When the *s* remains / does not remain an *s*:
Further explorations in the acoustics of the English plural suffix

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Whether or not specific variables trigger an acoustic distinction between phonologically identical forms has been a hotly debated territory. A key example is word-final *s* in English, and the question whether it systematically varies with different grammatical characteristics or functions. It has been demonstrated that affixal *s* (as in *laps*) differs from non-affixal word-final *s* (as in *lapse*) in duration (see, e.g., Plag et al. 2017; Seyfarth et al. 2018). Moreover, within affixal s, studies have revealed that several types differ in duration, such as plural (*cars*) and plural-genitive s (*cars'*) (see, e.g., Plag et al. 2020). These results put into question several established models of speech production, and the general understanding of the interplay of morphology, phonology, and phonetics (see, e.g., Bermúdez-Otero 2018; Fromkin 1971; Harley 1984; Kiparsky 1982; Levelt 1989; Levelt, Roelofs & Meyer 1999). In the spirit of such models, we should not expect acoustic variation since there is no direct connection between morphology and phonetics. Once the abstract and discrete phonological character of, say, the *s* has been formed, we should no longer expect duration differences, provided that the different conditions are comparable in terms of sentence position, frequency, and so on. The results reported above are thus more compatible with models that allow a flexible interplay between phonetics and other domains, such as morphology (see also, e.g., Pierrehumbert 2001, 2002). Here, we present two other studies to investigate the duration of the *s* in English, and to further examine the plausibility of different (psycho-) linguistic models.

The first experiment (Schlechtweg & Corbett 2021) investigated whether the *s* duration is distinct in regular plural (RPN, e.g., *toggles*) and pluralia tantum nouns (PTN, e.g., *goggles*). We conducted a reading experiment with Praat (Boersma & Weenink 2019) and tested the hypothesis that the *s* differs in duration. Two theoretical reasons for a possible duration difference are the informative and paradigmatic characteristics of the *s* in RPN and PTN (see also, e.g., Cohen 2014; Demuth 2011; Rose 2017). That is, first, the *s* is more informative in RPN than in PTN, since it distinguishes the plural from the singular form only in RPN (*toggles* vs. *toggle*) but not in PTN, which do not have a singular counterpart. Second, in terms of paradigmatic predictability, the *s* is more predictable in PTN than in RPN, since the former do not have a singular form. These two characteristics could in principle produce a difference in *s* duration.

One example of our test sentences is given in (1), and all 18 test items are given in Table 1.

(1) a. *The goggles appear to be broken and they're useless.*
    b. *The toggles appear to be broken and they're useless.*

Table 1. Test items used.

PTN	RPN
shears	*beers*
trousers	*browsers*
earnings	*yearnings*
pliers	*fires*
tweezers	*freezers*
goggles	*toggles*
tongs	*gongs*
jeans	*screens*
odds	*pods*

We used nine test pairs with one PTN and a comparable singular-dominant RPN each. Potentially confounding variables were controlled for across the two conditions. The 18 test items ended in [z] and were inanimate. In each pair, identical sentences were used, the only difference being the

target noun, which was either the PTN or the RPN. The PTN and the equivalent RPN had the same number of syllables, the same stress pattern, the same rhyme in the ultimate syllable, and at least two identical segments before the target segment [z]. Moreover, the frequencies of the two were not different (Mean RPN = 4.2 per million words (pmw); SD RPN = 4.7 pmw; Mean PTN = 4.2 pmw; SD PTN = 5.4 pmw; independent t test: t = 0.02, *p* = .988). The frequencies were gathered from the ukWaC corpus[1], a two-billion-words corpus containing materials from UK-based web pages. Also, the sequence "target noun + following word" had a frequency of 0 pmw in the ukWaC for all 18 test items and we therefore controlled for the syntagmatic probability (see, e.g., Cohen 2014). Each subject was tested on both items of a pair to exclude the influence of inter-subject variability. 36 filler sentences increased the distance between the two members of each pair. The two conditions were counterbalanced in the experiment. Analysis of the data of 40 native speakers of English and nine item pairs revealed no significant difference between the two conditions (for the descriptive statistics, see Table 2). Linear mixed effects models, conducted with the lme4 package (Bates, Maechler, Bolker & Walker 2015) in R (R Core Team 2021) and containing a random (intercepts for subject and item) and fixed effects structure (fixed effect of interest: noun type; several fixed effects control variables such as speech rate, frequency, and agreement) confirmed the finding.

Table 2. Descriptive statistics. Duration of *s* in seconds. Statistical outliers excluded. Total of 648 sound files.

Type of value	PTN	RPN
Mean	0.067	0.067
Standard deviation	0.017	0.017

Although we did not find a difference in *s* duration between PTN and RPN, another interesting effect was detected. Independently of the distinction between PTN and RPN, we found that the nouns in sentences with a past verb (e.g., *The odds / pods eventually dropped.*) contained a longer plural suffix than the nouns in sentences with a present tense verb (e.g., *The goggles / toggles appear to be broken and they're useless.*). Put differently, the *s* became longer if there was no overt number agreement between the noun and the verb in the sentence. One problem was, however, that the sentences did not only differ in terms of agreement but also in other respects, which might have caused the effect (e.g., *goggles / toggles* have two syllables, *odds / pods* have only one syllable). We decided to conduct another experiment to see whether the effect remains if different agreement conditions are entirely controlled for.

In the second study, we asked whether and how morphosyntactic agreement has an impact on the duration of word-final *s*. For this purpose, consider the examples in (2).

(2) a. *The blue cabs always break down.*
    b. *The blue cabs always broke down.*
    c. *These blue cabs always break down.*
    d. *These blue cabs always broke down.*

We see four different situations. When we have a present tense verb, one finds an overt distinction in agreement between singular and plural (see (2a) *cabs break* (plural) in comparison to *cab breaks* (singular)). In (2b), however, there is no overt agreement of the past tense verb (see *cabs broke* (plural) in comparison to *cab broke* (singular)). In (2c), we observe agreement not only between the plural noun and the present tense verb, as in (2a), but also between the determiner and the plural noun (see *These cabs* (plural) in comparison to *This cab* (singular)). In

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(2d), there is no agreement between the plural noun and the past tense verb, as in (2b), but there is agreement between the determiner and the plural noun. We examined whether the plural *s* on the noun differs in duration across these conditions, with informative and syntagmatic reasons being potential candidates for acoustic differences (see, e.g., Rose 2017). For one, the *s* is more informative of plurality if there is no overt agreement, hence if there is no other plurality indication. Second, without overt agreement, the *s* is less predictable in the sentence.

We tested 12 native speakers of English, using 16 nouns in a reading study conducted with Praat (Boersma & Weenink 2020). Each person was exposed to all items in all conditions (16 items per person x 4 conditions per item = 64 experimental cases per person). As can be seen in the examples, we carefully controlled for potentially confounding variables by using the same sentences in all conditions and by exposing all subjects to all items in the four conditions. All target nouns are regular plurals, singular-dominant, monosyllabic, inanimate, and contain the voiced /z/ in the plural. All verbs are irregular and have the same number of syllables in the present and past tense. The order of the four conditions was counterbalanced both within and across subjects. In a very first analysis, based on the automatic segmentation with the MAUS tool (Kisler et al. 2017; Schiel 1999), we did not detect acoustic differences. However, in a subsequent analysis based on the important and more reliable and accurate manual segmentation (see, e.g., Schiel, Draxler & Harrington 2011; Schuppler, Grill, Menrath & Morales-Cordovilla 2014), we found that, using linear mixed effects models, the *s* was shorter if *these* occurred at the sentence beginning in comparison to if *the* was used.

In sum, after several studies showed that different types of the English *s* systematically differ in their duration, we did not find differences between PTN and RPN but between different agreement conditions. Our results provide some further and slight support for models permitting a flexible interaction between phonetics and higher-order levels such as morphology or morpho-syntax.

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