



Assessing incomplete neutralization of final devoicing in German



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ABSTRACT

It has been claimed that the long established neutralization of the voicing distinction in domain final position in German is phonetically incomplete. However, many studies that have advanced this claim have subsequently been criticized on methodological grounds, calling incomplete neutralization into question. In three production experiments and one perception experiment we address these methodological criticisms.

In the first production study, we address the role of orthography. In a large scale auditory task using pseudowords, we confirm that neutralization is indeed incomplete and suggest that previous null results may simply be due to lack of statistical power. In two follow-up production studies (Experiments 2 and 3), we rule out a potential confound of Experiment 1, namely that the effect might be due to accommodation to the presented auditory stimuli, by manipulating the duration of the preceding vowel. While the between-items design (Experiment 2) replicated the findings of Experiment 1, the between-subjects version (Experiment 3) failed to find a statistically significant incomplete neutralization effect, although we found numerical tendencies in the expected direction. Finally, in a perception study (Experiment 4), we demonstrate that the subphonemic differences between final voiceless and “devoiced” stops are audible, but only barely so. Even though the present findings provide evidence for the robustness of incomplete neutralization in German, the small effect sizes highlight the challenges of investigating this phenomenon. We argue that without necessarily postulating functional relevance, incomplete neutralization can be accounted for by recent models of lexical organization.

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1. Introduction

Many languages such as Catalan, Dutch, German, Polish, Russian and Turkish contrast voiced obstruents intervocally but neutralize the contrast syllable or word finally in favor of voiceless obstruents. An example from German is given in (1) and (2): in syllable final position, the voicing of the alveolar stop is neutralized, leading to apparent homophony between e.g. *Rad* [ʁa:t] ‘wheel’ and *Rat* [ʁa:t] ‘council’.

(i) *Rad* [ʁa:t] ‘wheel’; *Räder* [ʁæ:də] ‘wheels’

(ii) *Rat* [ʁa:t] ‘council’; *Räte* [ʁæ:tə] ‘councils’

(1)

(i) *Radschlag* [ʁa:tʃla:k] ‘cartwheel’

(ii) *Ratschlag* [ʁa:tʃla:k] ‘advice’

(2)

This asymmetrical distribution is commonly described in terms of final devoicing, a process that is often described in purely phonological terms. In fact, final devoicing in German¹ has been called the “universally recognized archetype of phonological neutralization” (Fourakis & Iverson, 1984: 141) and described as a “classic example of a phonological rule” (Wiese, 1996: 204).

In traditional formal theories of phonology, *Rad* and *Rat* are thought to differ only in their “underlying” lexical representations, while the surface form of the voiced stop is thought to be phonetically indistinguishable from that of the corresponding voiceless stop. In other words, neutralization of the final voicing distinction is assumed to be phonetically complete, resulting in homophony between the two lexical items. However, numerous experimental studies have

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¹ Kohler (1984) argues that German voiced and voiceless stops are better characterized as fortis and lenis. To remain consistent with the terminology adopted in the incomplete neutralization debate, we retain the terms “voiced”, “voiceless” and “final devoicing”.

argued that there are small acoustic and articulatory differences between words such as *Rad* and *Rat*, suggesting that in German this neutralization is in fact *incomplete* (Charles-Luce, 1985; Dinnsen, 1985; Dinnsen & Garcia-Zamor, 1971; Fuchs, 2005; Greisbach, 2001; Mitleb, 1981; O'Dell & Port, 1983; Port & Crawford, 1989; Port, Mitleb, & O'Dell, 1981; Port & O'Dell, 1985; Piroth & Janker, 2004). Further studies suggest that listeners can distinguish “devoiced”² stops from voiceless ones with above-chance accuracy (Kleber, John, & Harrington, 2010; Port & Crawford, 1989; Port & O'Dell, 1985).

The results obtained in the above mentioned experiments are difficult to reconcile with traditional linguistic descriptions of German (Jespersen, 1913; Trubetzkoy, 1939; Wiese, 1996; Zifonun et al., 1997) that assume abstract phonological categories devoid of gradient phonetic information. Accounts based on this view have problems incorporating intermediate categories as the purported “semi-voiced” final obstruents. Most early formal attempts to incorporate incomplete neutralization (e.g., Charles-Luce, 1985; Port & O'Dell, 1985) involved a proliferation of post-hoc repairs (such as the “phonetic implementation rules” of e.g., Dinnsen & Charles-Luce, 1984) which led Port & Crawford (1989: 257) to claim that incomplete neutralization poses “a threat to phonological theory” (see also Port & Leary, 2005).

More recent attempts to account for incomplete neutralization are rooted in psycholinguistic models of lexical organization. There is mounting evidence suggesting that, far from being impoverished, lexical representations are rich in information, and may contain both detailed phonetic information of individual word forms (e.g., Brown & McNeill, 1966; Bybee, 1994; Goldinger, 1996, 1997; Palmeri, Goldinger, & Pisoni, 1993; Pisoni, 1997) as well as completely inflected forms (e.g., Alegre & Gordon, 1999; Baayen, Dijkstra, & Schreuder, 1997; Butterworth, 1983; Bybee, 1995; Manelis & Tharp, 1977; Sereno & Jongman, 1997). Such models of lexical organization and access assume that German speakers have inflected forms such as *Räder* in their mental lexicon. Due to its phonological and semantic relations with the singular form *Rad*, these two forms will be closely connected to each other. Ernestus and Baayen (2006) consider the possibility of incomplete neutralization effects being due to the co-activation of these related forms, i.e., when speakers pronounce *Rad*, they also activate the non-neutralized *Räder*. If some or most of the co-activated forms contain a non-neutralized segment that is fully voiced, these voiced forms could influence the motor commands used in speech production in subtle ways, leading to the observed incomplete neutralization effects.

A similar account has been advanced to explain the finding that speakers are able to distinguish forms like *Rat* and *Rad* with above-chance accuracy. Kleber et al. (2010) found that there is a greater probability of identifying a stop as voiceless after lax than after tense vowels. They further found that, following tense vowels, the (putatively neutralized) stop voicing contrast in syllable final position was recoverable more often when the stop was alveolar than when it was velar. Since in German phonologically short/lax vowels tend to occur more often before bilabial and velar voiceless stops, this suggests that sensitivity to statistical patterns of the German lexicon may affect the perception of incomplete neutralization, and thus it seems plausible that knowledge of phonotactic probabilities might play a role in production as well.

It seems safe to say that the predominant response to incomplete neutralization studies has been one of skepticism. Given that several early studies found no evidence for incomplete neutralization (Fourakis & Iverson, 1984; Jassem & Richter, 1989), some researchers have considered the debate to be settled (e.g., Kohler, 2007, 2012). However, other researchers have continued to investigate the phenomenon (e.g., Kleber et al., 2010; Piroth & Janker, 2004), and studies have since been carried out on both incomplete neutralization of final devoicing in other languages (e.g., in Dutch (e.g., Warner, Jongman, Sereno, & Kemps, 2004), Catalan (e.g., Charles-Luce & Dinnsen, 1987), Polish (e.g., Slowiaczek & Dinnsen, 1985) and Russian (e.g., Dmitrieva, Jongman, & Sereno, 2010; Kharlamov, 2012)) as well as incomplete neutralization of other processes (Bishop, 2007; Braver & Kawahara, 2012; de Jong, 2011; Dinnsen, 1985; Gerfen, 2002; Gerfen & Hall, 2001; Simonet, Rohena-Madrado & Paz, 2008).

Thus, the debate surrounding incomplete neutralization is still very much ongoing. However, the numerically small effect sizes common across incomplete neutralization studies have attracted serious criticism on methodological grounds (Kohler, 2007; Manaster-Ramer, 1996). Fuchs (2005: 25) points out that the debate surrounding incomplete neutralization has become increasingly a debate about methodology rather than the phenomenon per se. As such, our first and foremost aim in the present work is to address the methodological and conceptual concerns raised against previous studies, thereby placing the debate surrounding incomplete neutralization on firmer empirical footing. Our second aim is to interpret our findings in light of recent psycholinguistic models of lexical organization.

In Section 2, we summarize previous empirical findings as well as their critiques, with a particular focus on Fourakis and Iverson (1984) and Jassem and Richter (1989). In Sections 3–5 we discuss the results of three production experiments that were inspired by Fourakis and Iverson's study. Section 6 presents the results of a perception experiment. In Section 7, we discuss the implications of our work for an assessment of the status of incomplete neutralization in German in light of co-activation accounts.

2. Methodological debate and the problem of “proving the null”

Across different studies, numerous phonetic properties have been found to distinguish voiceless from devoiced stops in final position. These include the duration of the preceding vowel, the closure duration, the duration of the “voicing-into-the-closure”, as well as the burst and aspiration durations. Across different studies and languages, the duration of the preceding vowel has been shown to be the most reliable correlate of obstruent “voicing” in final position. Thus in the present study we shall focus on this acoustic parameter. This has the added advantage that we avoid statistical issues surrounding multiple comparisons: with each additional measure taken into account we have an added probability of rejecting the global null hypothesis that there is no acoustic correlate of incomplete neutralization at all. Standard ways of correcting for multiple comparisons, such as Bonferroni correction, increase the probability of missing a true effect and according to Bender and Lange (2001: 347) the “easiest and best interpretable approach is to avoid multiplicity as far as possible”. We do this by focusing on vowel duration.

The direction of the vowel duration difference mirrors the durational difference in the intervocalic context, i.e., vowels tend to be longer before final devoiced stops than before final voiceless stops. Numerically, incomplete neutralization effects of vowel duration are minute. For example, Port and Crawford (1989) report a difference of 1.2–6.2 ms between devoiced and voiceless stops in German, while Warner et al. (2004) report a difference of 3.5 ms in Dutch. The magnitude of the incomplete neutralization effect appears to be dialect- and speaker-dependent (Piroth & Janker, 2004), as well as highly sensitive to the phonetic, semantic and pragmatic context (Charles-Luce, 1985, 1993; Ernestus & Baayen, 2006; Port & Crawford, 1989; Slowiaczek & Dinnsen, 1985).

As German maintains an orthographic contrast between voiced/devoiced and voiceless stops in all positions, the biggest issue surrounding previous results was the influence of this orthographic representation.³ Most of the above-mentioned experiments used stimuli that had to be read aloud by the participants,

² We refer to the segment in words such as *Rad* as “devoiced”. This term is theoretically loaded because it assumes the presence of an underlying voiced segment. However, for this paper, we merely use the term as shorthand to refer to a segment corresponding to an intervocalic voiced segment within the same morphological paradigm, e.g., *Räder* [d] vs. *Rad* [t], without necessarily invoking a phonological process of devoicing.

³ There are other concerns with incomplete neutralization studies. These include minimal pair awareness, second language proficiency of experimenter and participants and stimuli selection. These concerns have been dealt with at length in Fourakis and Iverson (1984), Manaster-Ramer (1996), Kohler (2007) and Winter and Roettger (2011).

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