Why are repeated words produced with reduced durations? Evidence from inner speech and homophone production

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ARTICLE INFO

ABSTRACT

Acoustic reduction for repeated words could be the result of articulation and motor practice (Lam & Watson, 2014), facilitated production (Gahl, Yao, & Johnson, 2012; Kahn & Arnold, 2015), or audience design and shared common ground (Galati & Brennan, 2010). We sought to narrow down what kind of facilitation leads to repetition reduction. Repetition could, in principle, facilitate production on a conceptual, lexical, phonological, articulatory, or acoustic level (Kahn & Arnold, 2015). We compared the durations of the second utterance of a target word when the initial production was aloud or silent. The silent presentation either involved unmouthed or mouthed inner speech. Overt production, unmouthed and mouthed inner speech all led to reduction in target word onsets, but target word durations were only shortened when a word was initially said aloud. In an additional experiment, we found that prior naming of a homophone of the target word also led to duration reduction. The results suggest that repetition reduction occurs when there is a recently experienced auditory memory of the item. We propose that duration may be controlled in part by auditory feedback during production, the use of which can be primed by recent auditory experience.

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Introduction

Acoustic reduction is a change in the speech signal that makes an utterance, or part of it, less prominent. Reduction is multidimensional: reduced words are shorter in duration, more co-articulated, quieter, and have flatter pitch contours (Bard et al., 2000; Bell, Brenier, Gregory, Girand, & Jurafsky, 2009; Fowler & Housum, 1987). Words that are acoustically less prominent are often predictable (e.g. Aylett & Turk, 2004; Bell et al., 2009), in common ground, and given (Bard et al., 2000). Repeated and predictable words may be reduced because they are easy to produce by speakers (Gahl, Yao, & Johnson, 2012) and easy for

listeners to understand (Lieberman, 1963). One claim is that reduction is an emergent property of the production system; speakers reduce when production is facilitated or easy. This paper explores the production components that contribute to reduction that is associated with repeated words, which we call *repetition reduction*. If a speaker says, "I saw a *clown* the other day. The *clown* was unhappy," the second utterance of clown will typically be reduced.

One hypothesis proposed by Kahn and Arnold (2012, 2015) is that priming at any level of production leads to reduction, including repetition reduction. Under the *facilitation reduction hypothesis*, facilitation can arise from priming if it occurs at the conceptual, syntactic, lexical, phonological, or articulatory level. In a referential communication task, Kahn and Arnold (2012) found that referring expressions were reduced both when a speaker could anticipate the target to be named from the affordances of the task and when that referent had been previously

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mentioned, suggesting that priming at conceptual and lexical levels can lead to reduction. Similarly, Bell et al. (2009) found a correlation between word duration and predictability, frequency, and repetition. They argued that duration reduction is linked to the ease of lexical retrieval.

An alternative hypothesis is that effects of facilitation on repetition reduction are limited to just the phonological representations that support articulation. Some evidence from the literature supports this hypothesis. In a referential communication task, Lam and Watson (2010) found that words that were expected were produced with less intensity than words that were unexpected, but words that were repeated were produced with shorter durations, suggesting that the phonological priming that arises from repetition is more strongly linked to duration than the cognitive factors that underlie speaker expectations. In another study, Lam and Watson (2014) investigated whether the givenness of a referent or the givenness of a name were critical for repetition reduction. In a picture description task, they found that reduction only occurred when a referring expression was repeated, independent of whether the referent was new or given. Furthermore, repetition of a referent by itself did not lead to reduction. Similarly, Kahn and Arnold (2015) found that simply hearing a word on the first trial was sufficient to create reduction when that word was then said aloud (see also Bard et al., 2000). These results, like the previous ones, suggest that reduction has some basis in the priming of the form of the word, and that word form may have a privileged effect on word duration.

Additional evidence for the form-facilitation hypothesis comes from work by Kahn and Arnold (2015). In their study, participants described two events in which objects undergo simple actions (e.g. "The cat shrinks", "The barn flashes", or "The artichoke spins"). In *congruent* conditions, the noun in the second sentence (e.g. "cat", "barn") was mentioned in the first. In the *incongruent* condition, the noun in the second utterance was new. Critically, Kahn and Arnold also conducted a study in which the first utterance was just a single noun. They manipulated whether that noun was spoken aloud or produced as inner speech. The second utterances were entire sentences and were always aloud. This inner speech manipulation allowed Kahn and Arnold to probe the level of production at which facilitation occurs and which levels affect reduction. Inner speech lacks sound and articulation, and has been argued to be phonologically impoverished. Nonetheless, it is conceptually and even lexically just as rich as overt speech (Oppenheim & Dell, 2008). Finding robust repetition reduction in duration when the first utterance is produced as inner speech would suggest that priming lower-level linguistic, articulatory, and auditory representations is not necessary for reduction.

Kahn and Arnold (2015) found that inner speech and overt speech led to speeded production in congruent conditions, most dramatically for the time to start the sentence, thus demonstrating that priming at higher levels in the production system can speed the time to articulation. For the actual duration of the second target word, Kahn and Arnold found that congruent targets were 22 ms shorter than incongruent ones in aloud trials, while there was only a 2 ms shortening in inner speech trials. Because repetition reduction only occurred in the aloud condition and not in the inner speech condition, these data suggest that reduction depends on engaging form-based representations that accompany overt articulation, including low-level phonological, articulatory, or auditory representations.

In the present study, we examine more fully the extent to which repetition reduction is the result of articulation, as opposed to other mechanisms. First, we sought to replicate the results of Kahn and Arnold's (2015) inner speech study in a more highly powered experiment. The goal was to determine whether there was any effect of facilitation on reduction in an inner speech condition. The presence of reduction in an inner speech condition would suggest that priming lexical or message level representations in production can potentially lead to repetition reduction. If priming only occurs in overt speech, this would suggest that only priming lower-level, form-based representations affects the duration of words.

In the first two experiments, we examined whether unmouthed (Experiment 1) and mouthed (Experiment 2) inner speech led to duration reduction. Speakers described two events, each containing a noun that could be either *repeated* (referred to as congruent in Kahn and Arnold) or *not repeated* (incongruent). Both types of inner speech are silent, but mouthed inner speech engages articulatory processes. Oppenheim and Dell (2008, 2010) found that mental speech errors made during mouthed inner speech showed the classic phonetic similarity effect – similar consonants were more likely to exchange with each other – but this effect was diminished in unmouthed inner speech. Unmouthed inner speech thus appears to lack full access to the phonological details of a word, while this information is available to mouthed inner speech. If articulatory practice contributes to reduction, we should expect repetition reduction with mouthed inner speech, but not unmouthed inner speech. If repetition reduction is linked to facilitation at higher levels of the production system, we expect repetition reduction in both mouthed and unmouthed inner speech.

Experiment 1

Method

Participants

Participants were 55 native speakers of English who were recruited through the University of Illinois Paid Subject Pool. Each person received $8 for their participation in the study.

Materials

A total of 96 colorized images from the Snodgrass and Vanderwart (1980) dataset (Rossion & Pourtois, 2004) were used, following Lam and Watson (2010). 48 of these images were designated as the critical items. From these critical items, 24 pairs were created (e.g. pear-ruler, axe-rooster). There was no phonological overlap between the names of pair members.