**On the nature of phonology-morphology interaction:
Modelling allomorphy in Maaloula Aramaic feminine nouns**

Ingo Plag[1] & Ghattas Eid[2]
[1] Heinrich-Heine-Universität Düsseldorf, [2]Universität Bonn

Abstract

The allomorphy of feminine nouns in Maaloula Aramaic (Eid 2024: chapter 5) presents an interesting theoretical problem for traditional modular and rule-based accounts of morpho-phonological alternations, as no "correct" analysis (in the sense of Hayes 2009:203) is available. We challenge such traditional accounts by demonstrating that the data can be modeled quite accurately on the basis of very limited phonotactic information alone, using the principles of discriminative learning (R. A. Rescorla 1972; Rescorla 1988), a theory from cognitive psychology that has recently been extended to language (e.g. Baayen et al. 2011; Chuang & Baayen 2013). The results support the view that morpho-phonological effects may emerge directly from experience-based associations of forms in the lexicon. The study shows that data from small, understudied languages like Maaloula Aramaic can be very valuable in testing, and further developing, linguistic theory.

1. Introduction

Allomorphy is the bread and butter of the morphologist. In the world of morphemes, an allomorph is often defined as a phonologically distinct variant of a particular morpheme (e.g. Lieber 2010: 158). In a recent article on the relation of infixation and allomorphy, Kalin (2022: 642) defines a morpheme as "an abstract morphological element corresponding to (i) a meaning or morphosyntactic function, and (ii) a set of phonological forms (exponents)". Crucially, "when (ii) is a nonsingleton set, the phonological forms are referred to as allomorphs of the morpheme."

An important distinction is made between suppletive and non-suppletive allomorphy. The latter refers to cases in which the exponents are phonologically related in the sense that much of the phonological material is the same (or very similar) across the exponents, and the exponents may even be derived from some assumed underlying form. A classic example is the plural in English, whose regular exponents are [z], [s], and [ɨz], with the underlying form /z/. The distribution of non-suppletive allomorphs is a consequence of clearly motivated phonological processes. In the English example, this motivation is assimilation of voicing across the morpheme boundary, and dissimilation through vowel epenthesis to break up the sequence of two identical sounds, two perfectly natural phonological processes. Another well-known case of non-suppletive allomorphy is the Dutch past tense suffix (Trommelen & Zonneveld 1979:119), which surfaces as [tə] after stem-final underlyingly voiceless obstruents, and as [də] elsewhere, as shown in (1) (examples are taken from Ernestus & Baayen (2004:874):

(1)	**stem**			**singular past tense form**		
	rook	/rok/	‘smoke’	rookte	/roktə/	‘smoked’
	stop	/stop/	‘stop’	stopte	/stoptə/	‘stopped’
	klaag	/klaɣ/	‘complain’	klaagde	/klaɣdə/	‘complained’
	roof	/rov/	‘steal’	roofde	/rovdə/	‘stole’
	kam	/kam/	‘comb’	kamde	/kamdə /	‘combed’

Suppletive allomorphs, in contrast, are exponents that are not phonologically related, and their selection or distribution can be conditioned by a range of factors, listed in (2):

(2) a. lexical conditioning: a root or class of roots
b. morphological conditioning: morphosyntactic features
c. phonological conditioning: phonological features
d. prosodic conditioning: prosodic size, weight, and/or shape

This rather neat picture of phonology-morphology interaction may be an idealization that is not entirely justified, however.

In this paper, we present a challenge for this view of allomorphy selection with data from a lesser known language, Maaloula Aramaic, and demonstrate that it is possible to account for the data in a completely different way, using only phonotactic information instead of morpho-phonological rules or constraints. We implement a discriminative learning network (see, for example, Baayen et al. 2011; Chuang & Baayen 2013; Plag, Domahs & Heitmeier 2024; Tomaschek et al. 2021) in which biphones are directly associated with variant forms that are exponents of morpho-syntactic features. In this kind of framework, morphology is conceived of as the gradient relationships between representations in the lexicon, instead of a rule- or constraint-based system that combines and manipulates sublexical units.

2. The challenge: Maaloula Aramaic feminine nouns

2.1 Singular feminine nouns

Western Neo-Aramaic is a Semitic variety traditionally spoken in three villages in Syria. One of them is Maaloula, whose dialect we are focusing on in this paper. In terms of word structure, Western Neo-Aramaic is characterized by a root-and-pattern morphology in which inflectional categories are expressed through particular patterns of so-called root consonants and the specific vowels and CV-patterns that characterize each morphological category. This is illustrated in (3) for words generated from the triliteral root *ṭʕn* ($C_1C_2C_3$) ‘carrying’. The symbols C_1, C_2, and C_3 refer to the three consonants (or ‘radicals’) which make up the triliteral root.

(3)

Word	Meaning	Pattern	morpho-syntactic specification
iṭʕan	'he carried'	$iC_1C_2aC_3$	*preterit verb*
yiṭʕun	'(that) he carries'	$yiC_1C_2uC_3$	*subjunctive verb*
ṭʕōn	'carry (2M.SG)!'	$C_1C_2\bar{o}C_3$	*imperative verb*
ṭōʕen	'he carries'	$C_1\bar{o}C_2eC_3$	*present verb*
iṭʕen	'he is carrying'	$iC_1C_2eC_3$	*perfect verb*
ṭʕōna	'(the act of) carrying'	$C_1C_2\bar{o}C_3a$	*noun*
ṭaʕna	'load'	$C_1aC_2C_3a$	*noun*

In addition to these non-concatenative morphological CV-patterns, suffixation is also quite common. In this paper we concentrate on the marking of feminine gender and of plural marking on feminine nouns. In Maaloula Aramaic, a given singular feminine noun is apparently marked for gender by one of two feminine suffixes: *-ṯa* [θa] in some nouns, *-ča* [t͡ʃa] in others (Spitaler 1938; Arnold 1990). The examples in (4) (from Eid 2024:80ff) illustrate this.

(4)	a.	šaʕ**ṯa**	'hour'
		xall**ṯa**	'daughter-in-law'
		ʕaym**ṯa**	'cloud'
		rxopp**ṯa**	'knee'
		matras**ṯa**	'school'
	b.	ġūr**ča**	'hole'
		ṯinaġel**ča**	'hen'
		ʕžīp**ča**	'miracle'
		ḥīr**ča**	'confusion; puzzlement'
		frīs**ča**	'right'

Eid (2024:93ff) divides each *-ṯa* and *-ča* into two affixes, and proposes the feminine markers *-ṯ*, i.e. a dental voiceless fricative, and *-č*, i.e. a voiceless palato-alveolar affricate, followed by the nominal ending *-a*. This analysis is shown in (5a). This analysis is supported by the fact that the nominal ending *-a* is not restricted to feminine nouns. It also appears in masculine nouns (e.g., *ṭūr**a*** 'mountain', *ḏīk**a*** 'rooster'). Additionally, it can be observed that this nominal ending is restricted to the citation form of nouns. If, for instance, a pronominal suffix is attached to a feminine noun, the nominal ending *-a* will disappear, but not the *-ṯ* or *-č* , see (5b).

(5) a. šaʕ-**ṯ**-a tinaġel-**č**-a

hour-F-NE[1] hen-F-NE

'hour' 'hen'

b. soləf-**ṯ**-e ḥōl-**č**-iš

story-F-3M.SG uncle-F-2F.SG

'his story' 'your (F.SG) aunt/stepmother'

(Eid 2024:93-95) analyzes the distribution of the two allomorphs by way of an underlying underspecified segment /T/, which represents a voiceless coronal obstruent which is not specified for the features [continuant], [strident], and [anterior], and the two rules, palatalization and spirantization, that determine the distribution as shown in (6).

(6) a. Environment for /T/ palatalization: (V)VC___ (where C is not a glide)

b. Environment for /T/ spirantization: elsewhere

The formalization of the two rules need not concern us here. What is important in the context of this paper is the fact that the two sounds in question are phonologically related, but their distribution is phonologically not motivated. There is no good synchronic reason why a palatalization rule should kick in the specific environment given in (6a).[2] Furthermore, Eid demonstrates that the distribution could also be accounted for by templatic patterns. This is not a coincidence since the templates are phonologically specified and their specifications vary by the presence or absence of final (V)VC. Another striking observation is that, in the subset of words that do not behave in accordance with the rules in (6), sonority is to some extent predictive of the allomorph distribution. The more sonorous the preceding consonant, the more likely the palatalized variant becomes.

Applying all of the above generalizations to the data set of 618 singular feminine nouns (407 of them featuring -*ṯ*-, 211 -*č*-) taken from the MASC corpus (Eid, Seyffarth & Plag 2022; Eid et al. 2022), we arrive at the accuracies for rule-based approaches shown in table 1.

Table 1: Accuracy of rule-based analyses of feminine marker allomorphy.

	accuracy	**wrong predictions**
phonology only	0.93	45/618
morphology only	0.94	36/618
phonology and morphology combined	0.97	19/618

[1] The following abbreviations are used in the glossing of examples: ∅ = 'zero-morph', 1 = 'first person', 2 = 'second person', 3 = 'third person', CST = 'construct state', DEF = 'definite', DTR = 'detransitivizing prefix', EPL = 'enumerative plural', F = 'feminine', IMP = 'imperative', INDF = 'indefinite', LM = 'linking morpheme', M = 'masculine', NE = 'nominal ending', OM = 'object marking', PL = 'plural', PRET = 'preterit', PRF = 'perfect', PRS = 'present', SBJV = 'subjunctive', SG = 'singular'

[2] For a historical explanation see Bergsträßer (1928:8), Spitaler (1938:12-21), Arnold (1990:12-14), Arnold (2008:171-176).

At the empirical level, a rule based approach makes very good predictions, with a small proportion of words not behaving as expected. From a theoretical perspective, however, the marking of feminine gender does not lend itself to a straightforward analysis of the nature of its allomorphy as either suppletive or non-suppletive. The exponents are clearly phonologically related, but their distribution seems to be regulated not by natural phonological rules but by rules that usually determine suppletive allomorphy. In such situations one cannot decide what the correct analysis would be: a phonological one that relates the two exponents but works on the basis of a rule that is not otherwise motivated, or morpheme-specific suppletion rule that no longer captures the similarity of the exponents. In such cases, Hayes acknowledges that "advances in linguistic theory and methodology will be needed before we can confidently advocate one or the other [analysis]" (Hayes 2009:202). A similar situation can be found with feminine forms in the plural, as we will see in the next section.

2.2 2.1 Plural feminine nouns

Feminine plural nouns in the vast majority end with either *-ōṯa* [oːθa], or *-yōṯa* [joːθa], no matter which singular marker the noun would have (*-ṯ* or *-č*), as shown in (7):

(7)	a.	*Singular*	*Plural*	
		ḏokk**ṯ**a	ḏukk**ōṯa**	'place'
		farw**ṯ**a	farw**ōṯa**	'sheepskin (cloak)'
		ṯinaġel**č**a	ṯinaġl**ōṯa**	'hen'
		žawhar**č**a	žawəhr**ōṯa**	'gem; jewel'
	b.	maščū**ṯ**a	mašču**yōṯa**	'wedding'
		htī**ṯ**a	hti**yōṯa**	'gift'
		ġūr**č**a	ġur**yōṯa**	'hole'
		aġīr**č**a	aġir**yōṯa**	'maid; maidservant'

Eid provides a morphological analysis analogous to that of the singular feminine forms and posits a base with three affixes: the plural marker *-ō* or *-yō*, the feminine marker *-ṯ* (invariable in the plural), and the nominal ending *-a*. Based on a data set of 337 word types, Eid shows that bases with a long vowel strongly prefer *-yōṯa* (135 out of 144 words), while bases without long vowel strongly prefer *-ōṯa* (157 out of 164 words). If the base ends in [j] (29 words), *-ōṯa* occurs. If we formulate these generalizations as phonological rules, they can account for 95 percent of the data.

From a theoretical perspective, however, there are similar problems as with the singular feminine allomorphy. The two most important environments do not motivate the alternation, and the rules do not repair, or lead to the avoidance, of phonologically ill-formed sequences or syllables. For example, there is no good phonological argument that [spaʕ**ō**ṯa] is well-formed but *[spaʕ**yō**ṯa] would not be. Other words in the language can be found that have this allegedly ill-formed sequence <aʕyō> (e.g., ***waʕyō**ṯa* 'clothes', ***ḳaʕyō**la* 'she/it (f) sits'. There is even a templatic pattern with this sequence attested (CCaCyōṯa, as in *šhatyōṯa* 'certificates; degrees', *ġraryōṯa* 'querns') (Eid 2024:104). Due to the lack of an independent phonological motivation, we are again faced with a situation where a phonological description is possible, but not convincing.

In the following we will develop a radically different approach, using a computationally implemented learning theory to model the two cases of allomorphy, discriminative learning. These models abandon rules and abandon the concept of a modular morpho-phonology and conceive morphology as relations of representations in the mental lexicon.

3. Discriminative learning

Discriminative learning is a theory of associative learning mechanisms developed in cognitive psychology (e.g. Robert A. Rescorla 1972; Rescorla 1988). The theory can account for classic learning phenomena in both human and animals, including the blocking effect (Kamin 1969) and the feature-label ordering effect (Ramscar et al. 2010). More recently, a wide range of linguistic studies have implemented this theory with impressive results, especially in the domain of morphology (e.g. Baayen et al. 2011; Chuang & Baayen 2013, see Plag 2018, Lieber 2021 for introductions).

Discriminative learning theory assumes that learning essentially means building associations between events. In language learning, associations are built up through exposure to language-related events, so-called 'cues' and 'outcomes', and updated with each learning event. The strength of the association changes through the co-occurrence or non-co-occurrence of cues and outcomes. The association strength increases when the same cue occurs with the same outcome, and decreases if this outcome is not present in the presence of the cue. The strength of the cues is calculated using the so-called Rescorla-Wagner equations (Wagner & Rescorla 1972). This model is computationally implemented in the `ndl` package (Arppe et al. 2015) in R (R Core Team 2020).

In our implementations we want to associate base forms with the available allomorphs. If the model is successful it will associate a given base form with the correct allomorph. Following similar work (e.g. Arndt-Lappe, Schrecklinger & Tomaschek 2023; Plag, Domahs & Heitmeier 2024), we use only phonotactic information, i.e. biphones, as cues. As outcomes we use the two available allomorphs. Figure 1 illustrates the associations in an NDL network with the base *šaʕ* and the feminine singular markers. The hash marks indicate the word boundaries.

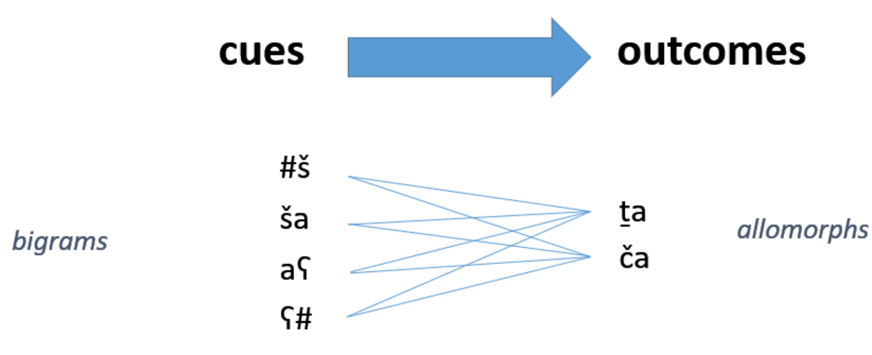

Figure 1: NDL network with the base *šaʕ* and the feminine singular allomorphs.

Based on the existing base forms in the lexicon, the model first comes up with a list of all bigrams. The model then calculates for each bigram how strongly it is associated with either allomorph. For instance, the initial bigram of *šaʕ*, i.e. #*š*, has an association of 0.28 with -*ča* and an association of 0.26 with -*ṯa*. The final bigram, i.e. *ʕ*#, has an association of 0.19 with -*ča* and an association of 0.25 with -*ṯa*. In order to arrive at the associations of a base form with the two outcomes, we add the associations of the constituent bigrams. For the base *šaʕ*, we arrive at an association of 1 with -*ṯa* and of only 0.035 with -*ča*. To take a decision between the two allomorphs we simply take the higher association. In the case of *šaʕ*, the allomorph -*ṯa* is chosen, which is a correct decision.

4. Results

We implemented two discriminative learning networks, one for the feminine singular forms and one for the feminine plural forms, using the two data sets described above, with bigrams as cues and the respective allomorphs as outcomes.[3] We calculated the accuracy for the training set, but we also performed a ten-fold cross-validation to see how each model performs on unseen data. The cross-validation was done in two ways, using 10 folds and 100 folds. In the 10-fold cross-validation for each fold of 10 percent held-out data, we used the 90 percent remaining data as the training set. In the 100-fold cross-validation for each fold of 1 percent held-out data, we used the 99 percent remaining data as the training set, to give the model a better chance to learn. Table 2 gives an overview of all accuracies. The rule-based accuracy for the singular forms is given for all three possible rule systems. The accuracy of the NDL models is averaged over the ten folds.

Table 2: Accuracies of rule-based models and corresponding NDL models.

	rule-based			**NDL**		
	only phonology	only morphology	phonology and morphology combined	training set	10-fold cross-validation	100-fold cross-validation
feminine singular	0.93	0.94	0.97	0.92	0.84	0.87
feminine plural	0.95			1.0	0.88	0.89

A comparison of the rule-based accuracies and the training set accuracies shows that the two types of model are more or less on a par. For the singular, the rule-based models are slightly better, while for the plural allomorphy, NDL makes perfect predictions, which is a sign of over-fitting. For a more meaningful comparison of the two types of model, a look at the cross-validated NDL

[3] The data used in this study, as well as the statistical and computational analyses are available here: https://osf.io/9jtd7/overview?view_only=47d7c955bebf43048616a9cff03f7a95

predictions shows that accuracy expectedly drops, but both models still make very good predictions, even if a bit worse than the rule-based models.

5. Discussion and conclusion

In this paper we have shown that data from small, understudied languages like Maaloula Aramaic can be very valuable in testing, and further developing, linguistic theory. We have seen that two entirely different models, rules and discriminative learning networks, can be used to quite successfully model the allomorphy of singular and plural feminine nouns in Maaloula Aramaic. What do these results mean for the analyst who wants to understand how this language, or language at large, works?

At the empirical level, the rules seem to be slightly more accurate in their predictions, but they beg the question of how to explain leakage. Why do certain forms not obey the rule? The traditional answer to this is the lexicalization of exceptions. Over the past two decades, however, this 'words-and-rules' account has been shown to be rather problematic. In their review of the available psycholinguistic evidence, Arndt-Lappe & Ernestus (2020:218) come to the conclusion that "storage is ubiquitous, and that stored representations include more detail than is usually assumed to form the basis of traditional phonological rules." The dichotomy of rules vs. storage runs counter to strong empirical evidence that there seems to be a continuum from words whose alternation does not carry over to other words to highly productive and predictable alternations. A case in point is the textbook example of the alternation of the Dutch past tense suffix introduced in section 1, which is completely regular, but speakers nevertheless sometimes use the inappropriate allomorph, and do so especially for verbs that are phonologically similar (e.g. by ending in a similar vowel or in an obstruent of the same place and manner of articulation) and take the other allomorph (Ernestus & Baayen 2003; Ernestus & Baayen 2004; Ernestus & Baayen 2006). The gradient differences in the generalizability of morpho-phonological alternations thus emerge as a function of gradient support from the lexicon, which makes it difficult to uphold long-cherished dichotomies of such as 'regular' vs. 'irregular', or 'phonologically conditioned' vs. 'suppletive'. In this perspective, Hayes' problem disappears.

The fact that morpho-phonological alternations can be modelled with an architecture that has no information about morphological structure challenges theories in which morphemes (i.e. units of form and meaning) play a role, or in which rules make reference to such entities (see, for example, Baayen et al. 2011 for discussion). In the alternative account proposed here there is also no need for positing different modules that need to interact with each other in ways that are theory-internally, but not psycho-linguistically, motivated. Note also that any rule-based account begs the question of how the rules are learned, and how the lexicalized exceptions can be exempt from rule application.

Critics of a learning system that only uses bigrams to represent form may want to say that in such a system, phonological generalizations are entirely lost. This criticism is, however, only valid in a rule-based formal grammar universe. In usage-based frameworks, phonological (or other) generalizations emerge in a gradient system through the processing mechanisms that are at work when speakers and listeners produce and comprehend language (cf., for example, Bybee 2001; Bybee 2010; Baayen et al. 2011; Baayen et al. 2019; Plag & Balling 2017).

Another potential problem of the NDL approach as implemented in this paper is that the status of bigrams as cues may appear somewhat dubious. In NDL bigrams are taken to be simplistic representations of rather complex articulatory and acoustic events. In a production model, bigrams represent the articulatory transitions speakers make when uttering words, and in a comprehension model bigrams stand for the acoustic properties of neighboring sounds. But not much seems to depend on the exact nature of these representations. Related work in discriminative learning (Shafaei-Bajestan et al. 2021) has demonstrated that spectral properties directly gleaned from the acoustic signal can be used instead of bigrams (or trigrams) to model the mapping of form and meaning that is the essence of morphology.

This mapping is best viewed as involving variable association strengths between sound and meaning, on a cline from direct and clear associations that run under the name of 'morpheme' at the one end, and much less strong and less consistent associations at the other end. There is a growing body of evidence that such associations may underlie the structure the mental lexicon and largely determine the processing of words in language production and comprehension.

References

Arndt-Lappe, Sabine & Mirjam Ernestus. 2020. Morphology-phonology interaction. In Vito Pirelli, Ingo Plag & Wolfgang U. Dressler (eds.), *Word knowledge and word usage: A cross-disciplinary guide to the mental lexicon*, 191–227. Berlin & New York: de Gruyter Mouton.

Arndt-Lappe, Sabine, Robin Schrecklinger & Fabian Tomaschek. 2023. Stratification effects without morphological strata, syllable counting effects without counts–modelling English stress assignment with Naive Discriminative Learning. *Morphology*. Springer 33(4). 433–457.

Arnold, Werner. 1990. *Das Neuwestaramäische: V. Grammatik*. Wiesbaden: Otto Harrassowitz Verlag.

Arnold, Werner. 2008. The begadkephat in Western Neo-Aramaic. In Geoffrey Khan (ed.), *Neo-Aramaic dialect studies*, 171–176. Piscataway, NJ: Gorgias Press.

Arppe, Antti, Peter Hendrix, Petar Milin, R. H. Baayen, Sering Tino & Cyrus Shaoul. 2015. *ndl: Naive Discriminative Learning*. https://CRAN.R-project.org/package=ndl.

Baayen, R. Harald, Yu-Ying Chuang, Elnaz Shafaei-Bajestan & James P. Blevins. 2019. The Discriminative Lexicon: A Unified Computational Model for the Lexicon and Lexical Processing in Comprehension and Production Grounded Not in (De)Composition but in Linear Discriminative Learning. *Complexity* 2019. 39. https://doi.org/10.1155/2019/4895891.

Baayen, R. Harald, Petar Milin, Dusica Filipović Djević, Peter Hendrix & Marco Marelli. 2011. An amorphous model for morphological processing in visual comprehension based on naive discriminative learning. *Psychological Review* 118(3). 438–481.

Bergsträßer, Gotthelf. 1928. *Einführung in die semitischen Sprachen. Sprachproben und grammatische Skizzen*. München: Hueber.

Bybee, Joan. 2010. *Language, Usage and Cognition*. Cambridge: CUP.

Bybee, Joan L. 2001. *Phonology and language use*. Cambridge: Cambridge University Press.

Chuang, Yu-Ying & R. Harald Baayen. 2013. Discriminative Learning and the Lexicon: NDL and LDL. In Mark Aronoff (ed.), *Oxford research encyclopedia of linguistics* (Oxford Research Encyclopedias). New York, NY: Oxford University Press. https://doi.org/10.1093/acrefore/9780199384655.013.375.

Eid, Ghattas. 2024. *The phonology of Maaloula Aramaic*. Düsseldorf: Düsseldorf University Press. https://www.degruyterbrill.com/document/doi/10.1515/9783111447124/html.
Eid, Ghattas, Esther Seyffarth, Werner Arnold & Ingo Plag. 2022. The Maaloula Aramaic Speech Corpus (MASC). Zenodo. https://doi.org/10.5281/zenodo.6496714.
Eid, Ghattas, Esther Seyffarth & Ingo Plag. 2022. The Maaloula Aramaic Speech Corpus (MASC): From printed material to a lemmatized and time-aligned corpus. In *Proceedings of the Thirteenth Language Resources and Evaluation Conference*, 6513–6520.
Ernestus, Mirjam & Harald Baayen. 2003. Predicting the unpredictable: Interpreting neutralized segments in Dutch. *Language* 79. 5–38.
Ernestus, Mirjam & Harald Baayen. 2004. Analogical effects in regular past tense production in Dutch. *Linguistics* 42. 873–903.
Ernestus, Mirjam & Harald Baayen. 2006. The functionality of incomplete neutralization in Dutch. The case of past-tense formation. *Laboratory Phonology* 8. 27–49.
Hayes, Bruce. 2009. *Introductory phonology*. Malden, MA: Wiley-Blackwell.
Kalin, Laura. 2022. Infixes really are (underlyingly) prefixes/suffixes: Evidence from allomorphy on the fine timing of infixation. *Language*. Linguistic Society of America 98(4). 641–682.
Kamin, L. J. 1969. Predictability, surprise, attention, and conditioning. In B. A. Campbell & R. M. Church (eds.), *Punishment and Aversive Behavior*, 276–296. New York: Appleton-Century-Crofts.
Lieber, Rochelle. 2010. *Introducing Morphology*. Cambridge: Cambridge University Press.
Lieber, Rochelle. 2021. *Introducing morphology*. Cambridge: Cambridge University Press.
Plag, Ingo. 2018. *Word-formation in English*. 2nd edition. Cambridge: Cambridge University Press.
Plag, Ingo & Laura Winther Balling. 2017. Derivational morphology: An integrated perspective. In Vito Pirrelli, Wolfgang U. Dressler & Ingo Plag (eds.), *Word knowledge and word usage: A cross-disciplinary guide to the mental lexicon*. Berlin: de Gruyter Mouton.
Plag, Ingo, Frank Domahs & Maria Heitmeier. 2024. German nominal number interpretation in an impaired mental lexicon: A naive discriminative learning perspective. *The Mental Lexicon* 18(3). 417–445. https://doi.org/10.1075/ml.23017.pla.
R Core Team. 2020. R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing. https://www.R-project.org/.
Ramscar, Michael, Daniel Yarlett, Melody Dye, Katie Denny & Kirsten Thorpe. 2010. The effects of feature-label-order and their implications for symbolic learning. *Cognitive Science* 34(6). 909–957.
Rescorla, R. A. 1972. “Configural” conditioning in discrete-trial bar pressing. *Journal of Comparative and Physiological Psychology* 79(2). 307–317.
Rescorla, R. A. 1988. Behavioral studies of Pavlovian conditioning. *Annual Review of Neuroscience* 11(1). 329–352.
Rescorla, Robert A. 1972. `Configural' conditioning in discrete-trial bar pressing. *Journal of Comparative and Physiological Psychology* 79(2). 307.
Shafaei-Bajestan, Elnaz, Masoumeh Moradipour-Tari, Peter Uhrig & R. Harald Baayen. 2021. LDL-AURIS: a computational model, grounded in error-driven learning, for the comprehension of single spoken words. *Language, Cognition and Neuroscience* 1–28. https://doi.org/10.1080/23273798.2021.1954207.
Spitaler, Anton. 1938. *Grammatik des neuaramäischen Dialekts von Maʿlūla (Antilibanon)*. Leipzig: Brockhaus.
Tomaschek, Fabian, Ingo Plag, Mirjam Ernestus & Harald R. Baayen. 2021. Modeling the duration of word-final S in English with Naive Discriminative Learning. *Journal of Linguistics* 57. 123–161. https://doi.org/10.31234/osf.io/4bmwg.
Trommelen, M. & W. Zonneveld. 1979. *Inleiding in de generatieve fonologie*. Muiderberg: Coutinho.
Wagner, A. R. & R. A. Rescorla. 1972. Inhibition in Pavlovian conditioning: Application of a theory. In R. A. Boakes & M. S. Halliday (eds.), *Inhibition and learning*, 301–336. New York: Academic Press.