Processing of German noun plurals: Evidence for first- and second-order schemata*

Klaus-Michael Köpcke
University of Münster

Sarah Schimke
TU Dortmund University

Verena Wecker
University of Münster

Abstract

This article addresses the question of how morphologically complex words are represented in the mental grammar of monolingual adult speakers of German. We contend that in perception, speakers assign a plural or singular meaning according to the degree of reliability to which a given shape is associated with the function singular or plural. In this article, we present the results of two lexical decision experiments with nonce words. In experiment 1, the nonce words presented are preceded by the article form *die*, and, in experiment 2, the same nonce words are presented as bare nouns. It turns out that the results for experiment 1 and 2 differ. Nevertheless, we argue that the results for both experiments can straightforwardly be explained by a schema account. More precisely, we distinguish between first- and second-order schemata. First-order schemata rely on the pure word form onto which a specific function is mapped. But, recent developments of the schema approach argue that in the speaker's representation of word forms not only single schemata are stored and mapped onto specific functions, but rather schema-pairs, e.g. a singular and its most likely plural partner, referred to as

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'second-order schema'. The results of our experiments support the assumption of first- and second-order schemata and their interaction.

Keywords: German, plural, processing, schema

1. The German plural system

German is morphologically rich; its plural formation is quite different from English, since it has a number of distinct, but nevertheless productive plural markers, which hardly can be seen as allomorphs of an underlying plural morpheme (cf. Köpcke 1993). Table 1 gives an overview of the plural markers in German.

In Table 1, the first four plural markers are suffixes; the fifth is phonetically zero and is analysed as a zero morpheme. The sixth is an umlaut mutation in the stem vowel of the singular form of the noun, e.g. the change from [u] to [y] in *Mutter – Mütter* 'mother' – 'mothers'. *Umlaut* (*UL*) can combine with *-Ø*, *-e*, and *-er*.[1] Obviously, the gender class (masculine, feminine, or neuter) to one of which each noun in German belongs is to a certain extent responsible for the plural form of a noun, since some of the morphemes are limited to two of the three gender classes. It is thus important to note that grammatical gender does not predict the choice of a plural morpheme, though it does constrain its selection: masculine and neuter nouns form their plural predominantly with

Table 1: Native plural markers in German (cf. Köpcke 1993: 36).

Plural Marker	masc.	fem.	neut.
-e	Fisch/Fische ('fish')	Kenntnis/-nisse ('knowledge')	Jahr/Jahre ('year')
-(e)n	Bauer/Bauern ('farmer')	Tür/Türen ('door')	Auge/Augen ('eye')
-er	Geist/Geister ('ghost')	-	Kind/Kinder ('child')
-s	Park/Parks ('park')	Mutti/Muttis ('mom')	Auto/Autos ('car')
-Ø	Adler/Adler ('eagle')	-	Fenster/Fenster ('window')
Umlaut (UL)	Vater/Väter ('father')	-[a]	-[b]
UL + -e	Sohn/Söhne ('son')	Kuh/Kühe ('cow')	-[c]
UL + -er	Wald/Wälder ('wood')	-	Volk/Völker ('people')
def. article	der SG/die PL	die SG/die PL	das SG/die PL

[a]In the entire lexicon there are only two instances, namely *Mutter – Mütter* 'mother – mothers' and *Tochter – Töchter* 'daughter – daughters'.

[b]Only one instance, namely *Kloster – Klöster* 'monastery – monasteries'.

[c]Only one instance, namely *Floß – Flöße* 'raft – rafts'.

[1] There have been attempts to reduce the number of plural markers. From a structural point of view, Wegener (1995) suggests that, due to phonological regularities, the number of plural markers can be reduced to a set of five forms, namely *-(e)n, -(e), -s, (UL +) -er, UL + -(e)*. We do not discuss this line of argumentation, since it is irrelevant to the point made in this article.

the suffix *-e*, feminines with *-(e)n*. Furthermore, nouns ending in an unstressed full vowel form their plural with *-s*, irrespectively of their gender, e.g. *der Opa* 'grandfather', *die Oma* 'grandmother', *das Auto* 'car', etc. Noun stems ending in *-e* form their plural with *-(e)n*, again independently of their gender. Finally, there are preferences based on a combination of gender and phonological shape: masculine and neuter nouns ending in a closed schwa-syllable (*-el*, *-er*, *-en*), with rare exceptions, form their plural with *-Ø*.

Although in structural analyses determiners (*der*, *die*, and *das*) are not viewed as plural markers, one of them, i.e. *die*, is included in one of the present studies, since determiners are an additional source of information in the NP regarding grammatical number. This is particularly true when they co-occur with a zero-suffixed noun, because in that case they are the only source of information in the NP, e.g. *der Wagen – die Wagen* 'car' – 'cars'.

2. Linguistic and psycholinguistic models of inflectional morphology

2.1 Rule-based models

Basically, there are two competing theoretical accounts: (i) The German number system is rule-based. Rule based Item-and-Process (IP) approaches assume that rules operate on the singular form of the noun and generate the appropriate plural form based on specific features of the singular form. For perception, this means that speakers have to segment a given form into the stem and the plural affix in order to assign a singular or plural meaning to a given word form. For theoretical purposes only, the extreme opposite of a rule-based account would be (ii) an item-specific assignment of plural forms, where nouns simply would be members of a long list, which has to be learned by the speaker. In between these two poles we favour (iii) a schema approach that assumes that speakers form the plural of a given noun according to more or less reliable plural shapes. In an IP approach, a morphologically complex word is viewed as being put together by its component parts, which, in the case of German plural morphology, are the nominal word stem and the plural marker. The German plural form *Hunde* ('dogs') can be segmented into $\{\text{hund}\}_{\text{St}}$ + $\{\text{e}\}_{\text{Pl}}$. However, this analysis seems to be less obvious with German singular/plural-pair forms like *Garten – Gärten* ('garden – gardens'), *Buch – Bücher* ('book – books'), *Wagen – Wagen* ('car – cars'), etc. where the plural is marked by an umlaut, by a combination of *UL+* suffix, or by *-Ø*, in which case the plural is not marked overtly on the noun. These facts constitute problems for any structuralist or generative IP analysis of morphology. IP-like rules account for a considerable number of nouns, but by far not all; as a result, the forms not predicted by the rules have to be enumerated in a long list of exceptions (cf., e.g., Mugdan 1977). Bybee (2003: 126) refers to these rules as source-oriented, as they "act on a specific input to change it in well-defined ways into an output of a certain form." The structuralist descriptions of the German plural morphology have in common that the gender and the phonological shape of the final syllable of the singular form are the relevant factors on which the rules are grounded, e.g. feminine nouns ending in schwa take the plural marker *-n* (for a more detailed description of the German number system cf. Köpcke 1993). One important objection to this view is its implication that the derived form (plural) has no independent

representation in the speaker's mental lexicon (e.g. Bybee 1985; 1988; Köpcke 1993). Instead, this word form is always derived from the singular.

From a psycholinguistic perspective, the IP account would be classified as a symbolic model of language representation and processing. It is thus assumed that speakers take the singular stem and change it according to specific rules to derive the desired plural form. Irregular plural forms that cannot be derived by a rule are stored holistically (cf. Günther 2004). These approaches thus assume two processes to be at work, i.e. parsing (segmenting a given word form into its parts) and single-processing of words (applying a holistic representation) (cf. Schreuder & Baayen 1995; Clahsen 1999; Pinker 1999). A prominent instance of this approach is the dual-mechanism model (cf. Clahsen et al. 1992; Clahsen 1999; Pinker 1999; Sonnenstuhl-Henning 2003), which in earlier versions postulated one regular default plural marker (*-s*) and long lists of exceptions to account for the German number system. It is assumed that the irregular plurals are stored holistically and pattern according to phonological similarities. There are a number of empirical studies using different experimental techniques that have provided evidence for this claim (cf. Clahsen, Eisenbeiss & Sonnenstuhl-Henning 1997; Sonnenstuhl, Eisenbeiss & Clahsen 1999; Beretta et al. 2003; for an overview, cf. Clahsen, Sonnenstuhl & Blevins 2003). These studies often rely on the observation that, while the frequency of plural word forms that are irregular according to these models typically influences lexical decision times, regular plural forms seem to be less susceptible to frequency effects. The plural marker *-s* in German is relatively infrequent but processed much faster than other plural markers. This has been interpreted as an indication that these regular forms cannot be accessed holistically in the mental lexicon, and rather, that the stem and the affix are processed separately, such that the decision is influenced by the affix only and is not determined by the frequency of the word form.

Given the complex German number system (cf. section 1), it is quite difficult to believe that *-s* should qualify as the only default (regular) marker for plural in German. In the extended later version of the dual-mechanism model (Penke & Krause 2002; Sonnenstuhl-Henning 2003), it is argued that the *-n* plural for feminines ending in schwa does not have the same status as the other irregular plurals, as its appearance is highly predictable.[2]

An alternative approach is that parsing and retrieval operate within the same system, which is called the 'dual route race model' (cf. Schreuder & Baayen 1995; Frost et al. 1997). Baayen and others have moved away from a traditional competence model to dynamic modelling of the speech production process and the representations that speakers use as they produce utterances. This model is influenced by two important movements in modern (psycho-)linguistics: One is the usage-based grammar movement within Cognitive Linguistics; the other is work within computational and

[2] Some specifications of dual route models distinguish, when referring to retrieval from lexical memory, between different factors that influence recognition, i.e. the type of suffix (e.g. Marslen-Wilson et al. 1994 or Taft 1994), the productivity of the affix (e.g. Bertram, Schreuder & Baayen 2000), the transparency of form-meaning relations between the parts of the complex word form (e.g. Feldman & Soltano 1999), and finally the speaker's age (Reifegerste 2014).

psycholinguistics. Both have led to a hybrid model of linguistic mental representations. The core idea is the following: as the frequency of an expression increases, the more likely the speaker will store a composite, holistic representation of that expression. Empirical studies of a number of different expression types support this hypothesis, in particular, studies on inflected lexemes such as past tense and plural (e.g. Baayen et al. 2015). The hybrid representation approach (Baayen & Ramscar 2015) generalizes from such findings to present a whole new way of conceptualizing the problem of holistic vs. computed representations. It proposes a dual channel lexical access process: all complex (non-minimal) expressions are computed in one channel and accessed as a (holistic) memory trace in the other. Which channel is utilized depends on the relative strength of the competing channels (computation vs. memory). In simple terms: everything is stored as a whole, and everything is computed (Baayen, et al. 2019).

2.2 Schema-based models

The extreme opposite to a symbolic account of morphology would be that each single word has its unique representation. We do not want to follow this line of argumentation, but it should be clear that alternative accounts to the symbolic representation of inflectional morphology assume that the speaker and his or her individual linguistic experience influence the construction of grammatical systems in crucial ways. These approaches are somewhere in between a symbolic account and a word-specific account. They can be subsumed under the label of usage-based linguistics (cf. Bybee 2006). In a usage-based model, concrete word forms are stored independently from base forms and the grammatical organization emerges as a result of the storage itself. Through the recognition of phonological and semantic similarities between stored word forms, speakers are able to make decisions regarding the grammatical structure of a specific word form. Most likely, this idea has its roots in analogy theory. However, whereas, in extreme cases, analogy can be viewed as the result of establishing a specific ad hoc relation between a known and an unknown word form, schemata are abstractions of many known word forms. This means that language users do not have to recall specific word forms and then make decisions on the basis of these individual exemplars. The assignment of a specific grammatical function is the result of the relative strength of a *gestalt*, compared with competing functions that reveal the same or a similar *gestalt*. A schema is product-oriented, in the sense that it generalizes over many forms that belong to a specific grammatical category (e.g., plural).

Connectionist models of language representation (cf. Rumelhart & McClelland 1986; Bates & MacWhinney 1987) follow the same lines of argumentation as schema models, since these models simulate rule-like behaviour without the notion of rules, such that there is no need for assuming two mechanisms as in dual-mechanism models. Rather, in these single-route models (Bybee 1995; Elman et al. 1996; Seidenberg & Elman 1999), all elements are processed in the same way, i.e. by associative patterning (cf. Gor 2010).

Köpcke (1993) notes that none of the plural formations in German can be exclusively associated with the semantic notion of plurality. For example, a schema that ends in

Table 2: Singular and plural schemata in German.

	Schemata			
	Xe	XULe	Xs	Xen
plural	*Hunde* ('dogs')	*Bäume* ('trees')	*Parks* ('parks')	*Blumen* ('flowers')
singular	*Blume* ('flower')	*Mücke* ('mosquito')	*Gans* ('goose')	*Wagen* ('car')

schwa can be associated with a singular meaning as well as with a plural meaning. This holds for all schemata that can be abstracted from German plural forms. Table 2 illustrates this fact for those schemata that we tested.

Nevertheless, there are clear differences concerning the reliability with which the various schemata signal plural (or singular). In order to define the degree of reliability, it is assumed that the **type** frequency with which a phonological ending occurs in the plural **and** singular function is decisive (cf. Köpcke & Wecker 2017). This is in line with assumptions in the framework of usage-based linguistics where it is assumed that high type frequency leads to the abstraction of schemata, whereas high token frequency "leads to entrenchment and storage as 'chunk[s]'" (Behrens 2009: 386).[3] Therefore, a word ending that is very frequent in the plural and, at the same time, infrequent in the singular, is more reliable for the plural function. One that is equally frequent in both, singular and plural, is then less reliable for the plural function. Therefore, for a word with a specific ending to be reliable for the plural meaning, its *gestalt* should be more frequent in the plural than in the singular, and the difference between its frequency in the singular and plural should be as large as possible.[4]

In order to determine the relative validity of the schemata we tested, we conducted an analysis of the German nominal lexicon (Mater 1967; Augst 1975; Köpcke 1982). Table 3 gives an overview of the total number of singular and plural nouns that display a certain schema. In the singular, we differentiate between nouns of all gender classes and feminine nouns (in brackets) because of the special status of the determiner *die*, given that this form is the same for feminine nouns in the singular and, independent of their gender class, all nouns in the plural.[5]

The important message of Table 3 is that the type frequencies of schemata are mostly unevenly distributed over the lexicon, regardless of whether nouns of all three genders

[3] As Casenhiser & Goldberg (2005) show, a certain degree of token frequency is also necessary for the abstraction of a schema, but type frequency still seems to be decisive for schema abstraction.

[4] This corresponds to the criterion of *validity* in Köpcke (1993).

[5] The article form *die* is used in the singular (with feminine nouns in the nominative and accusative case) and in the plural (with nouns of all gender classes in the nominative and accusative) and is thus ambiguous in this regard. The other forms of the definite article, *der* and *das*, appear predominantly in the singular. The only exception is the use of *der* in the genitive plural, a case that is frequently replaced with a periphrastic construction, e.g. *das Haus der Männer* 'the men's house' > *das Haus von den Männern* 'the house of the men'.

Table 3: Type frequency of schemata with singular and/or plural function.

	Sg.	Pl.
Monosyllabic: X (die X)	1466 (205)	-
Bisyllabic: Xe (die Xe)	2218 (2068)	778
Bisyllabic: XULe (die XULe)	175 (166)	256
Monosyllabic: Xs (die Xs)[a]	72 (2)	90
Bisyllabic: Xen (die Xen)	271/0	2980

In brackets we give the number of feminine nouns, i.e. nouns that take the *die*-form in the singular. The first line of Table 3 then means that among the 1466 monosyllabic nouns are 205 feminines.

[a]We only counted monosyllabic nouns ending graphematically in -<s>. Nouns ending only phonologically but not graphematically in -[s] were not considered, e.g. *Tanz* [tants] ('dance').

are taken into consideration or just the feminine ones. Irrespective of its gender, a *gestalt*, such as a monosyllabic noun, is always associated with singular, and a bisyllabic noun ending in schwa (*Xe*) has a strong tendency towards singular. Specifically, this tendency also holds for feminine nouns. In contrast, nouns ending in *-s* and *-en* have a bias for plural. This bias is even stronger for singular feminine nouns. At first sight, the number of nouns with the plural ending *-s* is fairly low, but it should be kept in mind that the number of plurals ending in *-s* increases when the productive plural form *-s* for proper nouns (*die Müllers*), acronyms (*die LKWs*), nominalizations (*die Hochs und Tiefs* 'the ups and downs'), and for borrowings (*die Bars* 'the bars') is taken into account (cf. also Clahsen, et al. 1992). In all of these cases *-s* mostly seems to be the default, which is only used in very specific circumstances (cf. Fraser & Corbett 1997).

Finally, a *gestalt* like *XULe* occupies the middle ground since it shows up almost with the same frequency in the singular and the plural.

Empirical evidence for the schema approach comes, among other things, from acquisition studies of the German plural system showing that children (L1 and L2 learners) produce and interpret plural forms according to their degree of reliability for the function of singular or plural, respectively (cf. e.g. Köpcke 1993; Köpcke 1998; Ewers 1999; Behrens 2002; Wegener 2008; Wecker 2016; Köpcke & Wecker 2017). Compatible results are reported on the acquisition of an artificial language by adults (e.g. Kapatsinski, 2012; 2013).

Recent developments of the schema approach (Wecker 2016; Köpcke & Wecker 2017) argue that, in the speaker's representation of word forms, not only single schemata are stored and mapped onto specific functions, but rather schema-pairs that we refer to as 'second-order schemata' (cf. Nesset 2008); i.e., we contend that the speaker associates a schema like *die Xe* with a complementary partner *die Xen* and a schema *der/das Xen* with a partner *die Xen*. In other words, the speaker builds up something that could be called a paradigmatic relation between singular and plural. We will come back to the issue of second-order schemata in section 3.

Against this background, our studies aim at providing a new answer to the question of how the knowledge of the grammatical category 'number' is mentally represented.

3. The current study

In two experiments, in which participants had to decide whether a given nonce word form was singular or plural, we aimed at elucidating the type of knowledge adult native speakers of German use when processing nonce words. In both experiments, we used the same nonce words. The only difference was that in experiment 2 the nonce words were presented in isolation, whereas in experiment 1 all nonce words were accompanied by the article form *die*, which can be either the singular feminine article form or the plural form for all three genders in German. The reason for presenting the items in the first experiment with the article *die* was that this is the only article form in German that is, at least in the nominative case, ambiguous regarding its number value, since it appears in both singular and plural contexts. In both experiments, we focused on five different phonological shapes that were created by combining monosyllabic (nonce) stems with either no suffix, the suffix *-e*, a combination of *Umlaut* and *-e*, *-s*, and *-en*. According to the schema approach, the shapes should form a continuum with respect to the likelihood of being perceived as a plural form. More precisely, this likelihood should increase in the order shown in Figure 1.

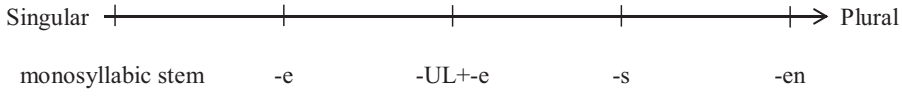

Figure 1: Continuum of word forms and their likelihood to be perceived as plural.

3.1 Experiment 1: article + noun

The aim of experiment 1 was to test for effects of schema-based knowledge in explicit judgments of nonce words as singular or plural. We decided to present all test items accompanied by the article form *die*, for reasons given above. Furthermore, we assumed that a combination of article form and noun would sound more natural to the participants than bare nouns, since bare nouns hardly occur in German and are mostly limited to abstract and mass nouns.

3.1.1 *Method*

Participants

Participants were 58 adult native speakers of German (mean age: 24.3, range. 21–33, 4 male and 54 female). They were beginning students of German philology and participated in the experiment in exchange for course credit.

Materials

We created 60 monosyllabic nonce stems, all of which followed the phonotactic patterns of German and ended in a consonant or consonant cluster (see Appendix 1). At the same time, stems were selected that, as much as possible, do not have rhyming counterparts in

Table 4: Five phonological shapes tested for the nonce-word *Knolk*.

bare stem (-Ø)	-e	Umlaut + -e (UL+-e)	-s	-en
Knolk	Knolke	Knölke	Knolks	Knolken

the German lexicon. Furthermore, we avoided the presentation of nonce stems that are otherwise strongly associated with existing lexical items. Each of these stems was either presented on its own or combined with the suffix *-e*, *UL+e*, *-s*, or *-en*, resulting in five phonological shapes for each stem. To give an example, the resulting shapes for the stem *Knolk* are listed in Table 4.

Overall, there were 300 different stimuli. Each participant saw 60 of these stimuli, 12 of each type, following a Latin square design. Thus, each nonce stem appeared once in each list, with a different shape in each of the lists, and each of the five shapes appeared an equal number of times in each list. During the experiment, all shapes were preceded by the article *die*. We assumed that this article form may influence decisions, favouring plural over singular decisions, given that *die* occurs more often in plural than in singular contexts, since, for all three genders, it is the plural form used in subject and direct object noun phrases. It is important to note, however, that the article form *die* is also used for feminine subjects and direct objects in the singular.

Procedure

Participants took the test in groups of up to twenty people. They were each seated individually in front of a computer screen and were informed that they were to see non-existing words, and that they should "decide as fast and accurately as possible whether the word sounded plural or singular to them". They indicated this by pressing the button "0" or "1" with their index finger (of the left and right hand, respectively). Which of the two numbers denoted which concept was counterbalanced across the participants. The participants then read six nonce-words, all preceded by the article form *die*, three of them ending in *-er* and three of them ending in *-el*,[6] to practice the task. After all participants had finished the practice session, they started the main experimental session. During the main session, each participant was presented, in a random order, with the 60 forms of the experimental list that had been randomly assigned to him or her. Participants were instructed to wait in silence, when they had finished judging the 60 nonce words, until the main session had been completed by all participants. They then filled out a background questionnaire. Finally, the participants were informed about the purpose of the experiment. The entire session lasted approximately 45 minutes.

[6] Both forms were not part of the experimental stimuli, but *-er* is a possible plural marker whereas *-el* is not.

3.1.2 *Hypotheses*

Data were examined with respect to the influence of the shape on the percentage of plural decisions, and on the speed with which these decisions were taken. With respect to the percentage of plural decisions, a schema model would predict that there should be a gradual increase in the percentage of plural decisions the more reliably the shape signals the function of singular and plural, respectively. Thus, for the shapes tested here, the likelihood of a plural decision should increase in the following order: stem, *-e*, *UL+-e*, *-s*, *-en*, cf. Figure 1. With respect to the speed with which the decision is made, we hypothesize that the decision may be faster for schemata with a high reliability, as this implies that there should be less competition from the opposite function, i.e. singular. Shapes ending in *-s* and *-en* have a high reliability for the function plural. On the other hand, monosyllabic stems have a high reliability for singular. We thus predict higher decision times for the more ambiguous shapes ending in *-e* and *UL+-e* than for the less ambiguous shapes ending in *-s*, *-en*, or bare stems.

3.1.3 *Results*

Figure 2 displays the percentage of plural decisions out of all singular and plural decisions for each of the shapes.

For statistical analyses of this and the other data sets, we relied on several functions from the lme4 package in R (Bates et al., 2005). We first computed a logistic mixed effect model using the *glmer* function. We included "outcome" (singular, plural) as the dependent variable and "shape" (stem, *-e*, *UL+-e*, *-s*, *-en*) as predictor variable, as well as

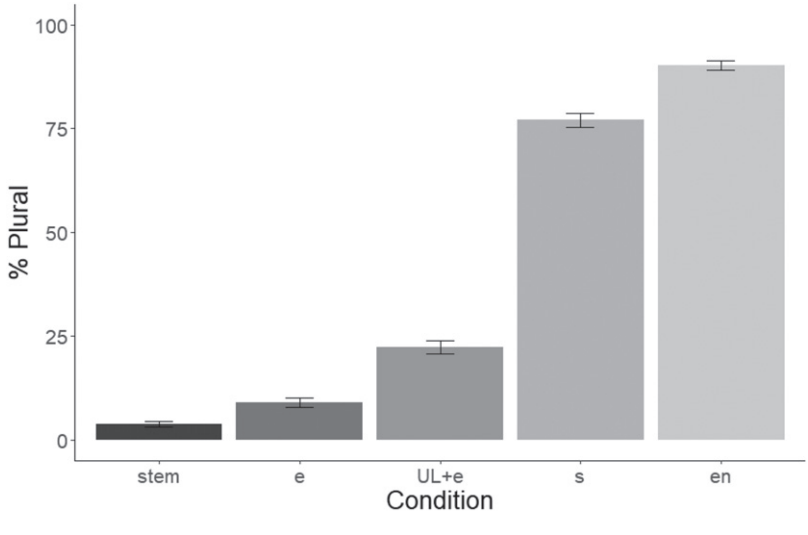

Figure 2: Percentage of plural decisions for each of the shapes in Experiment 1. Error bars represent the standard error.

Table 5: Estimates, standard error and Z-values for comparisons between the likelihoods of plural decisions for the different shapes in Experiment 1. P-values lower than .0125 are considered significant.

Comparison	Estimate	SE	z-ratio	p-value	Adjusted α
-stem vs. –e	0.954	0.243	3.925	.0001	0.0125
-e vs. UL+e	1.115	0.166	6.728	< .0001	0.0125
UL+e vs. -s	2.676	0.140	19.072	< .0001	0.0125
-s vs. -en	1.067	0.161	6.644	< .0001	0.0125

random intercepts for participants and items. Using the *drop1* function, we then computed a chi-square test to compare the model with the factor "shape" to a model without this factor. This test revealed that the model including the factor "shape" was a significantly better fit to the data (AIC of the model without "shape" =2519.9, with "shape" = 4678.5, $p < .001$). Having established this overall effect of the factor "shape", we performed pairwise comparisons using the *emmeans* function between the results for shapes that are adjacent in Figure 1. As there were four such comparisons (stem vs. *-e*, *-e* vs. *UL+-e*, *UL+-e* vs. *-s*, *-s* vs. *-en*), we used a bonferroni correction to adjust the alpha-level. The results are displayed in Table 5, and reveal that there was a significant difference in the likelihood of a plural decision between all shapes that we compared.

The general order of decisions is in line with a schema model. In absolute terms, however, some of these decisions are surprising, in that *-e* and *UL+-e*, which should not be unequivocal signals of singularity according to the criteria put forward by schema approaches, led to a relatively high number of singular decisions. Before we discuss this observation in more detail, we turn to the speed with which the decisions were made. Recall that we predicted that the less ambiguous shapes (stem, *-s*, and *-en*) should lead to faster decision times than the more ambiguous shapes (*-e* and *UL+-e*). Figure 3 presents the average decision times for the five phonological shapes.

We first computed a linear mixed effect model using the *lmer* function. We included "decision time" as the dependent variable and "shape" (stem, *-e*, *UL+-e*, *-s*, *-en*) as predictor variable, as well as random intercepts for participants and items. Using the *drop1* function, we then compared the model with the factor "shape" to a model without this factor. This test revealed that the model including the factor "shape" was a significantly better fit to the data ($F(4) = 10.928$, $p < .001$). Having established this overall effect of the factor "shape", we performed pairwise comparisons using the *emmeans* function between the results for shapes that are adjacent in Figure 1. As there were four such comparisons (stem vs. *-e*, *-e* vs. *UL+-e*, *UL+-e* vs. *-s*, *-s* vs. *-en*), we used a bonferroni correction to adjust the alpha-level. The results are displayed in Table 6, and reveal that while there was a significant difference in the decision time for the stem compared to the *-e* suffix, the differences in decision times between the other suffixes were not significant when only adjacent suffixes were compared.

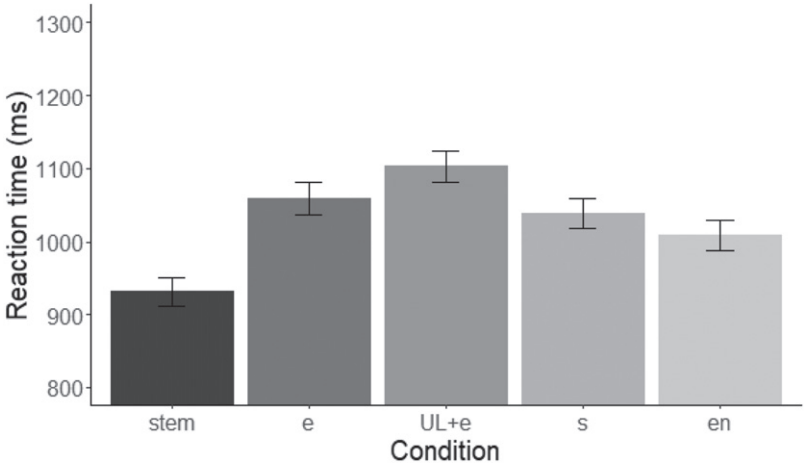

Figure 3: Average decision times for each of the shapes in Experiment 1. Error bars represent the standard error.

Table 6: Estimates, standard error and Z-values for comparisons between the decision times for the different shapes in Experiment 1. P-values lower than .0125 are considered significant.

Comparison	Estimate	SE	z-ratio	p-value	Adjusted α
-stem vs. –e	-128	27.5	-4.66	< .0001	0.0125
-e vs. UL+e	-44.4	27.5	-1.62	0.11 (ns)	0.0125
UL+e vs. -s	67.0	27.5	2.44	0.015 (ns)	0.0125
-s vs. -en	27.4	27.5	0.998	0.318 (ns)	0.0125

3.1.4 *Discussion*

Numerically, the speed with which the participants of the experiment made their decisions were in line with what would be expected based on a schema model. The shapes that have the highest reliability for a specific function (stem, *-s*, and *-en*) lead to faster decision times than the more ambiguous shapes *-e* and *UL+-e*. While this observation is compatible with the idea that the reliability of a shape associated with the function plural (or singular) determines how fast a decision is made, the absence of a statistically significant effect for most comparisons indicates that if this idea is correct, its effects are not strong enough to be detected with certainty at least with the method used in this study.

At first sight, the percentages of plural decisions taken for the five different shapes are also in line with the schema model, if we look at the order in which the likelihood of a

plural decision increases as a function of the shape. This order (*-Ø* < *-e* < *UL+-e* < *-s* < *-en*) corresponds exactly to what would be predicted by a schema approach. Moreover, the fact that all of the tested differences are significant is strong evidence that native speakers are sensitive to fine-grained differences between the reliabilities of different shapes, which is also in line with the schema model. On the other hand, however, it is clear that the decisions are not a direct reflection of the absolute frequencies of the different shapes in the language system. The shape *die Xe* is of almost equal frequency in the singular and the plural, due to the feminines ending in schwa in the singular and the many monosyllabic masculine and neuter nouns that form their plural with schwa. This thus suggests that the participants' decisions did not necessarily reflect their perception of the shapes in absolute terms, but that their relative appropriateness as markers of plurality given in the context of the experiment played a role. In an experiment without fillers and with only two possible decisions (singular or plural), participants may have had a tendency to produce an approximately equal number of "singular" and "plural" responses. Since, overall, we tested more shapes that are similar to existing plural than to existing singular word forms, this factor may have decreased the number of plural decisions for those shapes that were relatively less suitable as plurals than the two dominant shapes *-s* and *-en*.[7]

An alternative explanation of the results shown in Figure 2, which still would be in line with our hypotheses, centres around the middle ground, i.e. *-e* and *UL+-e*. The extremes on the left and on the right are exactly what we expected, but the results for *-e* and *UL+-e* are unexpected, since we predicted higher percentages of plural decisions. We assume that, because of the article form *die*, the participants of the experiment were in a feminine processing mode and constructed singular-plural-pairs instead of evaluating the given nonce word without possible singular or plural partners playing a role. In using the formulation "being in a feminine processing mode", we want to suggest that participants did not rely on their knowledge about plural and singular schemata for masculine and neuter nouns at all. If we follow this interpretation, most of the results can be explained. The decision for monosyllabic nouns as being singular is in line with our expectations, since monosyllabic nouns are singulars, no matter what their gender is. The only exceptions are a relatively small number of nouns that form their plural with *-s*, e.g. *der Park – die Parks* 'park', cf. Table 3. The results most in need of an explanation are those for the nonce nouns ending in a schwa, since we expected a higher rate of plural decisions here. But, since by far most nouns in the German lexicon ending in schwa belong to the feminine gender class, one could interpret schwa not only as a plural marker, but also as a marker for feminine nouns. Against this background, it becomes plausible that the participants of the experiment processed those nonce nouns as singular.

[7] It is possible that this also contributed to the higher reaction times for these two shapes.

The regular plural, without exception, of feminine nouns ending in schwa is formed with *-en*.[8] As a consequence, the participants of the experiment favoured a form like *die Xen* as being plural. The results for *UL+-e* are significantly higher for the plural decision than those for *-e*. Again, this is compatible with the idea that the participants in the experiment were in a feminine mode, since, for only roughly 40 out of the total of about 200 monosyllabic feminine nouns, *UL+-e* is the designated plural marker, e.g. *Kuh, Nuss, Brust* > *Kühe, Nüsse, Brüste*. The results for *UL+-e* reflect this ratio. Finally, the decisions for *-s* are also compatible with this assumption, since there are only two monosyllabic feminine nouns that, in the singular, have a postvocalic consonantal cluster of the structure 'consonant followed by <s>', i.e. *Gans* und *Gams*.

To conclude, in addition to an orientation that focuses simply on the shape of one word form (first-order schema), the participants also (and maybe more strongly) relied on second-order schemata in order to decide for singular or plural. This differentiation between first-order and second-order schemata follows Nesset (2008). Köpcke & Wecker (2017: 84–85) assume that a first-order schema corresponds to a generalization about word forms that is mapped to a specific grammatical function (for example, plural). A second-order schema, on the other hand, "accounts for the paradigmatic relations between different first-order schemas. A second-order schema is thus a kind of a 'super'-schema that relates two first-order schemas to each other" (Köpcke & Wecker 2017: 85). In contrast to a first-order schema, a second-order schema is source-oriented as it captures generalizations about paradigmatically related forms. An example of such a super-schema would be the associative connection between a first-order schema for singular, e.g. *die Xe* as in *die Katze* ('the cat') and a first-order schema for plural (e.g. *die Xen* as in *die Katzen* ('the cats'). The advantage of assuming these two kinds of schemata is that it allows us to account for paradigmatic as well as product-oriented generalizations within one unified theoretical framework, without necessitating two completely different processing mechanisms (such as storage and computation in the dual-mechanism model).

The results of our experiment suggest that – metaphorically speaking – speakers were searching their mental lexicon for possible singular or plural partners of the presented word in order to make a decision. This means that second-order schemata played a decisive role in their decisions. Seeing a word like *die Knölke*, speakers easily find a partner which is more plural-like: *die Knölken*. The pair *die Knölke – die Knölken* represents a very common second-order schema in German, since all feminine nouns ending in *-e* form their plural with *-n*. Furthermore, we assume that the presence of the definite article *die* throughout the whole experiment made it harder for the participants to activate masculine and neuter singular nouns (which are never preceded by the definite article *die*), which would be an additional factor that would have favoured

[8] It should be noted at this point that all nouns ending in schwa regardless of their gender mark their plural with *-n*. Forms that would create a hiatus are avoided in German, therefore for purely phonological reasons only *-n* is attached as a plural marker, e.g. *die Kurve – die Kurven* ('curve – curves').

singular decisions in general. These considerations also hold for the explanation of the results for the other items (stem, *-e*, *-s* and *-en*): For monosyllabic items of the type *die Knolk* and for items ending in *-en* like *die Knolken*, it is impossible to find a singular partner or a plural partner, respectively. Accordingly, the participants very consistently decided for singular or plural, respectively. For items ending in *-e* (*die Knolke*), participants easily find a more plural-like partner ending in *-n* (*die Knolken*), which results in a strong second-order schema, leading them to choose the singular in most of the cases. For items ending in *-s*, it is easy to find a more singular-like partner (*die Knolk – die Knolks*). If the participants had made their decisions solely on the basis of first-order schemata (i.e. without searching for a singular or plural partner to the given word), according to the frequencies given in Table 3, the plural decisions would have had to be higher for items ending in *-e* and *UL+-e*. The fact that they are not leads us to believe that second-order schemata played a role in this experiment. This line of argumentation, according to which second-order schemata or, more generally, higher order schemata are thought of as important elements in language systems, their acquisition and processing, currently receives more and more attention in the theoretical discussion (cf. Hilpert 2019, Kapatsinski 2013).

3.2. Experiment 2: bare nouns

The possible restraining influence of the definite article *die* and the theory of second-order schemata led us to conduct a second experiment. This time we presented the pseudo-nouns without definite articles, i.e., bare nouns. A different solution would have been to present the items with the three article forms *der*, *die* and *das*. We decided against this option, because in the given context the forms *der* and *das* would be almost unambiguously singular cues for the participants. We expected that they would rely on this unambiguous cue and choose the singular for all items presented with *der* and *das*, whereas all the items presented with the article *die* would be judged as plurals. Consequently, the different shapes of the items would not have the same influence on the participants' decisions as in cases where the article is ambiguous (*die*) or non-existing.

3.2.1 *Method*

Participants

Participants were 36 adult native speakers of German (mean age: 22.2 years, range 20–29, 3 male, 33 female). They were beginning students of German philology and participated in the experiment in exchange for course credit.

Materials and Procedure

The materials and procedure were the same as for Experiment 1, except that all nouns were presented without the preceding article.

3.2.2 *Hypotheses*

We expect that in this experiment, the overall validity of the tested schemata, as opposed to the validity of schemata when considering feminine nouns only, will influence decisions. This means that the results should reflect the ratio of singular and plural forms as shown in Table 3 more closely than they did for Experiment 1.

3.2.3 *Results and discussion*

The results for experiment 2 with respect to plural decisions are as presented in Figures 4 and 5.

Concerning the number of plural decisions, we computed a logistic mixed effect model using the *glmer* function. We included "outcome" (singular, plural) as the dependent variable and "shape" (stem, *-e*, *UL+-e*, *-s*, *-en*) as predictor variable, as well as random intercepts for participants and items. Using the *drop1* function, we then calculated a chi-square test to compare the model with the factor "shape" to a model without this factor. This test revealed that the model including the factor "shape" was a significantly better fit to the data (AIC of the model with "shape" = 1692.9, without "shape" = 2951.4, $p < .001$). Having established this overall effect of the factor "shape", we performed pairwise comparisons using the *emmeans* function between the results for shapes that are adjacent in Figure 1. Again, we used a bonferroni correction to adjust the alpha-level. The results are displayed in Table 7, and reveal that there was a significant difference in the likelihood of a plural decision between all shapes that we compared, except for the difference in decisions between *–s* and *–en*, for which no difference could be observed.

For the decision times, we computed a linear mixed effect model using the *lmer* function. We included "decision time" as the dependent variable and "shape" (stem, *-e*,

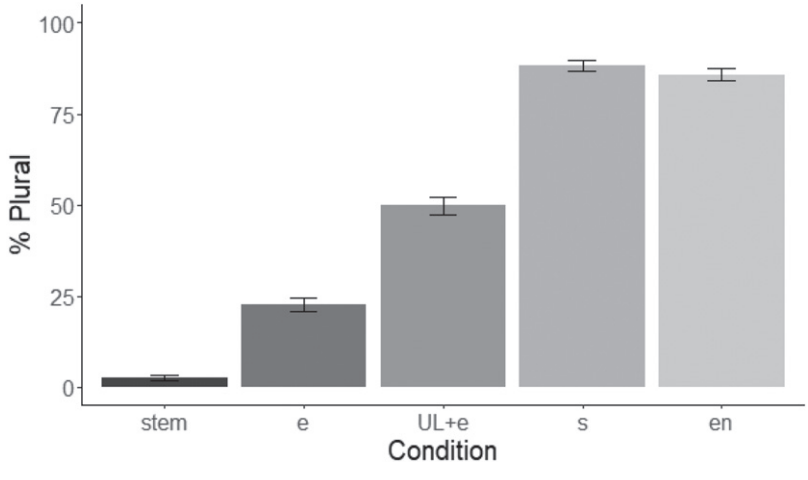

Figure 4: Percentage of plural decisions for each of the shapes in Experiment 2. Error bars represent the standard error.

Table 7: Estimates, standard error and Z-values for comparisons between the likelihoods of plural decisions for the different shapes in Experiment 2. P-values lower than .0125 are considered significant.

Comparison	Estimate	SE	z-ratio	p-value	Adjusted α
-stem vs. –e	2.689	0.345	7.793	.0001	0.0125
-e vs. UL+e	1.502	0.171	8.774	< .0001	0.0125
UL+e vs. -s	2.353	0.195	12.052	< .0001	0.0125
-s vs. -en	-0.227	0.213	-1.064	0.287 (ns)	0.0125

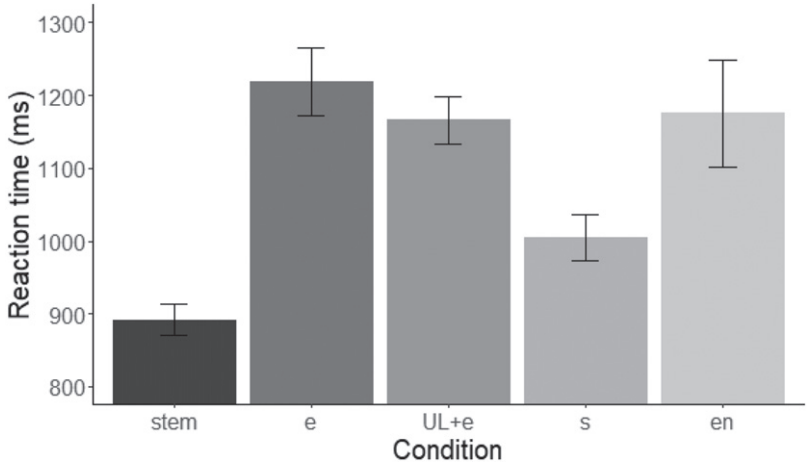

Figure 5: Average decision times for each of the shapes in Experiment 2. Error bars represent the standard error.

UL+-e, *-s*, *-en*) as predictor variable, as well as random intercepts for participants and items. Using the *drop1* function, we then compared the model with the factor "shape" to a model without this factor. This test revealed that the model including the factor "shape" was a significantly better fit to the data ($F(4) = 10.405$, $p < .001$) Having established this overall effect of the factor "shape", we performed pairwise comparisons using the *emmeans* function between the results for shapes that are adjacent in Figure 1. We again used a bonferroni correction to adjust the alpha-level. The results are displayed in Table 8, and reveal that there were significant differences between the decision times for the adjacent shapes that we compared, except for the difference in decision times between *-e* and *UL+-e*.

Our basic assumption was that the structure of the nominal lexicon, i.e. the type frequency of the different schemata and the frequency of their appearance in the singular and plural function should explain the number of plural vs. singular decisions in this experiment.

Table 8: Estimates, standard error and z-ratio for comparisons between the decision times for the different shapes in Experiment 2. P-values lower than .0125 are considered significant.

Comparison	Estimate	SE	z-ratio	p-value	Adjusted α
-stem vs. –e	-330.29	60.9	-5.420	< .0001	0.0125
-e vs. UL+e	53.44	60.9	0.878	0.380 (ns)	0.0125
UL+e vs. -s	161.68	60.9	2.653	0.008	0.0125
-s vs. -en	-168.82	60.9	-2.773	0.006	0.0125

In particular, we hypothesized above that the surprisingly low number of plural decisions for shapes ending in *-e* and in *UL+-e* in Experiment 1 could be due to participants being in a "feminine processing mode". As can be seen from Figures 2 and 4, in line with this explanation, there were indeed more plural decisions for items ending in *-e* and *-UL+-e* in Experiment 2 than in Experiment 1. As a complex statistical model with data from both experiments that included both the factors "Experiment", "Shape" and their interaction failed to converge, we decided to run two logistic mixed effect models concerning only the specific comparisons that we predicted based on Experiment 1, namely, the comparison between the number of plural decisions for *-e* and *UL+-e* in Experiment 1 compared to Experiment 2. These models included "Experiment" as a predictor, as well as participants and items as random intercepts, and were run on the subsets of the data including only the *-e* and the *UL+-e* shape, respectively. We found that the difference in the number of plural decisions between the two experiments was significant for these two shapes (effect of "Experiment" for the shape *UL+-e*: estimate: −1.2822, standard error: 0.1697, z-value: −7.553, $p < .001$ effect of "Experiment for the shape *-e*: estimate: −1.0610, standard error: 0.2047, z-value: −5.184, $p < .001$. Note that these differences are significant also when assuming an alpha-level of .025, adjusted for the fact that we conducted two comparisons). Moreover, while there was a significant difference between the number of plural decisions for items ending in *-en* as compared to *-s* in Experiment 1, this was not the case in Experiment 2. The high number of plural decisions for *-e* and *UL+-e* in experiment 2 strengthen our assumption that the definite article *die* in the first experiment led the participants to neglect masculine and neuter nouns and that they were in a feminine processing mode.

The number of plural decisions for items ending in schwa reflects type frequency effects of the lexicon, since there are far more nouns ending in schwa in the singular (cf. Table 3). The case of *UL+-e* in the second experiment matches the relations in the German nominal lexicon: nouns with Umlaut ending in *-e* exist in the singular (*Brücke* 'bridge') and plural (*Wölfe* 'wolves') function. In fact, a backwards dictionary (Mater 1967) reveals that the absolute number between singular and plural is almost equal for this *gestalt*, cf. Table 3. We thus think that 50% plural decisions for items of the type *UL +-e* reflect the relations in the nominal lexicon quite well.

Turning to the number of plural choices for items ending in *-s* and *-en*, the relatively lower number of plural choices for *-s* that was observed in Experiment 1 could not be found in Experiment 2, where both suffixes led to a roughly equal number of choices of the plural. We assume that the article *die* in the first experiment reinforced a singular interpretation of the pseudo-words just like we argued for items of the type *-e* or *UL+-e*. To our mind, this difference between the first and the second experiment concerning items ending in *-s* also shows that *-s* does not have a special status, as assumed in the dual-mechanism model. If speakers treated nouns with a plural *-s* systematically differently from nouns with other plurals, this special treatment should not be influenced by the presence or absence of the definite article. The high number of decisions for the *s*-plural in the second experiment can partly be explained by the fact that new words that are not yet integrated into the speaker's lexicon tend to receive the *-s* plural. This can be seen with loans and acronyms. In a way, our nonce words could be seen as very recent nouns from the participants' perspective.

Our general hypothesis is strengthened by the differences in the reaction times of the participants. They decided very quickly for items that represented an (almost) unambiguous schema (monosyllabic items and items ending in *-s* and *-en*). However, it took the participants longer to decide on items which did not represent an unambiguous schema (*-e*, *UL+-e*). To our mind, the time difference can be attributed to the fact that the participants retrieved singular as well as plural shapes in their mental lexicon.

4. Conclusion

We asked what kind of knowledge native speakers use when making explicit decisions about German nonce words. Our data largely confirmed predictions based on schema models. We found that the probability with which speakers assign the function plural to a nonce word increased gradually, the more the shape of the nonce word was reliable as a signal of this function. Moreover, the more reliable the schemata were for the function of plurality the faster the decision times compared to more ambiguous schemata.

Furthermore, the results of experiment 1 provide evidence that the participants of the experiments decided not on the basis of only one isolated word form (first-order schema), but rather on singular-plural pairs (second-order schemata). If a pure word form account were true, the definite article form *die* should have evoked a higher number of plural decisions, since it could be interpreted as a further cue of plurality. As a matter of fact, *die* does not point in this direction. The results of experiment 1 rather suggest that the participants of our study activated second-order schemata. The results demonstrate that in the speaker's mental lexicon not only pure word forms are represented, but also probabilistic relations to competing functions, i.e. 'singular' versus 'plural'. It looks as if the speaker searches in the mental lexicon for the best partner of a given word form.

Finally, the results of our experiments show no evidence for the special status of the plural marker *-s*, which the dual-mechanism model or its descendants assume. Arguments in favour of this view are the relatively limited number of nouns that take *-s* as their plural marker, cf. Table 3. The fact that speakers prefer an infrequent affix

is of course a strong argument, since it undermines a central claim of single mechanism theories, namely, that type frequency is the most important determinant of productivity. Instead of taking this rather strong theoretical position of giving *-s* a special status, we would like to argue that *-s* is a kind of a "Notplural" ('emergency plural'), i.e., if language users do not have an intuition on which marker might be appropriate, they will fall back on *-s*. Arguments that support this view are that *-s* is the only plural suffix that has no phonological *limitations*, in the sense that it can be affixed to virtually any given noun stem, and, unlike Umlaut, it always leaves the noun stem transparent (cf. Bornschein & Butt 1987).

Apart from the factors mentioned above, we think that the fact that our participants' decisions about singular or plural were influenced by the appearance of the definite article *die* is incompatible with the assumptions of the dual-mechanism model, which makes predictions about language processing without taking into account that speakers adapt to specific contextual conditions.

Limitations of our study are that we examined only data gained from metalinguistic experiments with non-words. These data can well be explained in the theoretical framework of the schema model, especially when considering first and second order schemata. In order to ultimately test the predictions of the schema model against those of the dual-mechanism model, data should be analysed from experiments with both words and non-words.

Appendix 1: List of nonce stems

1	(Die) Wont
2	(Die) Blund
3	(Die) Zurf
4	(Die) Drolp
5	(Die) Grant
6	(Die) Blomp
7	(Die) Funt
8	(Die) Spruhn
9	(Die) Plon
10	(Die) Bold
11	(Die) Fank
12	(Die) Zauk
13	(Die) Gocht
14	(Die) Mank

15	(Die) Knuk
16	(Die) Knauk
17	(Die) Fump
18	(Die) Lurt
19	(Die) Drott
20	(Die) Krun
21	(Die) Wonk
22	(Die) Drut
23	(Die) Sor
24	(Die) Nuck
25	(Die) Brocht
26	(Die) Bratt
27	(Die) Knutt
28	(Die) Knaff

29	(Die) Dolk
30	(Die) Bamp
31	(Die) Paff
32	(Die) Broff
33	(Die) Klamp
34	(Die) Fluck
35	(Die) Plaft
36	(Die) Mulp
37	(Die) Kolk
38	(Die) Tump
39	(Die) Drunk
40	(Die) Kuft
41	(Die) Strunt
42	(Die) Tork
43	(Die) Sunk
44	(Die) Stalk

45	(Die) Bran
46	(Die) Pand
47	(Die) Stun
48	(Die) Kurm
49	(Die) Puft
50	(Die) Gron
51	(Die) Bonk
52	(Die) Prun
53	(Die) Tonk
54	(Die) Haff
55	(Die) Lurf
56	(Die) Malp
57	(Die) Halk
58	(Die) Purt
59	(Die) Lauk
60	(Die) Wuft

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1. The primary goal of the EUP Journals Blog

To aid discovery of authors, articles, research, multimedia and reviews published in Journals, and as a consequence contribute to increasing traffic, usage and citations of journal content.

2. Audience

Blog posts are written for an educated, popular and academic audience within EUP Journals' publishing fields.

3. Content criteria - your ideas for posts

We prioritize posts that will feature highly in search rankings, that are shareable and that will drive readers to your article on the EUP site.

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- Flexible length, however typical posts range 70-600 words.
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- No heavy restrictions to the style or format of the post, but it should best reflect the content and topic discussed.

5. Linking policy

- Links to external blogs and websites that are related to the author, subject matter and to EUP publishing fields are encouraged, e.g.to related blog posts

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