Effect of alcohol intoxication on the production of (dis)fluent repetitions

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Introduction Repetitions of short words or phrases, often single syllable function words, at the beginning of some larger phrases (such as "*the the* argument you've made so far...") are a common kind of disfluency frequently found in spontaneous speech. Research on repetitions generally assumes that repeating words at the beginning of a phrase reflects either hesitation or the need for making covert repair due to higher-level planning problems (Hieke 1981, Clark and Wasow 1998, Lickley 2015). However, both acoustic and textual evidence suggests that certain repetition forms may be related to the motor planning and control of a formulated utterance plan (Shriberg 1995). In this study, we look at repetitions in a special type of speech, where speakers are under the influence of alcohol intoxication. Alcohol is known as a general depressant of the central nervous system. Alcohol consumption may lead to reduced inhibition and impaired movement control (Dawson and Reid 1997). Previous research on disfluencies in alcohol speech only found minor changes in the rate of silent and filled pauses, false starts, interruptions, and the duration of pauses. However, changes in the rate of repetitions and phonemic lengthening are found to be much greater (Schiel and Heinrich 2015). More interestingly, the change in repetition rate as reported in Schiel and Heinrich (2015) is in the opposite direction if the assumption that alcohol disturbs the speech planning process at some higher level is withheld. Here we aim to further explore the differences between repetitions in sober and alcohol intoxicated states. We hope these descriptions can bring further insights to neurologically plausible models of speech production.

Data and methods We use the speech produced from the spontaneous speech tasks of the Alcohol Language Corpus (ALC) (Schiel et al 2008). ALC contains speech produced by same speakers in both sober and intoxicated conditions. For each speaker, recordings in two intoxication conditions were made with most potential confounding factors controlled. Therefore the data set allows causal interpretations. Repetitions are identified from the manual annotations provided in the corpus. In the following analyses, we approach the task from two perspectives: what is the group difference caused by alcohol intoxication, and how alcohol intoxication affect the speech production for individual speakers. We ask both how the distribution of repeated forms may differ in two intoxication conditions, and how their acoustic manifestations, mainly in terms of duration, are different.

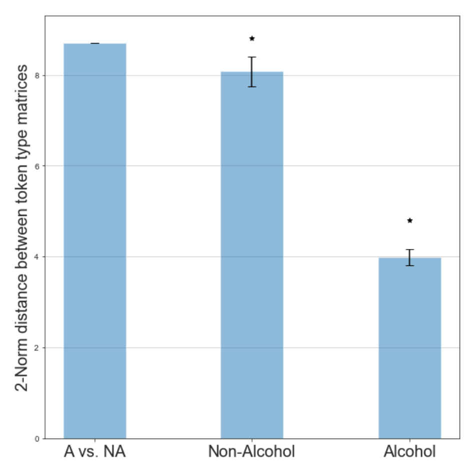

Figure 1: Form differences across and within intoxication states.

Feature space Three kinds of features are explored: *overall frequency*, *form type*, and *form duration*. Overall frequency is calculated as the relative frequency of repetitions in the speech produced by each speaker in each condition. To compare form type difference, we construct a binary vector for each speaker condition whose indices correspond to forms that are repeated at least twice in the combined alcohol (A) non-alcohol (NA) conditions. For duration properties, only repetitions that repeat same form twice are considered. Form duration considers three duration measurements: the duration of first (R1) and second (R2) repeat, as well as the pause duration between the two repeats (P).

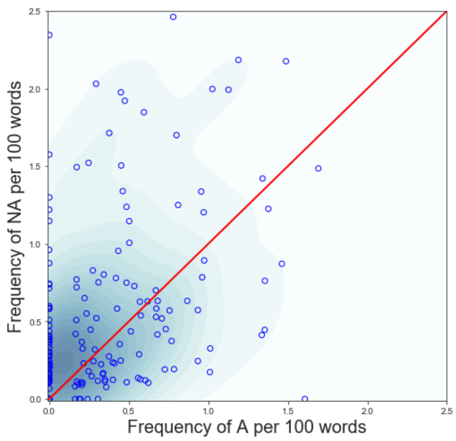

Figure 2: Individual frequency differences between states.

Group difference The overall repetition frequency is about the same as reported in (Schiel and Heinrich 2015), who used 12 fewer speakers from the same corpus. The frequency of repetition in NA condition is higher (7.27 per 1k words) than in A condition (4.58 per 1k words). Form difference is calculated as the 2-norm of the difference matrix, $||\mathbf{B_A} - \mathbf{B_{NA}}||_2$, where $\mathbf{B}$ represents the $nspeaker \times nform$ $0-1$ matrix in each condition. For comparison, 50 random half-matrices in each condition are also compared to the other half of the same state (within-condition difference). Results show, as plotted in figure 1, that between-condition difference is greater than both of the average within-condition differences. NA also has larger within-state difference compared to A, suggesting greater variability in repeated forms. In terms of duration features, both R1 and R2 are on average 56 ms longer in A, and the differences are statistically significant ($p = 0.007$ *and* $p = 0.002$ *respectively*). However, the ratio of R1/R2 is not significantly different.

Individual difference Frequency difference between A and NA for each speaker is plotted in figure 2. Three broad individual groups can be observed: those who repeat predominantly in NA, represented by those closely follow the vertical axis (i.e., do not repeat in A), those who repeat more in A, represented by those dots roughly parallel to the horizontal axis, and those who repeat more or less with the same frequency, represented by those scattered along the equal distance line. Form difference for each speaker is measured as the cosine similarity between the two form vectors in two intoxication conditions. As figure 3 shows, for majority speakers, their similarity scores are essentially 0, suggesting that the repeated forms in A and NA are likely to be quite different. Since most people do not have enough samples to make duration comparisons meaningful, duration features are not compared here.

Discussion and Conclusion Our comparisons have identified several interesting patterns that tend to support the hypothesis that repetitions may reflect more motor control issues than planning problems. First, the observation of longer overall duration but not relative duration between repeated forms suggest a change in motor execution under alcohol intoxication. Second, less repeated form diversity and frequency in A contradict the view that repetition is primarily resulted from planning problems, given the known disturbing effect of alcohol on speech planning. Last, but not the least, dissimilarity of repeated forms in A and NA suggests that repetitions under alcohol intoxication may be in part attributable to different causes than those occurring in sober speech.

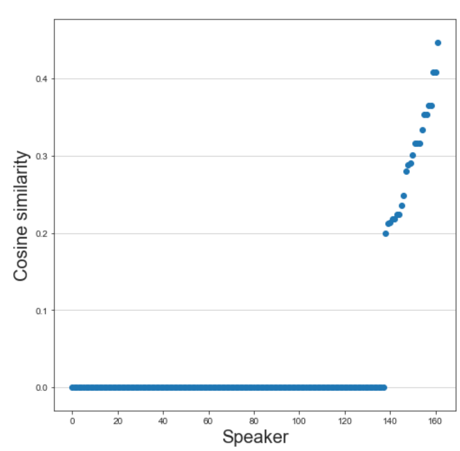

Figure 3: Individual form differences between intoxication states.

References Clark and Wasow (1998) Cog. Psych; Dawson and Reid (1997) Nature; Hieke (1981) Lang. and Spch.; Lickley (2015) Handbook of Spch. Prod.; Schiel and Heinrich (2015) Int'l. J. of Spch. Lang and Law; Schiel et al (2008) Proc. of LREC 2008; Shriberg (1995) Proc. of ICPhS.