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The German negative prefixes *in-* and *un-*: nasal place assimilation

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Abstract

The morphological and prosodic classification of the two German negative prefixes *in-* and *un-* has often been based on the prefixes' behavior with regard to nasal place assimilation: *in-* is said to assimilate to the following plosive's place of articulation, while *un-* has been claimed to retain its alveolar nasal. The study presented in this paper investigated whether this longstanding claim can indeed be confirmed empirically via a production experiment that compared F2 trajectories of German *in-* and *un*-sequences followed by either an alveolar or a velar plosive: a) between words; b) at morpheme boundaries (i.e., as a prefix); c) within a morpheme and between syllables; d) within a morpheme and within a syllable. Results showed that *un-* is subject to nasal place assimilation as a prefix, in stark contrast to previous claims in the literature. Furthermore, a clear difference was found between the four contexts, with strongest assimilation patterns in the within-morpheme environments, weaker assimilation at the morpheme boundary, and no assimilation between words. This paper thus demonstrates the importance of empirical experimentation for the formulation of phonological generalizations.

Index Terms: nasal place assimilation, negative prefixes, German, F2

1. Introduction

German (and similarly English) features several stressed negative prefixes for adjectives. The native Germanic prefix *un-* is the most frequent in German and can be traced back to Indogermanic *n-. It prefers to combine with native adjectives, although it is not restricted to these contexts, and is highly productive in that it is frequently a part of new word coinings. The negative prefix *in-* is a loan prefix from Latin and derivational formations are restricted to loan words from Latin (or its descendants). As a consequence, the prefix is not very productive.

In contrast to *un-*, *in-* has a distinct assimilation pattern: in some contexts, the prefix's nasal assimilates to the place of articulation of the following sound. Some of these assimilations are reflected in the orthography, e.g. in words like *illegal* or *implausible*, but no orthographic representative exists for regressive nasal place assimilation (NPA) to a following velar plosive (/n/ $\rightarrow$ [ŋ] / _ [+velar]). Table 1 illustrates the assimilation patterns for the prefix *in-* in German.

Table 1: *NPA patterns for the Latin prefix 'in-' in German*

Sequence	Prefix *in-*	Translations
in+l	illegal	illegal
in+r	irregulär	irregular
in+[lab]	immobil	immobile
in+[alv]	intolerant	intolerant
in+[vel]	i[ŋ]konsequent	inconsistent

The assimilation found with the prefix *in-* in German follows the same pattern as originally applied in Latin. It is very likely that a majority of the forms were loaned as fully-formed derivatives from Latin or Old French, and later also from English [1]. Especially the orthographically represented (l/r/m) assimilation patterns of the prefix *in-* are not productive in German (or English). Nevertheless, this orthographic difference between the two prefixes *in-* and *un-* has been one of the defining arguments for the morphological and phonological classification of the negative prefixes in German and English [2, 3, 4, 5, 6].

Research concerned with the morphological and phonological/prosodic classification of prefixes sort *in-* and *un-* into two different categories based on NPA, degemination (from the following homorganic sound), and/or linear prefix order. The separation of affixes into two different classes is based on the theory of lexical morphology and phonology [7] which extended the assumption of different boundary types between morphemes formulated in SPE [8]. Assigning different classes to affixes can explain why certain phonological processes only apply at specific stages of word-creation and why some affixes always occur outside of other affixes (relative to the stem), but never vice versa. A class 1 prefix is assumed to undergo NPA and degemination, while class II prefixes are blocked from these processes. Accordingly, *in-* is classified as a class 1 prefix as it is assumed to obligatorily assimilate to the onset of the following stem and to degeminate if an identical nasal stem onset is present. In contrast, *un-* is categorised as as class 2 prefix, where degemination and NPA are not applied. While these models can explain many complex interactions between phonology and morphology, it must be noted that not all problems with regard to word-formation can be resolved. Especially problematic are level-ordering paradoxes (as in *ungrammaticality*), where there is evidence that class 2 prefix *un-* must have been added before a class 1 suffix (see [9] for discussion).

Based on these categorisations into different classes, the two prefixes are assumed to be phrased differently with respect to prosodic constituency. [3] and [4] assume that the domain of NPA is the foot. [5] proposes that stressed prefixes form independent phonological words, with the notable exception of *in-*. Under this approach, NPA applies within the phonological word. Consequently, if *in-* undergoes NPA, it cannot form an independent prosodic word. [10] also assumes that all stressed prefixes (including both *in-* and *un-*) form an independent prosodic word based on syllabification and stress patterns. Since *in-* (but not *un-*) undergoes NPA, NPA is excluded as a criterium for prefix classification and prosodic word formation.

Most previous research assumes that NPA can be postlexically applied to *un-* in restricted contexts (e.g., in casual speech, or with increased speaker tempo). [5] assumes that prefixes like *un-* and preceding function words can optionally form a prosodic word with the following word/stem in which case they also can undergo NPA (as in (*i[m] Berlin*)$_{\omega}$), but *un-* is generally assumed to have a lower tendency for assimilation as it

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does not display the orthographic variation discussed above for the prefix *in-*.

[11] assumes that both prefixes form individual prosodic words and that there is no lexical NPA between the prefixes and the following stem. However, he also assumes that postlexical regressive NPA can take place for both prefixes and (at least) for prepositions (see also [12]). Furthermore, some research showed that NPA can also occur between two lexical words (i.e., between two prosodic words, as in *(gree[m])*$_\omega$ *(boats)*$_\omega$), see, e.g., [13, 14]. [15] proposed a hierarchical structure with regard to assimilation, where he suggests assimilation to be obligatory within a morpheme, but facultative between affixes and stems or members of compounds.

There is also evidence suggesting that the two prefixes are more similar than assumed by previous research. [16] conducted a study for English which examined the behavior of the prefixes with respect to degemination from a following nasal. They showed that both prefixes geminate; hence, gemination cannot be used as a criterium for prefix classification (in contrast to claims made in previous literature).

With respect to the prefixes *in-* and *un-* there is a broad range of assumptions concerned with their morphological and phonological behavior, but notably little systematic research. This paper aims to shed some light on a) NPA patterns of both prefixes and b) the environments, in which NPA can occur for these sequences in German.

2. Experiment

2.1. Methods

2.1.1. Materials

The materials comprised sequences of *in-* or *un-* followed by either a velar or an alveolar plosive in four environments where NPA could in principle occur (Table 2). Environment 1 included the sequence within a morpheme and within a syllable, where the nasal and the following plosive were both part of the syllable's coda. Environment 2 also included the sequence within one morpheme, but across two syllables, i.e., the final plosive was in the onset of the following syllable. Environment 3 consisted of words with prefixes *in-* and *un-* followed by an adjective stem. Environment 4, finally, placed the target sequence at a prosodic word boundary between a noun and a following verb, where the nasal formed the noun's final coda, and the plosive the onset to the verb.

Table 2: *Four environments for NPA with examples for the sequences 'unk' and 'ink'*

	Environment	**Examples**	**Translation**
1.	within morpheme	Funk	radio
	& within syllable	Fink	finch
2.	within morpheme	Dun.kel	dark
	& between syllables	Schmin.ke	makeup
3.	within word	un-kritisch	uncritical
	& between morphemes	in-korrekt	incorrect
4.	between words	Monsun k...	monsoon
	(noun+verb)	Rubin k...	ruby

Only target words with *un/in*-sequences before velar and alveolar plosives were used. Labials were excluded from this experiment. The reason is that the prefix *un-* never appears with orthographic 'm' before labial plosives, while *in-* never appears with 'n' before labials. Furthermore, for some of the environments (Table 2), sequences for both *un-* and *in-* followed by a bilabial stop are not available. Specifically, in environments 1 and 2 (within one morpheme), both **unp* and **inp* are not possible. As this particular experiment also focused on NPA in different environments, bilabial NPA was excluded for the sake of comparability. In addition, only materials with voiceless plosives [t] and [k] were used. The reasons were that a) in the monosyllabic environment, the final plosive will always be(come) unvoiced due to final devoicing, and b) it is more likely that voiceless plosives are indeed pronounced as stops, while voiced plosives are more likely to undergo spirantisation.

As both prefixes are stressed, all sequences of *un-* and *in-* were placed in a lexically stressed syllable. This lead to unavoidable differences in vowel quality, in that, e.g., the target items in environment 4 all had long and tense vowels ([u:] or [i:]), while all other environments featured the short and lax vowels [ɪ] and [ʊ] (with deviating F2-values).

2.1.2. Participants

Thirteen participants took part in the experiment (mean age 27.3, all female). All were native speakers of German and none reported any hearing or speaking disabilities. Each participant received a small compensation for their effort.

2.1.3. Procedure

All participants were recorded in the soundproof studio of the Phonlab at the University of Konstanz with a condenser microphone (sampling rate 44.1 kHz, 16-Bit, stereo). The target sentences (interspersed with fillers) were presented one by one on a computer screen. Participants were instructed to read the sentences out loud and were asked to repeat sentences in case of mistakes. Each session took about 30 minutes.

2.1.4. Data Analysis

In each recording, the vowel and the nasal were manually annotated in Praat [17]. Of the 520 recordings, 17 had to be discarded, mostly because the boundary between the nasal and the following vowel could not be reliably identified.

For the measurement of NPA, F2 trajectories at the transition zone between vowel and nasal were used. Depending on the following nasal (either velar [ŋ] or alveolar [n]) the F2 trajectory is expected to display a unique pattern [18] thus signalling NPA.

A Praat script was used to extract F2-values from any vowel longer than 0.03s to ensure enough material. Since the F2 trajectory signalling nasal place assimilation is mostly found towards the end of the vowel at the transition to the following nasal, the analysis focused on the second half of the vowel. In order to normalize differences in duration, the vowel's second half was divided into 5 sub-intervals and the mean F2-value was extracted for each of these intervals, with F2_1 signalling the value in the middle of the vowel, while F2_5 represents the value shortly before the boundary between the vowel and the following nasal. Furthermore, in order to allow for the comparison between the different environments, which feature differences in vowel quality ([i:]/[ɪ] and [u:]/[ʊ]), all data was transformed into semitones and the differences between adjacent semitones was calculated as a means to normalize the F2 trajectories.

2.2. Results

Differences in F2-values in the transition to the nasal preceding an alveolar or a velar stop was calculated for both sequences, *in-* and *un-*, in all four environments using linear mixed effects regression models with the place of articulation as fixed factor and participants and items as crossed-random factors with the Satterthwaite approximation implemented in the R-library lmerTest [19, 20].

2.2.1. Transition differences within each environment

Results for the *in*-sequence[1] showed higher F2-values for the velar in comparison to the alveolar condition. For environment 1 (within one syllable), significant results were registered starting with F2_2 ($p < 0.001$). Environment 2 (within a morpheme, between 2 syllables) showed significant effects in the first three intervals ($p < 0.05$), but not for the last two. No effects were found between words.

For the prefix *in-* (environment 3), only F2_1 and F2_2 showed significant differences between the velar and the alveolar condition ($p < 0.05$). All other measurements were not significant. Figure 1 shows the direct comparison of the velar and alveolar data for the prefix *in-* for all extraction points of F2 in the transition zone.

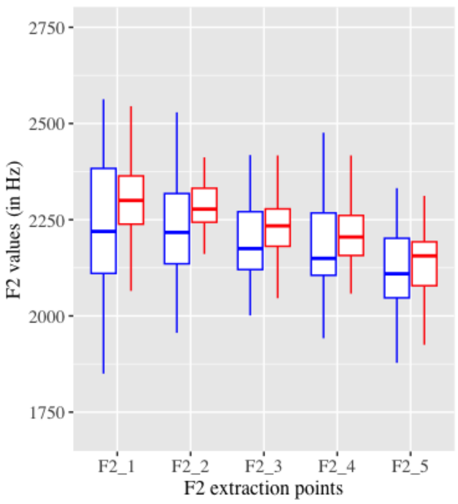

Figure 1: *F2-values for the transition zone of the prefix 'in-' followed by an alveolar or a velar plosive.*

The *un*-sequence showed the expected assimilation patterns for the sequences of environment 1 (within one syllable). Starting from the second extraction value, the velar had significantly lower F2-values compared to the alveolar condition, with a rising significance towards the nasal (F2_2/3: $p < 0.05$; F2_4/5: $p < 0.001$). For environment 2 (within a morpheme, between two syllables), extraction points F2_3–F2_5 showed significantly lower F2-values for the velar condition ($p < 0.05$). For environment 4, where the *un*-sequence occurred between an object and a following verb, no effects were found.

For the prefix *un-* (environment 3), results showed significant differences between the velar and the alveolar condition for all extraction points ($p < 0.01$ or lower). For instance, at the last extraction point in the transition, F2_5, the F2-values were 8% lower in the velar (β= -95.7, t = -4.3, $p < 0.01$). Figure 2 shows the direct comparison of the velar and alveolar data for the prefix *un-* for all extraction points of F2 in the transition zone.

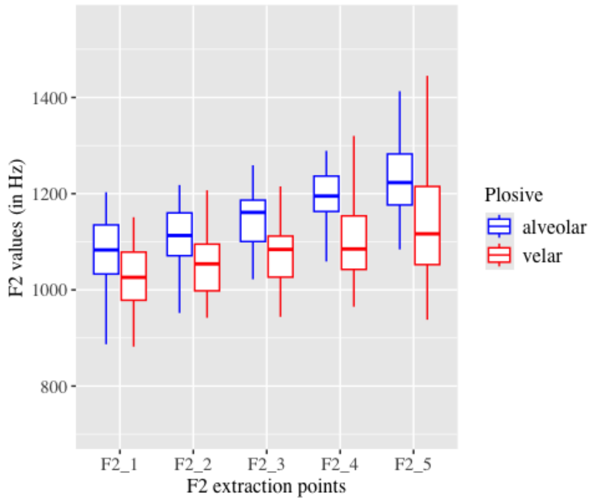

Figure 2: *F2-values for the transition zone of the prefix 'un-' followed by an alveolar or a velar plosive.*

2.2.2. Transition differences between the environments

Figures 3 and 4 show the normalized F2 trajectories for *un-* for the velar (Fig. 3) and alveolar (Fig. 4) conditions in all four environments. The Figures represent the differences between adjacent F2-semitone values with 0 as a common starting point. This allows for varying vowel quality to be normalised and makes the trajectories comparable.

In the velar condition in Figure 3, the prefix shows a deviating pattern from all other environments, with a significant difference from the two *un*-sequences within a morpheme ($p < 0.001$), but also from the between-words environment ($p < 0.05$). The prefix's transition scale is less pronounced compared to the *un*-sequence between words, while both within-word sequences (environment 1 and 2) have an opposite tendency.

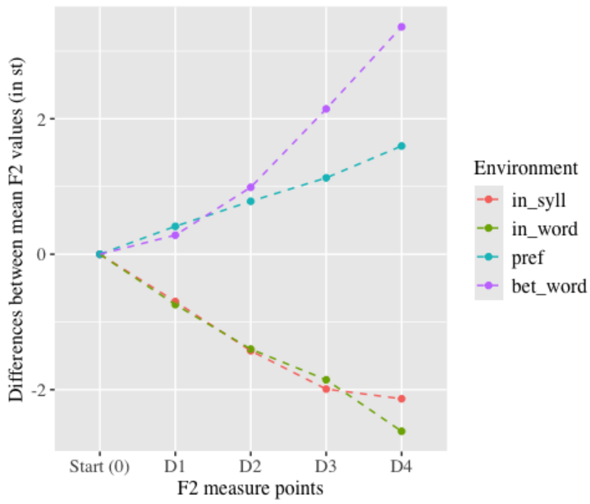

Figure 3: *F2 trajectory of 'un' in the velar condition over all environments, normalised as differences between adjacent semitones.*

[1]For the data concerning *in-* it is worth mentioning that there was a lot of variation and measurement errors where F2 values were far too low.

In the alveolar condition, the prefix showed a significant difference from the *un*-sequence between words and within the syllable ($p < 0.01$), but not from the within-word environment. Again, the transition zone scale is less pronounced for the prefix compared to the other environments.

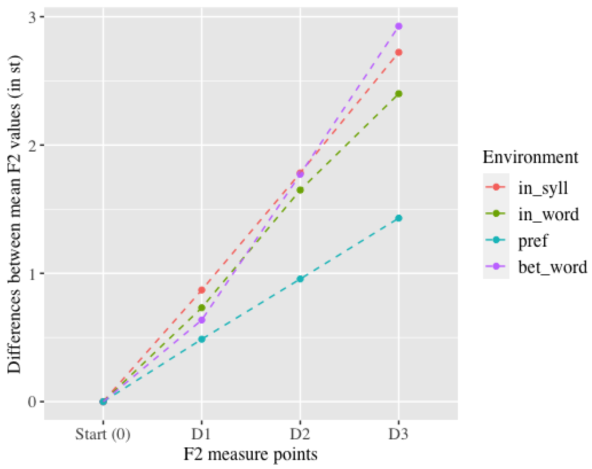

Figure 4: *F2 trajectory of 'un' in the alveolar condition over all environments, normalised as differences between adjacent semitones.*

As the sequence *in-* showed a lot of variation in all environments, a comparison between the different environments had to be postponed to future research.

3. Discussion and conclusion

The difference between the velar and the alveolar measurements for the prefix *un-* showed that the categorical rejection of NPA for the prefix *un-* is not justified. The NPA is clearly visible in the transition from vowel to nasal (Figure 2), with velar values reliably lower than alveolar ones. In addition, NPA was found within morphemes within and between syllables. As NPA is regarded obligatory in these cases, these results were not surprising. With regard to the position between two lexical words, no indications for NPA were found. Both object and verb can be assumed to each form a prosodic word, i.e., there is at least a two-sided prosodic word boundary in this position. This indicates that postlexical NPA cannot be applied freely, but is restricted to a specific prosodic domain; whether this domain is the prosodic phrase or the prosodic word remains to be determined, although findings in [13, 14] for English point towards the prosodic phrase as the restricting domain.

The comparison between the different environments showed that while F2 trajectories of prefixal *un-* differ from the ones found between words, they also differ from both morpheme-internal sequences. This supports the hypothesis that the boundary between the prefix and the following stem is stronger than a single syllable boundary, but weaker than the boundary between two lexical/prosodic words. A possible option would be that the prefix is phrased recursively with the following prosodic word, which would account for the differences between the prefix and within-morpheme environments on the one hand, and the prefix and the between-word environment on the other hand.

In contrast to *un-*, the NPA measurements for the prefix *in-* were less clear (albeit measurement mistakes might be a reason for this). Given the claims in the literature, the expectation was for *in-* to assimilate much more explicitly and consistently. However, the results suggest that there is no difference between the two prefixes with regard to NPA and prosodic phrasing. Instead, following earlier claims made on degemination [16], stress, and syllabification [10], it seems more feasible to reject NPA as a criterion for the morphological classification of prefixes and to assume identical posodic phrasing for both negative prefixes.

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