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Opa vs Oper: Neutralization of /ɐ/ and unstressed /a/ contrast in a perception and production study.

Bokelmann, J.¹; Ellert, M.-T.¹; Friesenhan, N.¹; Generlich, G.¹; Hiebert, Y.¹; Malon, T.¹; Naumann, F.¹; Sachs, R.¹; Swiech, A.¹; Walak, M.¹; Yovcheva, M.¹; Zander, I.¹; Rathcke, T.²; Mooshammer, C.¹

¹ Institut für deutsche Sprache und Linguistik, Humboldt Universität zu Berlin, Germany

² English Language and Linguistics, University of Kent, UK

T.V.Rathcke@kent.ac.uk, christine.mooshammer@hu-berlin.de (corresponding authors)

Abstract

The present study examined differences in production and perception of the German vowels /a/ and /ɐ/ in word-final, unstressed position. In the first experiment, 3 male and 3 female speakers produced minimal pairs embedded in meaningful sentences and varied in prosodic environment. In the second experiment, the minimal pairs were extracted from the context and presented to 44 listeners for a forced-choice identification task. Results showed a better-than-chance performance that was, however, mainly driven by one male speaker. Temporal and spectral measures confirmed that only this speaker produced an acoustic difference between /a/ and /ɐ/.

Index Terms: reduced vowels, German, vowel production, vowel perception

1. Introduction

Traditionally, the final Standard German vowels in *Opa* and *Oper* are transcribed with two different symbols, /a/ and /ɐ/, respectively. However, it is not clear if this contrast is indeed produced and perceived by native speakers of Standard German. In descriptions of German phonology the /ɐ/-schwa following consonants is derived from /ə/ (see e.g. Hall 1993 [7]). In this view, [ɐ] and [ɜ] are not two phonemes, but two allophones of one rhotic phoneme in complementary distribution: [ɜ] appears in the onset of a syllable, [ɐ] in any other position.

Meinhold (1989) [11] listed the following contexts for the occurrence of the /ɐ/-schwa: as a postvocalic /ɜ/-allophone, as in *hört* [hø:ɐt], as a realization of the <-er> suffix, as in *weiter* ['vaɪtɐ] and as a realization of the prefixes <er-, ver-, zer->. He further showed that both schwas, [ɐ] and [ə], could be correctly identified, provided there is sufficient context to follow the vowel.

Barry (1995) [1] investigated the relation between /ə/ and /ɐ/ and especially addressed the issue of how the context influenced the realisation of the two phonemes. He found less variability in the production of /ɐ/, but the results of the study were limited to just one speaker. The study by Dittrich and Reibisch (2006) [6] provided evidence against postvocalic diphthongisation following a long vowel /a:/, i.e. in words like *Paar* 'pair', unlike in words like *hört* [hø:ɐt], *mehrt* [me:ɐt], the stressed vowel showed formant trajectories of a

monophthong. Therefore, the authors argued against transcribing [a:ɐ] in this context.

The current perception and production experiment focuses on the difference between word-final unstressed /a/ and /ɐ/. Both vowels are supposed to be central vowels but the two IPA symbols imply a perceivable difference in vowel height with /a/ being lower than /ɐ/ (see e.g. Kohler 1990) [8]. Vowels in unstressed position usually undergo target undershoot (see Lindblom 1990) [10] which results in a more closed tongue configuration and a lower F1 frequency for German unstressed /a/ than for stressed /a/ (see Mooshammer & Geng 2008) [12]. Target undershoot could potentially lead to a neutralization of the contrast between these two vowels in unstressed position by raising the unstressed /a/.

According to Vennemann (1991)[14] the two vowels /a/ and /ɐ/ also belong to different vowel sets distinguished by a prosodic characteristic: /a/ is a full vowel of German that can occur in stressed position whereas /ɐ/ is a reduction vowel that cannot be stressed. Within Articulatory Phonology, the schwa vowel is assumed to be targetless, i.e. articulators that are not involved in an active gesture move towards a neutral position. Since German has two schwas /ə/ and /ɐ/, they cannot be completely targetless but they might still be more variable than other vowels (see Barry 1995 [1] for a discussion). Assuming a schwa vowel does not have a target it should be more prone to coarticulatory influences of the neighbouring segments.

The aim of this study is to investigate the perception and production of word-final unstressed /a/ and /ɐ/ in the following conditions: phrase-medial vs. -final position, accented and unaccented. When accented, the difference in production and therefore perception is expected to be more salient than in the unaccented condition due to hyperarticulation (de Jong et al. 1993) [5]. When in phrase-final position, the distinction is also expected to be less salient, due to lesser coarticulation. In the phrase-medial position, the coarticulation effects should support the distinction of the two phonemes and show higher recognition of /ɐ/.

2. Method

2.1. Speakers and Material

We recorded six speakers (3 male, 3 female) originating from the area of Kiel.

The minimal pairs of the investigation were:

- *Dina* – *Diener* ([di:nə] - [di:nə]); female first name – butler, servant)
- *Opa* – *Oper* ([ʔo:p^ha] - [ʔo:p^he]); grandfather – opera)
- *Feta* – *Väter* ([fe:t^ha] - [fe:t^he]); feta cheese – fathers),
- *Clara* – *klarer* ([kla:ʁa] - [kla:ʁe]); female first name – clearer).

Each word was embedded in meaningful sentences that were designed to vary the prosodic environment - the phrasal position (phrase-final vs. phrase-medial), level of prominence (accented vs. unaccented) – as well as the following segmental context - next word starting with /z/ vs. /l/. Here are 4 examples for our test sentences, varying the condition phrasal position for the minimal pair *Opa* – *Oper* (all accented and with following /l/ context):

- (1) *Meine Großeltern sind toll. Vor allem mein Opa lässt sich immer so spannende Geschichten einfallen. Es ist toll ihm zu zuhören.* (medial position)
My grandparents are amazing. Especially, my grandpa is always coming up with exciting stories. It is great listening to him.
- (2) *Ich liebe meine Oma, aber nicht so sehr wie meinen Opa. Lass es sich vielleicht gemein anhören, aber es ist nun mal so.* (final position)
I love my grandma, but not as much as my grandpa. It might sound mean but that's how it is.
- (3) *Auf den Kieler Bühnen läuft am Wochenende nicht viel. Ich habe die Oper letzte Woche schon gesehen. Aber wir können ins Schauspielhaus gehen.* (medial position)
On Kiel stages there is not much happening this weekend. I have already seen the opera last week. But we could go to the theatre.
- (4) *Ich gehe nicht oft aus. Nur ab und zu in die Oper. Letzten Monat war ich dreimal dort.* (final position)
I don't go out very often. Only sometimes to the opera. Last month I was there three times.

Each sentence was produced 3 times in randomized order. Thus each speaker produced a total of 192 target tokens (4 minimal pairs x 2 accent conditions x 2 contexts x 2 phrase positions x 3 repetitions).

2.2. Perception Test

2.2.1. Stimuli

In order to test the target words separately from their context, we selected one instance of the three repetitions for which the word was produced clearly, without errors, stutters or hesitation and could be extracted easily. Only words in /z/ context were used here. Silences of 100 ms were added before and after each word. These 384 stimuli (32 per speaker) were used to create a perceptual experiment script, using the speech analysis software *Praat* (Boersma & Weenink 2016)[3].

2.2.2. Listeners

44 native German speakers between 18 to 40 years old participated in the experiment. None of them reported any hearing impairment.

2.2.3. Procedure

For the experiment procedure, we used laptops running the experiment script in *Praat* [3] and a pair of headphones. A blank screen was shown for 100 ms before and after each stimulus. Then a choice of two buttons labelled with the respective minimal pair appeared on the screen alongside with the written question "Which word did you hear?". Participants were instructed to click on the button of their perceptual choice to give their answer as appropriate and to proceed to the next stimulus. Each stimulus was randomly presented twice during the experiment to counterbalance the position of the correct target button on the screen. Overall, the experiment took approximately 20 to 30 minutes.

2.3. Acoustic Annotation and Measurements

Praat [3] was used to annotate and analyse the characteristics of unstressed [a] and [ɐ]. Measurements included the durations of the initial stressed syllable, of the second unstressed syllable and of the vowel. Accent, boundaries, context, type of syllable and segments were annotated to compare the results. For acoustic analysis standard procedures in EmuR were used (Bombien et al. 2006) [4].

2.4. Acoustic Annotation and Measurements

All statistics were carried out using R 3.3.0 (see R Core Team 2016) [13] with the packages *lme4* (Bates et al. 2015) [2] and *lmeTest* (Kuznetsov et al. 2016) [9].

3. Results

3.1. Perception Test

Figure 1 shows the proportion of correct responses broken down by speaker and accentuation (pooled for all target words). For most speakers the number of correct responses was close to chance. The proportion of correctly perceived stimuli was slightly higher in accented than unaccented words. The results for the speaker M2 are remarkable: His scores were much higher compared to all other speakers.

Logistic linear mixed effects models indicate that there is a significant effect of accent ($p < 0.01$), position ($p < 0.05$), word ($p < 0.001$) and speaker ($p < 0.001$). The speaker effect is based on speaker M2 whose stimuli were recognised correctly more often than other speakers' items (see also Fig. 1). Excluding the perceptual results for this speaker, the effect of speaker and the effect of position are not significant. For this speaker words in final position were identified better than in medial position. For all speakers, the presence of accentuation improved recognition significantly.

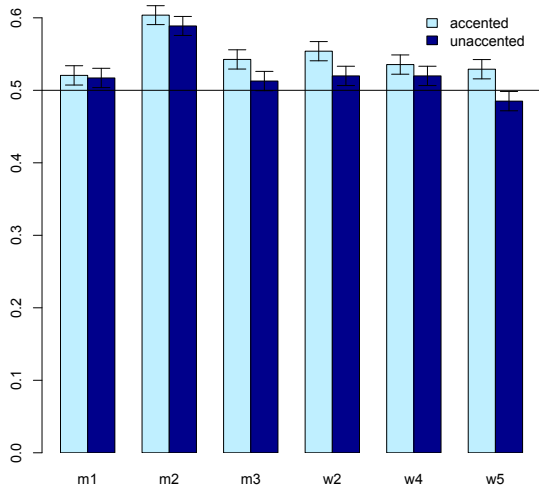


Figure 1: Means and standard deviation of correct answers for 6 speakers and two accentuation levels (light blue: accented; dark blue: unaccented).

3.2. Acoustic Analysis

So far, preliminary acoustic analyses have included exclusively three male speakers. The first parameter addressed here is the ratio of the duration of the stressed syllable to the unstressed syllable, shown in Figure 2 for the analysed speakers. The hypothesis is that reduced /*ɐ*/ syllables are shorter than unstressed syllables at the full vowel (yielding larger ratios for reduced /*ɐ*/ syllables). This was tested by calculating linear mixed effects models. There was no significant difference between reduced /*ɐ*/ syllables and unstressed /*a*/ syllables but as can be seen in the Figure 2, speaker M2 tends to have lower ratios for words with /*ɐ*/ syllables than for words with unstressed /*a*/ syllables.

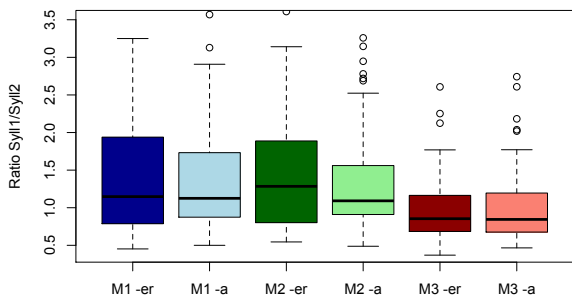


Figure 2: Boxplots of the duration ratios of syllable 1 to syllable 2 for speakers M1 (blue), M2 (green) and M3 (red). Darker colours represent items with reduced /*ɐ*/ and lighter colours items with unstressed /*a*/.

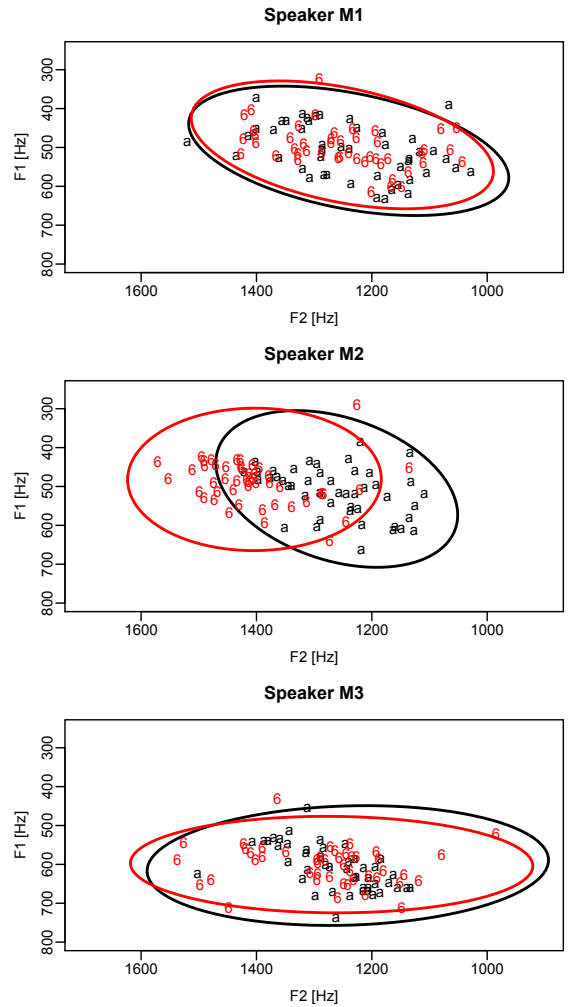


Figure 3: Scatterplots of the formant frequencies for F1 and F2 with 2 SD dispersion ellipses for the vowels /*ɐ*/ (denoted as "6") in red and /*a*/ in black.

Secondly, the formant frequencies of F1 and F2 were considered in order to quantify a potential quality difference between the two vowels. Figure 3 shows dispersion ellipses of the formant frequencies measured in mid vowel for reduced /*ɐ*/ (in red, denoted as "6") and unstressed /*a*/ (in black) for the three speakers. Speakers M1 and M3 display complete overlap of the ellipses for /*a*/ and /*ɐ*/, implying that there is no quality difference between the two variants. Speaker M2, however, does distinguish the two variants with the unstressed /*a*/ having a lower F2, suggesting a more retracted position compared to /*ɐ*/.

4. Discussion and Conclusion

Results from the perception test with around 53.5 % of correct recognition suggest that the difference between /*a*/ and /*ɐ*/ is subtle and therefore difficult to detect. Identification scores implied that accent enhanced the participant's ability to distinguish the given stimuli slightly but significantly to 54.8 %, supporting the associated hypothesis. Contrary to our hypothesis identification scores were improved in final

position. We assumed that more coarticulation in medial position might enhance the contrast because the reduced vowel /ɐ/ should be affected by the context to a greater degree than /a/. The opposite was the case. However, both effects, accent and position, vanished when one speaker, M1, was excluded from the data set.

This was corroborated by the analysis of the corresponding production data with almost no differences between temporal measures and formant values. This would lead to the conclusion that there is only a very slight contrast, most of the time not perceptible, between unstressed /a/ and /ɐ/. However, one speaker had improved recognition rates and at the same time showed a contrast for the acoustic measures, speaking for a clear connection between perception and production. For further investigating individual differences, we will provide acoustic data from the remaining speakers.

In conclusion, unstressed /a/ and /ɐ/ are almost undistinguishable because the difference is only rarely produced by speakers of German. Different IPA symbols should only be used for detectable differences.

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