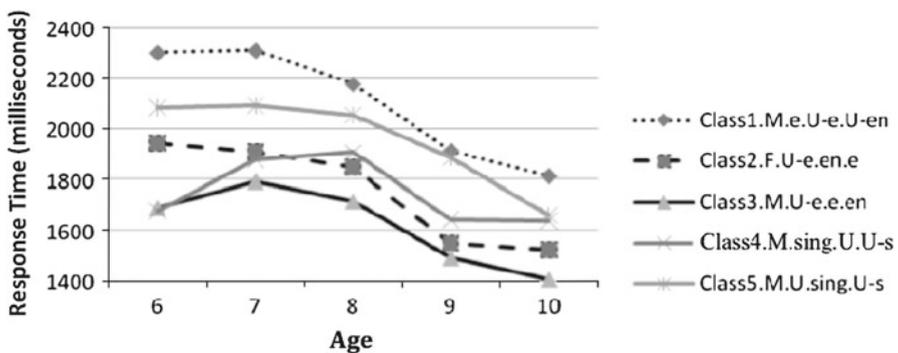
In the analysis of responses to nonwords, plural frequency and age were once again significant factors. The logistic regression analysis reported in Table 3 has Set 1

stimuli and illegal stimulus on the intercept. Against that background, potential plural forms received significantly more “yes” judgments than illegal ones ( $z = 14.67, p < 0.0001$ ). This represents the consistent pattern, shown in Fig. 2, in which potential plurals are judged to be more acceptable than illegal ones across all five stimulus categories. It is noteworthy that this trend holds irrespective of whether the potential forms are homophonous with singular forms and are thus existing words. As can also be seen in Fig. 2, Set 1 stimuli Set 5 stimuli showed the highest acceptance rates for illegal stimuli and potential stimuli in particular. As is shown in Table 3, Set 2, Set 3, and Set 4 stimuli differed significantly from Set 1 stimuli. Sets 1 and 5 do not differ significantly in this analysis.

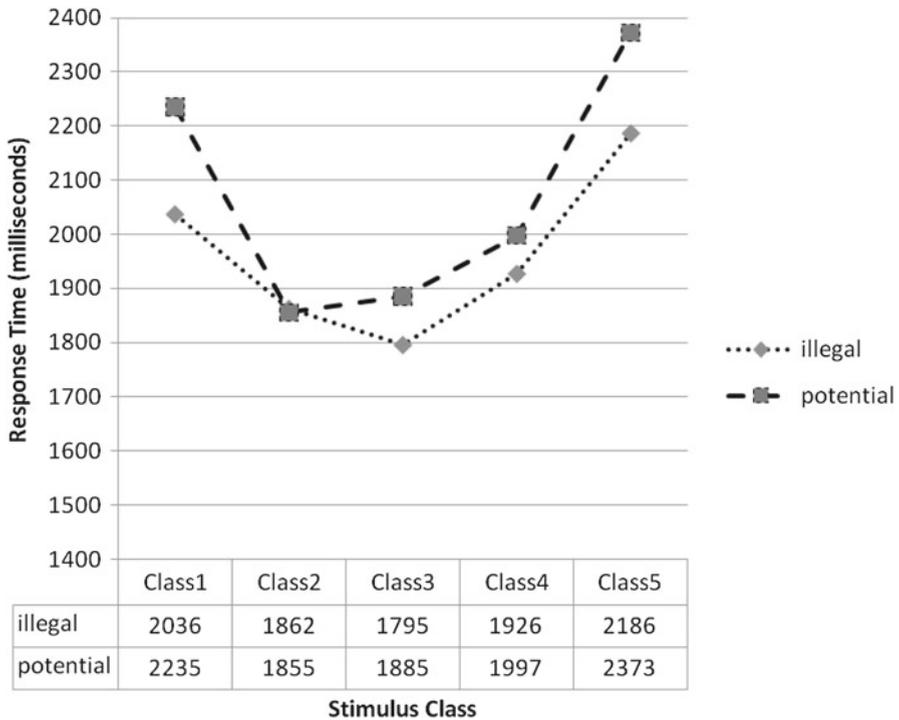
#### 4.3.4 Response latency

Although children’s response times were relatively high, they mirrored, to a large extent, the pattern that emerged from the analysis of response choices. Fig. 3 shows the overall response time for actual plurals across the five stimulus categories for each of the age groups. As can be seen in Fig. 3, there is a general decrease in response times associated with age. For actual plurals, Stimulus Sets 1 and 5 pattern together, showing longest times to press the “yes” button to real plurals of these types. This accords with the response type data, for which these categories showed the lowest rates of acceptance (see Fig. 2), but this must be considered together with the concomitant results for potential plurals (see Fig. 4).

If we turn our attention to the potential and illegal plural forms, the response time data again mirror the response choice patterns. As can be seen in Fig. 4, potential plurals take longer to reject than illegal ones. The distribution of this difference among the five stimulus categories again shows Sets 1 and 5 patterning together in a manner that is very similar to that seen in Fig. 2, i.e., the two sets where acceptance of actual plural forms takes longest are also those where the rejection of non-existing forms takes longest. And, as to potential forms, six- and seven-years old children show no big difference between the actual type *Buss-e* and the potential type *Büss-e* (with additional umlaut) and between the actual umlauting plural type



**Fig. 3** Response times for actual plurals across the five stimulus sets and five age groups. As in Fig. 2, the stimulus set labels are parsed as: SETNUMBER. GENDER. ACTUALFORM. POTENTIALFORM. ILLEGALFORM



**Fig. 4** Children’s mean rejection latencies for potential and illegal plurals across the five stimulus sets. The stimulus set labels are truncated for formatting puposes

*Äpfel* and the potential zero plural *Apfel*. Surprisingly there is no difference between rejection times for potential feminine *Braut-en* and illegal *Braut-e* (Set 2).

These data patterns were investigated statistically using a linear mixed effects regression model (Baayen et al. 2008) with random intercepts for participants and words (lemma). Response times were log-transformed to reduce skew and the potential distortion from outliers.

The analysis of “yes” responses to actual plural forms is shown in Table 4. The format of this table is similar to the one used for the logistic regression analysis. Variable names and levels are provided in the first column. The second column indicates how values of the dependent variable are adjusted in accordance with the values of the independent variable. In this case, the negative values indicate facilitation because they correspond to lower response latency values. The linear mixed effects model employs *t* values rather than the *z* values used in logistic regression. Values of *t* greater than 2.0 can be considered to be significant at the < 0.05 level. As Table 4 indicates, then, Sets 2, 3, and 4 differ significantly (*t* > 2.0) from Set 1, which is on the intercept. Sets 1 and 5 do not differ (*t* = 0.95). Both age and plural frequency significantly lower response latencies.

In Table 5, the analysis of response times for potential and illegal forms is reported. As can be seen in Table 5, we have the now familiar facilitating effects of

age and plural frequency. Potentiality has a significant effect ( $t = 4.61$ ). Sets 2 and 3 are significantly faster to reject than Set 1. Sets 4 and 5 do not differ from Set 1, which is on the intercept.

**Table 4** Effects of log plural frequency, age, and stimulus type on children's log-transformed response times to actual plural forms

	Estimate	Std. Error	<i>t</i> value
(Intercept)	8.10	0.13	61.33
Log plural frequency	-0.10	0.04	-2.63
Age	-0.06	0.02	-3.75
Set2.F.U-e.en.e	-0.16	0.06	-2.49
Set3.M.U-e.e.en	-0.24	0.06	-3.81
Set4.M.sing.U.U-s	-0.15	0.06	-2.41
Set5.M.U.sing.U-s	-0.06	0.06	-0.95

*Note:* Set 1 forms are on the intercept. The standard deviation for the by-participant random intercepts was 0.19, that for the by-item random intercepts was 0.13, and that for the residual error was 0.26

**Table 5** Effects of log plural frequency, age, stimulus type, and potentiality on children's log-transformed response times to potential and illegal plural forms

	Estimate	Std. Error	<i>t</i> value
(Intercept)	8.08	0.13	61.64
Log Plural Frequency	-0.07	0.03	-2.84
Age	-0.05	0.02	-3.52
Set2.F.U-e.en.e	-0.11	0.05	-2.43
Set3.M.U-e.e.en	-0.13	0.05	-2.91
Set4.M.sing.U.U-s	-0.06	0.04	-1.33
Set5.M.U.sing.U-s	0.09	0.04	1.96
Potential	0.04	0.01	4.61

*Note:* Set 1 and illegal forms are on the intercept. The standard deviation for the by-participant random intercepts was 0.20, that for the by-item random intercepts was 0.09, and that for the residual error was 0.23

## 5 Experiment 2: adults

### 5.1 Participants

Participants were 40 monolingual adults living in Vienna. All participants had native speaker competence in Austrian German. Their ages ranged from 18 to 30. Thirty-three of the participants were female and seven were male.

### 5.2 Procedure

The procedure was identical to that used for the children in Experiment 1. Participants were told at the outset of the experiment that the procedure had been

developed for children, and that we were investigating how adult performance and child performance compare. This explanation was designed to help them accept the obvious child-oriented presentation of instructions.

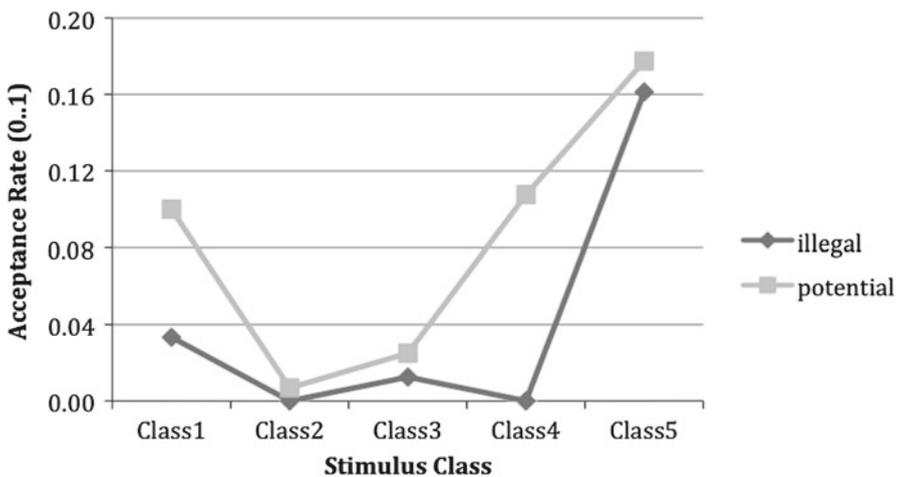
### 5.3 Results

The yes/no responses of 40 participants comprised the dataset. This yielded a total of 2,320 observations. Of these, three showed response latencies of over 5 s. We considered decisions at such latencies to no longer constitute on-line judgments and we therefore removed them from the data to be analyzed. Although the percentage decrease in observations is very small, this procedure ensured that outlier handling for children and adults was identical.

#### 5.3.1 Acceptance rates

Adults' acceptance rates for actual plural forms approached 100% and thus showed very little variation. Ninety-nine percent of the responses to Sets 2 and 3 stimuli were "yes". For the other three stimulus sets the rate of "yes" responses was 98%. However, for the potential and illegal plural forms, there was notable variation. The overall pattern of this variation is shown in Fig. 5.

As can be seen in Fig. 5, the potential plurals were judged by adults to be more acceptable than the illegal plural forms. Additionally, the productive plural forms of Sets 1 and 5 showed the highest acceptance rates (recall that, for Set 5, the potential plural is homophonous with the singular form). For Set 4 (and Set 1), there was a very large difference between the acceptability of the potential and illegal forms.



**Fig. 5** Acceptance across the five stimulus sets for potential and illegal plurals. The stimulus set labels are truncated for formatting purposes

As was the case for children, we fitted the acceptance data using a logistic regression model. For adults, the variable “age” was not used as a predictor. This analysis revealed a significant effect of log plural frequency, which decreased the likelihood of a “yes” response to non-actual plural forms. The analysis also revealed a significant effect of potentiality, for which potential forms showed increased likelihood of “yes” responses. As with our previous analyses, Set 1 stimuli are on the intercept. Set 2 showed significantly lower acceptance rates than Set 1. Set 5 showed significantly higher acceptance rates. Although this was not the pattern of significance that emerged for the children, the overall pattern that we have seen throughout the analyses is to be seen here as well: Acceptance rates are high for Sets 1 and 5 and lowest for Sets 2 and 3. It is also worth noting that, for adults, it is quite unlikely that the patterns of acceptance are related to the level of certainty for the actual plurals. Unlike the children, adults performed at ceiling for actual plural forms (Table 6).

**Table 6** Effects of log plural frequency, stimulus type, and potentiality on adults' judgments of potential and illegal plural forms

	Estimate	Std. Error	<i>z</i> value	<i>Pr</i> (>  <i>z</i>  )
(Intercept)	−3.15	0.46	−6.85	0.000****
Log plural frequency	−1.14	0.42	−2.69	0.007**
Set2.F.U-e.en.e	−2.84	1.28	−2.22	0.026*
Set3.M.U-e.e.en	−1.00	0.68	−1.46	0.143
Set4.M.sing.U.U-s	0.07	0.57	0.12	0.902
Set5.M.U.sing.U-s	1.60	0.53	3.01	0.003**
Potential	0.81	0.23	3.4	0.000****

*Note:* The standard deviation for the by-participant random intercepts was 0.48, that for the by-item random intercepts was 0.83.

The asterisks indicate the following significant levels (\*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$ , \*\*\*\*  $p < 0.0001$ )

### 5.3.2 Response latency

The analysis of response times mirrored the analysis conducted for the children's data, except for the fact that we did not include the variable “age” in our models. For the adults that we sampled, this variable did not play a role in influencing either response times or acceptance choices.

The first thing that is evident when considering the response time patterns shown in Figs. 6 and 7 is that adult response times are considerably faster than those of children. Nevertheless, a scalloped pattern of results across the five stimulus categories is to be seen for both “yes” response to actual stimuli (Fig. 6) and “no” responses to potential and illegal stimuli. Moreover, as expected (Libben 2009), no-responses to non-existing plural forms are nearly always slower than yes-responses to existing actual forms.

As was the case for the children's response time data, we fitted the data to a mixed effects regression model (Baayen et al. 2008) with random intercepts for

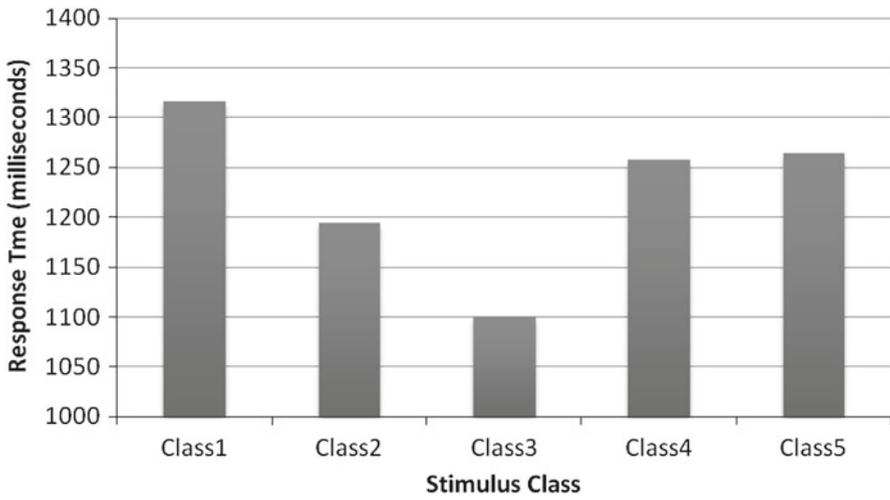


Fig. 6 Adults' mean acceptance latencies for actual plural forms across the five stimulus sets

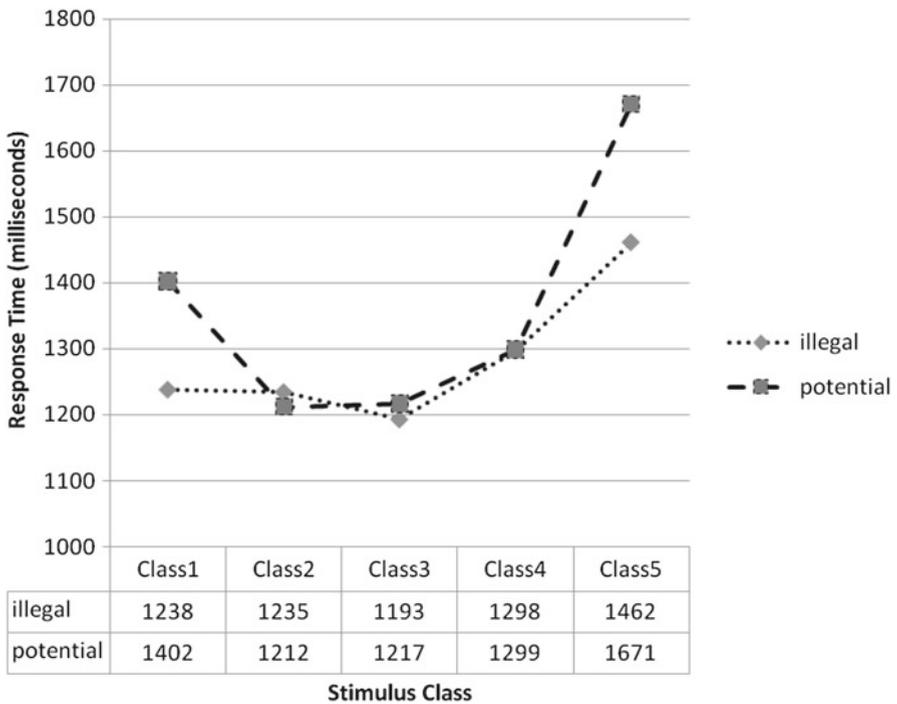


Fig. 7 Adults' mean rejection latencies for potential and illegal plural forms across the five stimulus sets

participants and words (lemma). As was the case for the responses of children, log-transformed response times served as the dependent variable.

The analysis of “yes” responses to actual plural forms is shown in Table 7. In this table, Set 1 stimuli are on the intercept. Only Set 3 stimuli differ significantly from Set 1 stimuli. Interestingly, for this analysis, log plural frequency did not show a significant facilitatory effect, as it did for the children, presumably because adults’ success was too high for showing an impact of frequency. In contrast, it took adults longer to process both umlaut and suffix in the actual forms of Set 3.

In Table 8, the analysis of response times for potential and illegal forms is reported. In this case, log plural frequency did have a significant effect, speeding up rejection times. Potentiality has a significant effect ( $t = 2.82$ ). Set 5 stimuli took significantly longer to reject ( $t = 5.71$ ). No other significant effects were observed.

**Table 7** Effects of log plural frequency and stimulus type on adults’ log-transformed response times to actual plural forms

	Estimate	Std. Error	<i>t</i> value
(Intercept)	7.16	0.05	154.28
Log Plural Frequency	−0.04	0.03	−1.15
Set2.F.U-e.en.e	−0.07	0.06	−1.24
Set3.M.U-e.e.en	−0.15	0.05	−2.66
Set4.M.sing.U.U-s	−0.02	0.05	−0.40
Set5.M.U.sing.U-s	−0.01	0.05	−0.26

*Note:* Set 1 forms are on the intercept. The standard deviation for the by-participant random intercepts was 0.11, that for the by-item random intercepts was 0.10, and that for the residual error was 0.19

**Table 8** Effects of log plural frequency, stimulus type, and potentiality on adults’ log-transformed rejection latencies to potential and illegal plural forms

	Estimate	Std. Error	<i>t</i> value
(Intercept)	7.14	0.04	176.80
Log plural frequency	−0.06	0.03	−2.37
Set2.F.U-e.en.e	−0.03	0.05	−0.65
Set3.M.U-e.e.en	−0.05	0.05	−1.08
Set4.M.sing.U.U-s	0.01	0.05	0.30
Set5.M.U.sing.U-s	0.22	0.05	4.71
Potential	0.03	0.01	2.82

*Note:* Set 1 and illegal forms are on the intercept. The standard deviation for the by-participant random intercepts was 0.09, that for the by-item random intercepts was 0.09, and that for the residual error was 0.22

## 6 Discussion

### 6.1 General differences among actual, potential and illegal forms

In the online acceptability judgment experiment, both children and adults showed sensitivity to the distinction between potential and illegal plural forms (which were

both distinct from the real existing plural forms) in both their acceptance rates and response times. This is the key finding of our study.

From the earliest age bracket onward, participants showed a clear pattern of accepting existing forms over either potential or illegal ones. Because, by definition, the potential plurals are as acceptable as the existing ones grammatically, we therefore conclude that children's preference for existing forms reveals their already established exposure to the plural forms of these words.

A salient trend in the data is that overall accuracy increases with age among children and is close to ceiling in adults. Our interpretation of this trend is that it is driven by the certainty with which participants are able to identify the existing forms. We can assume that participants hold the view that there is only one plural form per lemma, so that if one version is correct, all the others are not. What follows from this is that higher acceptance rates for actual plural forms will drive down the acceptance rates for the potential and illegal forms, even though these were, in our experiment, independent observations. As these acceptance values come closer to zero, a floor effect becomes evident and thus reduces the possibility of a difference being observed between the potential and illegal forms both with respect to each other and across different stimulus sets. This is the pattern that was observed for adult participants.

The effects of these dynamics are evident in our data. As children get older, they become more certain. Thus, the youngest children show the greatest difference between potential and illegal forms. At the other extreme, adults are close to ceiling on the acceptance rates of actual plurals. Their acceptance of potential and illegal forms is correspondingly low. Interestingly, adults nevertheless show significant effects of potentiality in both accuracy and response time.

There were significant age effects with children but, as expected, not with adults. Acceptance of actual plural forms increases with age, acceptance of potential and illegal forms, i.e. of all incorrect forms, decreases. But not even ten-year-olds, the oldest children investigated, reached ceiling. This seems to indicate that, even at this age, full mastery of (non-learned) plural formation had not yet been achieved. Thus the oldest children may not have reached Berman's (2004, p. 14) fifth stage of "proficient integration of knowledge and use", but only the preceding stage of knowledge of the rule system.

However, in our ongoing investigations on language acquisition, which have employed classical elicitation techniques as well as more naturalistic elicitation techniques and data from spontaneous speech (Bertl et al. 2006; Ravid 2008; Laaha et al. 2008; Laaha 2011), we have seen that performance development is fastest when spontaneous speech is analyzed and slowest when data from classical elicitation techniques are analyzed. The reason for this is that the requirement for language awareness (which in children lags considerably behind development of spontaneous production) is highest in the classical tests (Karmiloff-Smith 1992) and that classical experiments are more prone to test artifacts (Grimshaw and Rosen 1990; Bloom et al. 1994). This leads us to the view that the failure of older children to reach accuracy ceiling in the present online well-formedness judgment task (which has a substantial metalinguistic component) may not fully reflect their actual knowledge of plural formation in German. With very few exceptions (see below),

response times for accepting actual plural forms also decrease with age among children. This also represents a marker of their development towards mastery.

## 6.2 The role of frequency

Our analysis began with the decomposition of lemma frequency into the frequency of the singular word form and the plural word form. Of these two, it was the frequency of the plural form that played a role in the patterning of the data. Token frequency of actual plural forms played a significant role in children's acceptance rates and response times. This is compatible with all existing acquisition models, including dual route models, because the existing plural forms of our experiment did not include the only suffixes assigned in dual route models to the putatively frequency insensitive computational rule mechanism, namely, -s plurals (Clahsen et al. 1992; Clahsen et al. 1996; Marcus et al. 1995; Bartke et al. 1995; Clahsen 1999; Marcus 2000) and -n plurals of nouns ending in schwa (Penke and Krause 2002; Sonnenstuhl-Henning 2003; Clahsen 2006; Ković et al. 2008). But, as Laaha et al. (2006) have shown, there also exist frequency effects for -s plurals and -n plurals. Such data contradict a central claim of dual route models. There was no plural frequency effect in adult response accuracy for actual forms, because responses to all actual forms were at ceiling. Nor was there a frequency-related effect in adult response times to actual plural forms. This was at odds with our expectations. It should be noted that, in our stimulus selection, we targeted forms that had been acquired early in childhood (as evidenced by the fact that they were in the children's input). This was designed to reduce potential age-of-acquisition effects in the data.

## 6.3 The five stimulus sets and differences in productivity

In contrast to most studies on the acquisition of German plurals (but see also Laaha et al. 2006; Ravid et al. 2008; Spreng 2004), we distinguished as two different classes unlauded -e plurals which are masculine or neuter (class 3) from those which are feminine (class 2). This distinction has been supported by different acceptance rates and reaction times within each set.

As was discussed at the outset of this report, a central theme in this investigation is the extent to which the productivity framework which was originated in Dressler (1997) provides insight into children's online well-formedness judgments. According to this framework, actual and potential forms must be analyzed jointly. In Sets 1 and 3, both actual and potential forms are moderately productive (Set 1 Actual: *Buss-e*. Potential: *Büss-e*...). In Set 2, the actual form is unproductive and the potential form is slightly productive. This explains why the potential forms of Sets 1 and 3 have a higher acceptance rate as compared with the potential forms of Set 2. However, it does not explain why the unproductive actual form of Set 2 is judged nearly as highly as Set 3 and much higher than the actual form of set one. If we examine the comparable Sets 4 and 5, then the slight productivity of the actual form of Set 4 and of the potential form of Set 5 explain why each of them is judged more highly than the corresponding unproductive forms of the other set.

#### 6.4 The five stimulus sets and supplementary umlaut

The analysis of the five stimulus sets reveals, therefore, that the notion of productivity is insufficient to account for the full data pattern. We need at least one additional explanatory factor. As has been discussed above, one of these appears to be the presence vs. absence of a supplementary umlaut as preceding co-signal of the plural suffix. In Sets 1, 2, and 3, umlaut is a supplementary marker of the plural, in addition to suffixation. This additional marker serves to differentiate the plural more from the singular.

If we compare Sets 1 and 3, which show the inverse relationship between actual and potential forms, then the additional umlaut in the actual form of Set 3 (e.g., *Füchs-e*) renders it more acceptable for children than its absence in the actual form of Set 1 (e.g., *Büss-e*). In addition, the umlauted potential form of Set 1 (*Büss-e*) is valued much higher than the non-umlauted potential form of Set 3 (*Fuchs-e*), despite the fact that all forms are moderately productive. The presence of umlaut in the unproductive actual form of Set 2 (e.g., *Küh-e*) also explains why it is much more highly valued than the potential form (*Kuh-en*). However, in Sets 4 and 5, productivity is more important than umlaut, which in this case, because it is not combined with suffixation, is the only marker and thus does not benefit from being a co-signal.

Presence versus absence of umlaut also explains why the response times for children's actual forms of Set 3 are faster than those for Set 1 (see Fig. 3). The unproductive umlaut forms of Set 2 are the next fastest for the older children.

#### 6.5 The effect of homophony with actual forms

A third factor, albeit perhaps a minor one because it applies to only one stimulus type in our data, is homophony with actual forms. This might explain why the potential form of Set 5, which is identical with the singular (e.g., *Anker*), received both a high acceptance rate and low response times in children. We see this as focus of possible future investigations. It would be interesting to explore, for example, whether homophony with the genitive singular (*des Apfel-s*) increases acceptability of the potential plural (*die Apfel-s*) instead of the actual form (*die Äpfel*).

The homophony effect also explains a test artefact that we think may be affecting adult acceptance rates and slow response times for the illegal forms of Set 5 (e.g., *Äpfel-s*). This illegal form combines umlaut with suffix *-s* which never allows umlaut in German. This is thus similar to the illegal forms of Set 1 (*Büss-en*) and of Set 4 (*Änker-s*). The difference lies in the fact that *Äpfel-s* includes the actual plural form *Äpfel*, whereas, the illegal forms of Sets 1 and 4 do not. Some adult participants reported that they reacted to this legal subset form before they heard the suffix.

#### 6.6 The five stimulus sets and differences in illegality

A key generalisation about non-existing forms is that, both for children and adults, differences in both acceptance rates and response times among the different sets of

illegal forms are smaller than those for potential forms. This, we argued, is the result of a floor effect for illegal forms, so that when acceptance rates are close to the floor, inter-category variation cannot be observed. However, the fact that the same pattern is evident in response time, which is less prone to floor effects, suggests that this observation of how potential and illegal forms differ may nevertheless be noteworthy.

It is important to note that, within the set of illegal forms, there are substantial differences in the degree of illegality. The most illegal type is represented by the combination of an umlaut with a suffix that never allows an umlaut. This is the case in Set 1 (e.g., *Büss-en*), Set 4 (e.g., *Bägger-s*), and Set 5 (e.g., *Äpfel-s*). Thus, an initial expectation is that these types would show the lowest acceptance rates. This was not, however, what was observed. One reason for this, in our view, is the already noted relationship between the acceptance rates of the actual forms and the acceptance rates for the non-existing forms. Specifically, as can be seen in Figs. 2 and 4, higher certainty rates for the actual forms drive the acceptance rates of non-existing forms to the floor. For exactly these stimulus sets, certainty rates were the lowest. This allowed non-existing acceptance rates to rise. Another possible reason is the conflict with the above-mentioned umlaut in addition to suffixation, which renders the forms more plural-like.

## 6.7 Comparison with other models

Dual route models focus on the difference between a rule mechanism which is supposed to account for the acquisition of *-s* plurals and possibly *-n* plurals (of schwa-final nouns) and storage plus analogy of all the other plural forms without accounting for differences among the latter patterns (see Clahsen 1999, 2006; Ković et al. 2008). Since our contribution deals only with *-e* plurals, umlaut and zero plurals, our endeavours are complementary to those of dual route models and no reasonable comparison is possible.

Among single-route models Köpcke's (1998) schema model gives the most specific account of the acquisition of German noun plurals. Among actual plurals *-en* and *-s* plurals, which we did not include into our investigation, have the highest cue validity, *-e* plurals (with or without umlaut, see below) have rather low cue validity and zero plurals (with or without umlaut) the lowest degree. This may account for children's lower acceptance rates of classes 4 and 5 than of classes 2 and 3, but not for the slightness of these differences, nor for the much lower acceptance rates of class 1. Nor can the model explain why reaction times for the zero-suffix classes 4 and 5 are nearly as fast as for the suffixed class 3 and much faster than for the other suffixes classes 2 and 1. It is not clear whether the predictions of this schema model may also be applied to potential plurals. If so, then it does not account for the differences in acceptance rates of the different sets.

Köpcke (1998, p. 309) assigns medium cue validity to umlaut, highest for labiopalatal umlauts. But when counting such umlauted plurals and structurally similar singular base words in the input of our children, we found that there singulars of the type *Büchse* 'box' and *Körper* 'body' greatly outnumber similar plurals of the type *Füchs-e* 'fox-es' (Sg. *Fuchs*) and *Öfen* 'oven-s' (Sg. *Ofen*). Thus we

cannot find in children's input any increase of cue validity through umlaut. Köpcke (1998, p. 308) also assigns correctly low degrees of salience, type frequency and iconicity to umlaut.

Köpcke (1988, 1993) has found that animate (masculine) nouns prefer umlaut in -e plurals more than inanimate ones. However, testing this factor in sets 1 and 3 did not result in animacy effect for the actual stimuli in either children or adults. But for potential words there was an animacy effect of  $p = 0.001$  for umlaut. We interpret this as the expected animacy effect being overshadowed by the knowledge of actual plural forms, especially in adults.

## 7 Conclusion

The data we have obtained from both children and adults support the view that the division of plural forms into actual, potential and illegal forms provides a vantage point from which we can better understand the nature of native speaker knowledge in this domain of morphology. In particular, this allows us to discuss more profoundly the status of potential non-existing forms within this triad. According to our definition, a *potential* form is a non-existing form which fits a productive pattern applicable to a base form which meets the structural description of this productive rule (if we use the rule format for describing such productive patterns). In the framework we employ, based on Dressler (1997, 2003) and Libben et al. (2002, cf. Laaha et al. 2006), productivity is gradual, thus potentiality is also gradual. But gradualness is also true for actual forms, which may be more or less productive.

In acquisition, potentiality then means that productive patterns may be overgeneralised, particularly when the conditions for the application of a pattern are met. Well before the age of six, these conditions have been acquired. In spontaneous speech as well, children have ceased to produce the most illegal forms, i.e. those which do not exist as patterns in the language by age six. Therefore they cannot be overgeneralised but emerge due to recombination, of umlaut and incorrect suffixes in our case. Overgeneralisations of only slightly illegal plurals occur as long as the conditions for rule application have not yet stabilised. In contrast, potential forms remain as options well into adulthood. In addition to the favouring factor of productivity, a second factor has increased acceptability within the test, namely supplementary umlaut which co-signals a following pluralising suffix and also increases iconicity of the plural form insofar as plurality gets symbolised twice (multiple exponence). Similar results would be expected for productive patterns in other languages, notably when including co-signals such as umlaut in Germanic languages and morphological palatalisation of obstruent consonants in Slavic, Baltic and Romance languages.

Thus, taken together, our results point to the conclusion that *potentiality* does indeed make a difference and that it is graded in a manner that can be revealed through the examination of stimulus subclasses. Methodologically, the pattern of results support the view that the experimental paradigm of online acceptability judgment allows the use of a common protocol for both children and adults and that

it has the ability to capture stable judgment patterns, while also offering valuable latency data.

## Appendix A

Plural set		Singular	Actual plural	Potential plural	Illegal plural	Translation
Set1.	1	Bus	Busse	Büsse	Büssen	buses
M.e.U-e.U-en	2	Dachs	Dachse	Dächse	Dächsen	badgers
	3	Dolch	Dolche	Dölche	Dölchen	daggers
	4	Dom	Dome	Döme	Dömen	cathedrals
	5	Farn	Farne	Färne	Färnen	ferns
	6	Hund	Hunde	Hünde	Hünden	dogs
	7	Mond	Monde	Mönde	Mönden	moons
	8	Ort	Orte	Örte	Örten	places
	9	Pfau	Pfaue	Pfäue	Pfäuen	peacocks
	Set2.	1	Braut	Bräute	Brauten	Braute
F.U-e.en.e	2	Faust	Fäuste	Fausten	Fauste	fists
	3	Gans	Gänse	Gansen	Ganse	geese
	4	Hand	Hände	Handen	Hande	hands
	5	Kuh	Kühe	Kuhen	Kuhe	cows
	6	Maus	Mäuse	Mausen	Mause	mice
	7	Nacht	Nächte	Nachten	Nachte	nights
	8	Schnur	Schnüre	Schnuren	Schnure	strings, cords
	9	Stadt	Städte	Stadten	Stadte	towns, cities
	10	Wand	Wände	Wanden	Wande	walls
	11	Wurst	Würste	Wursten	Wurste	sausages
	Set3.	1	Ball	Bälle	Balle	Ballen
M.U-e.e.en	2	Bart	Bärte	Barte	Barten	beards
	3	Baum	Bäume	Baume	Baumen	trees
	4	Frosch	Frösche	Frosche	Froschen	frogs
	5	Fuchs	Füchse	Fuchse	Fuchsen	foxes
	6	Fuß	Füße	Fuße	Fußen	feet
	7	Hut	Hüte	Hute	Huten	hats
	8	Knopf	Knöpfe	Knopfe	Knopfen	buttons
	9	Kopf	Köpfe	Kopfe	Kopfen	heads
	10	Korb	Körbe	Korbe	Korben	baskets
	11	Turm	Türme	Turme	Turmen	towers
	12	Zug	Züge	Zuge	Zugen	trains
	Set4.	1	Anker	Anker	Änker	Änkers
M.sing.U.U-s	2	Bagger	Bagger	Bägger	Bäggers	diggers
	3	Brunnen	Brunnen	Brünnen	Brünnens	fountains

**Appendix A** continued

Plural set		Singular	Actual plural	Potential plural	Illegal plural	Translation
	4	Daumen	Daumen	Däumen	Däumens	thumbs
	5	Dotter	Dotter	Dötter	Dötters	yolks
	6	Hamster	Hamster	Hämster	Hämsters	hamsters
	7	Kater	Kater	Käter	Käters	tomcats
	8	Knochen	Knochen	Knöchen	Knöchens	bones
	9	Koffer	Koffer	Köffer	Köffers	suitcases
	10	Kuchen	Kuchen	Küchen	Küchens	cakes
	11	Schnuller	Schnuller	Schnüller	Schnüllers	pacifiers
	12	Tropfen	Tropfen	Tröpfen	Tröpfens	drops
Set5.	1	Apfel	Äpfel	Apfel	Äpfels	apples
M.U.sing.U-s	2	Bruder	Brüder	Bruder	Brüders	brothers
	3	Faden	Fäden	Faden	Fädens	threads, twines
	4	Garten	Gärten	Garten	Gärtens	gardens
	5	Hammer	Hämmer	Hammer	Hämmers	hammers
	6	Kasten	Kästen	Kasten	Kästens	cupboard
	7	Mantel	Mäntel	Mantel	Mäntels	coats
	8	Nagel	Nägel	Nagel	Nägels	nails
	9	Ofen	Öfen	Ofen	Öfens	stoves
	10	Schnabel	Schnäbel	Schnabel	Schnäbels	beak
	11	Vater	Väter	Vater	Väters	fathers
	12	Vogel	Vögel	Vogel	Vögels	birds
	13	Boden	Böden	Boden	Bödens	floors
	14	Hafen	Häfen	Hafen	Häfens	harbour

**Appendix B**

## English translation of the German introduction text (§Sect. 4.2)

Hi, my name is Susi and as you can see, I am a crocodile. Just like you, I am in elementary school. I've got lots of friends there, but sometimes they make fun of me and I have no idea why. Today, for example, when I asked Max if we could trade snacks (use of the incorrect plural pattern “*Jausenbröte*” instead of “*Jausenbrote*”), he laughed at me, saying “It's *Brote*, not *Bröte*!”

I guess, these mistakes happen pretty often to me and that's why I want to ask you if you could help me out. Together, we could look at some pictures. I'll say the word that I think is correct and you tell me whether I'm right.

Take a look at the buttons in front of you. There is a red one and a green one. If I say the right word, press the green button as quickly as possible. But if I say something that is wrong, please press the red button as quickly as possible. Don't

worry about the exact fit of word and picture, but only if I am saying the correct word, OK?

Come on, we'll try right now. Let's see if the buttons are working at all. Please push "correct"!

*If the wrong button was chosen:*

Something doesn't seem right. Could you please push the green button again? Remember, this is the button for correct words.

*If the right (green) button was pressed:*

This worked out just perfectly. Now please try the "incorrect" button!

*If the wrong button was chosen:*

Could you please try again, something didn't work out. Do you still know that you have to push the red button in case I say a wrong word.

*If the correct (red) button was pressed:*

Very good! You did a really great job. I am really looking forward to our game. Try to listen carefully; maybe I'll make a mistake at the very end of the word. Think thoroughly before you push the button. Nevertheless answer as fast as possible. You know what? Let's just try the game. Press the green button to start.

### *PRACTICE TRIALS*

You know what? I guess we are a great team! I have a lot of fun playing this game. During the practice, you already helped me a lot. But now we'll really get started, OK? When you are ready to start, press the green button again!

### *FIRST GROUP OF STIMULI*

Wow, that's quite exhausting, isn't it? But you are really awesome. If you'll continue to help me like that, nobody will laugh at me tomorrow.

You know what? We shake out our whole body and afterwards I'll bring some more words. I hope you still feel like it. I really need your help.

Let's start work again. If you are ready, press the green button again.

### *SECOND GROUP OF STIMULI*

It appears to me that the two of us deserve a short break again, what do you think? I already feel a little bit thirsty and that's why I'll take a sip of water. Do you want to drink something too?

A few words are still left, but after these we will be done. I promise.

Are you ready? Then you just push the green button.

### *THIRD GROUP OF STIMULI*

Yay! We did it! Thank you so much, you really helped me a lot! Now I am able to look forward to school tomorrow and of course I won't say "Bröte", but "Brote".

Thanks!

## References

- Aronoff, M. (1976). *Word formation in generative grammar*. Cambridge: MIT Press.
- Baayen, R. H., Davidson, D. J., & Bates, D. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, 59, 390–412.
- Baayen, R. H., Piepenbrock, R., & van Rijn, H. (1993). *The CELEX lexical database (CD-ROM)*. Philadelphia: Linguistic Data Consortium.
- Bartke, S. (1998). *Experimentelle Studien zur Flexion und Wortbildung. Pluralmorphologie und Komposition im unauffälligen Spracherwerb und im Dysgrammatismus*. Tübingen: Niemeyer.
- Bartke, S., Marcus, G. F., & Clahsen, H. (1995). Acquiring German noun plurals. In D. MacLaughlin & S. McEwen (Eds.), *Proceedings of the 19th annual Boston University conference on language development* (pp. 60–69). Boston: Cascadilla Press.
- Bartke, S., Rösler, F., Streb, J., & Wiese, R. (2005). An ERP-study of 'irregular' morphology. *Journal of Neurolinguistics*, 18, 29–55.
- Behrens, H. (2001). How to learn a minority default: The acquisition of the German –s plural. Ms. (under revision).
- Behrens, H. (2009). Usage-based and emergentist approaches to language acquisition. *Linguistics*, 47, 383–411.
- Berent, I., & Pinker, S. (2008). Compound formation is constrained by morphology. *The Mental Lexicon*, 3, 176–187.
- Beretta, A., Campbell, C., Carr, T. H., Huang, J., Schmitt, L. M., Christianson, K., & Cao, Y. (2003). An ER-fMRI investigation of morphological inflection in German reveals that the brain makes a distinction between regular and irregular forms. *Brain and Language*, 85, 67–92.
- Berman, R. A. (2004). Between emergence and mastery: The long developmental route of language acquisition. In R. A. Berman (Ed.), *Language development across childhood and adolescence* (pp. 9–34). Amsterdam: Benjamins.
- Bertl, J., Korecky-Kröll, K., & Laaha, S. (2006). *The plurality of plurals: A comparison of plural elicitation techniques in first language acquisition*. Poster presented at the Workshop "Acquisition and impairments of inflectional morphology", 12th international morphology meeting, Budapest, May 2006.
- Bittner, D., & Köpcke, K.-M. (2001). Acquisition of the German plural markings: A case study in natural and cognitive morphology. In C. Schaner-Wolles, J. Rennison, & F. Neubarth (Eds.), *Naturally! Linguistic studies in honour of Wolfgang Ulrich Dressler* (pp. 47–58). Torino: Rosenberg & Sellier.
- Bloom, P., Barss, A., Nicol, J., & Conway, L. (1994). Children's knowledge of binding and coreference: Evidence from Spontaneous Speech. *Language*, 70, 53–71.
- Bybee, J. (2001). *Phonology and language use*. Cambridge: Cambridge University Press.
- Chomsky, N. (1986). *Knowledge of language*. New York: Praeger.
- Clahsen, H. (1999). Lexical entries and rules of language: A multidisciplinary study of German inflection. *Behavioral and Brain Sciences*, 22, 991–1060.
- Clahsen, H. (2006). Linguistic perspectives on morphological processing. In D. Wunderlich (Ed.), *Advances in the theory of the lexicon* (pp. 355–388). Berlin: Mouton de Gruyter.
- Clahsen, H., Eisenbeiss, S., & Sonnenstuhl, I. (1997). Morphological structure and the processing of inflected words. *Theoretical Linguistics*, 23 (3), 201–249.
- Clahsen, H., Marcus, G., Bartke, S., & Wiese, R. (1996). Compounding and inflection in German child language. *Yearbook of Morphology*, 1995, 115–142.
- Clahsen, H., Rothweiler, M., Woest, A., & Marcus, G. F. (1992). Regular and irregular inflection in the acquisition of German noun plurals. *Cognition*, 45, 225–255.
- Cohen, J. D., MacWhinney, B., Flatt, M., & Provost, J. (1993). PsyScope: A new graphic interactive environment for designing psychology experiments. *Behavioral Research Methods, Instruments, and Computers*, 25(2), 257–271.
- Coseriu, E. (1975). System, Norm und Rede. In: E. Coseriu (Ed.), *Sprachtheorie und allgemeine Sprachwissenschaft* (pp. 11–101). München: Fink.
- Croft, W., & Cruse, D.A. (2005). *Cognitive linguistics*. Cambridge: Cambridge University Press.
- Cunnings, I., & Clahsen, H. (2008). The time-course of morphological constraints. *The Mental Lexicon*, 3, 149–175.
- Daugherty, K.G., & Seidenberg, M.S. (1994). Beyond rules and exceptions: A connectionist approach to inflectional morphology. In: S.D. Lima, R. L. Corrigan, & G. K. Iverson (Eds.), *The reality of linguistic rules* (pp. 353–388). Amsterdam: Benjamin.
- Dorfner, G. (1991). *Konnectionismus*. Stuttgart: Teubner.

- Dressler, W. U. (1985). *Morphonology*. Ann Arbor: Karoma Press.
- Dressler, W. U. (1997). On productivity and potentiality in inflectional morphology. In *CLASNET Working Papers 7*, Université de Montréal.
- Dressler, W. U. (2001). Extragrammatical vs. marginal morphology. In U. Doleschal & A. Thornton (Eds.), *Extragrammatical and marginal morphology* (pp. 1–10). München: Lincom Europa.
- Dressler, W. U. (2003). Degrees of grammatical productivity in inflectional morphology. *Italian Journal of Linguistics*, 15, 31–62.
- Dressler, W. U., & Ladányi, M. (2000). Productivity in word formation (WF): A morphological approach. *Acta Linguistica Hungarica*, 47, 103–144.
- Eisenbeiß, S. (2009). Generative approaches to language learning. *Linguistics*, 47, 273–310.
- Elman, J. L., Bates, E. A., Johnson, M. H., Karmiloff-Smith, A., Parisi, D., & Plunkett, K. (1996). *Rethinking innateness*. Cambridge/London: MIT Press/Bradford Books.
- Feldman, N. (2005). *Learning and overgeneralization patterns in a connectionist model of the German plural*. M.A. thesis, Vienna University.
- Grimshaw, J., & Rosen, S. T. (1990). The developmental status of the binding theory. *Linguistic Inquiry*, 21, 187–222.
- Hahn, U., & Nakisa R. C. (2000). German inflection: Single route or dual route? *Cognitive Psychology*, 41, 313–360.
- Karmiloff-Smith, A. (1992). *Beyond modularity: A developmental perspective on cognitive science*. Cambridge/London: MIT Press/Bradford Books.
- Klampfer, S., & Korecky-Kröll, K. (2002). Nouns and verbs at the transition from pre- to protomorphology: A longitudinal case study on Austrian German. In M. D. Voeikova & W. U. Dressler (Eds.), *Pre- and protomorphology: Early phases of morphological development in nouns and verbs* (pp. 61–74). München: Lincom.
- Klampfer, S., Korecky-Kröll, K., & Dressler, W. U. (2001). Morphological potentiality in children's overgeneralization patterns: Evidence from Austrian German noun plurals. *Wiener Linguistische Gazette*, 67–69, 25–43.
- Ković, V., Westermann, G., & Plunkett, K. (2008). Implicit vs. explicit learning in German noun plurals. *Psihologija*, 41, 387–411.
- Köpcke, K.-M. (1988). Schemata in German plural formation. *Lingua*, 74, 303–335.
- Köpcke, K.-M. (1993). *Schemata bei der Pluralbildung im Deutschen: Versuch einer kogniti-ven Morphologie*. Tübingen: Narr.
- Köpcke, K.-M. (1998). The acquisition of plural marking in English and German revisited: Schemata versus rules. *Journal of Child Language*, 25, 293–319.
- Korecky-Kröll, K., & Dressler, W. U. (2009). The acquisition of number and case in Austrian German nouns. In U. Stephany & M. D. Voeikova (Eds.), *Development of nominal inflection in first language acquisition. A cross-linguistic perspective* (pp. 265–302). Berlin: De Gruyter.
- Laaha, S. (2011). Eliciting noun plurals in German: a comparison of children's productions in a classical elicitation and a playful naming task. 12th Congress of the International Association for the Study of Child Language (IASCL 2011), Montreal, July 2011.
- Laaha, S., Levie, R., Bertl, J., Raz, E., Laaha, G., Dressler, W. U., & Ravid, D. (2008). *The lotto game*. Talk presented at the symposium "Why are noun plurals hard to acquire? A multi-task approach", 11th international congress for the study of child language, Edinburgh, July 2008.
- Laaha, S., Ravid, D., Korecky-Kröll, K., Laaha, G., & Dressler, W. U. (2006). Early noun plurals in German: Regularity, productivity or default? *Journal of Child Language*, 33, 271–302.
- Libben, G. (2009). Psycholinguistic techniques: Timing the lexicon. In D. Eddington (Ed.) *Quantitative and experimental linguistics* (pp. 197–233). München: Lincom.
- Libben, G., Jarema, G., Dressler W., Stark, J., & Pons, C. (2002). Triangulating the effects of interfixation in the processing of German compounds. *Folia Linguistica*, 36, 23–43.
- Marchand, H. (1960). *The categories and types of present-day English word-formation*. München: Beck.
- Marcus, G. F. (2000). Children's overregularization and its implications for cognition. In P. Broeder & J. Murre (Eds.), *Models of language acquisition: Inductive and deductive approaches* (pp. 154–176). Oxford: Oxford University Press.
- Marcus, G. F., Brinkmann, U., Clahsen, H., Wiese, R., Woest, A., & Pinker, S. (1995). German inflection: The exception that proves the rule. *Cognitive Psychology*, 29, 189–256.
- Penke, M., & Krause, M. (2002). German noun plurals – A challenge to the dual-mechanism model. *Brain and Language*, 81, 303–311.
- Pinker, S. (1998). Words and rules. *Lingua*, 106, 219–242.

- Plaut, D.C. (1995). Double dissociations without modularity: Evidence from connectionist neurophysiology. *Journal of Clinical and Experimental Neurophysiology*, 17, 291–321.
- Plunkett, K., & Marchman, V. A. (1991). U-shaped learning and frequency effects in a multi-layered perceptron: Implications for child language acquisition. *Cognition*, 38, 43–102, 1991.
- Plunkett, K., & Marchman, V. A. (1993). From rote learning to system building: Acquiring verb morphology in children and connectionist nets. *Cognition*, 48, 21–69.
- Ravid, D. (2008). *Methodology*. Talk presented at the symposium “Why are noun plurals hard to acquire? A multi-task approach”, 11th international congress for the study of child language, Edinburgh, July 2008.
- Ravid, D., Dressler, W. U., Nir-Sagiv, B., Korecky-Kröll, K., Souman, A., Rehfeldt, K., Laaha, S., Bertl, J., Basbøll, H., & Gillis, S. (2008). Core morphology in child directed speech. Crosslinguistic corpus analyses of noun plurals. In H. Behrens (Ed.), *Corpora in language acquisition research. History, methods, perspectives* (pp. 25–60). Amsterdam: Benjamins (=Trends in Language Acquisition Research 6).
- Rumelhart, D. E., & McClelland, J. L. (1986). On learning the past tenses of English verbs. In D. E. Rumelhart, J. L. McClelland, & PDP Research Group (Eds.) *Parallel distributed processing: Exploration in the microstructure of cognition*, (pp. 216–271), Bd. II. Cambridge, MA: MIT Press.
- Schaner-Wolles, C. (2001). On the acquisition of noun plurals in German. In C. Schaner-Wolles, J. Rennison, F. Neubarth (Eds.), *Naturally! Linguistic studies in honour of Wolfgang Ulrich Dressler presented on the occasion of his 60th birthday* (pp. 451–460). Torino: Rosenberg & Sellier.
- Schultink, H. (1961). Produktiviteit als morfologisch fenomeen. *Forum der Letteren*, 2, 110–125.
- Sedlak, M., Klampfer, S., Müller, B., & Dressler, W. U. (1998). The acquisition of number in Austrian German: A case study on the early stages. In S. Gillis (Ed.), *Studies in the acquisition of number and diminutive marking. Antwerp Papers in Linguistics*, 95, 51–76.
- Sonnenstuhl-Henning, I. (2003). *Deutsche Plurale im mentalen Lexikon. Experimentelle Untersuchungen zum Verhältnis von Speicherung und Dekomposition*. Tübingen: Niemeyer.
- Sonnenstuhl, I., & Huth, A. (2002). Processing and representation of German –n Plurals: A dual mechanism approach. *Brain and Language*, 81, 276–290.
- Spreng, B. (2004). Error patterns in the acquisition of German plural morphology: Evidence for the relevance of grammatical gender as a cue. *Toronto Working Papers in Linguistics*, 23(2), 147–172.
- Szagan, G. (2001). Learning different regularities: The acquisition of noun plurals by German-speaking children. *First Language*, 21, 109–141.
- Szagan, G. (2004). Learning by ear: on the acquisition of case and gender marking by German-speaking children with normal hearing and with cochlear implants. *Journal of Child Language*, 31, 1–30.
- Tomasello, M. (2003). *Constructing a language: A usage-based theory of language acquisition*. Cambridge: Harvard University Press.
- Vollmann, R., Sedlak, M., Müller, B., & Vassilakou, M. (1997). Early verb inflection and noun plural formation in four Austrian children. *Papers and Studies in Contrastive Linguistics*, 33, 59–78.
- Wegener, H. (1999). Die Pluralbildung im Deutschen – ein Versuch im Rahmen der Optimalitätstheorie. *Linguistik online*, 4.
- Weyerts, H., Penke, M., Dohrn, U., Clahsen, H., & Münte, T. (1997). Brain potentials indicate differences between regular and irregular German plurals. *Neuroreport*, 8(4), 957–962.
- Wurzel, W. U. (1994). Gibt es im Deutschen noch eine einheitliche Substantivflexion? oder: Auf welche Weise ist die deutsche Substantivflexion möglichst angemessen zu erfassen? In K.-M. Köpcke (Ed.), *Funktionale Untersuchungen zur deutschen Nominal- und Verbmorphologie* (pp. 29–44). Tübingen: Niemeyer (= Linguistische Arbeiten 319).