Influence of attention capture on disfluent speech under delayed auditory feedback among adults who stutter

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1. Introduction

It is classically known that speech disfluencies occur under delayed auditory feedback (DAF) among adults who do not stutter (AWNS) [1]. Although the underlying mechanisms of disfluent speech by DAF remain unclear, one potential explanation is the involvement of auditory attention toward their delayed voice [2,3]. Ishida et al. [3] conducted a dual task experiment (speech and reaction tasks) under DAF with AWNS and revealed an increase in speech disfluencies when the participants allocated their attention toward the auditory stimulus.

In contrast, some adults who stutter (AWS) showing a fluency disorder characterized by frequent word or part-word repetition, prolongation, and silent blocks that disrupt the rhythmic flow of speech [4] decrease their disfluent speech under DAF [5]. Previous literature has suggested the role of abnormal processing of auditory feedback in stuttering [6,7].

However, similar to AWNS, some AWS show increased speech disfluency under DAF [8]. It is proposed that there exists a subgroup of AWS because the stuttering severity of those AWS whose speech disfluencies are increased under DAF has been shown to be relatively mild compared with those who decrease speech disfluencies under DAF [8]. However, it remains unclear whether the mechanism of speech disfluency occurrence in AWS with mild severity could be similar to that of AWNS.

The purpose of the present study was to examine the mechanism of disfluency occurrence of AWS (mild) in a DAF condition. We used Ishida et al.’s dual task experiment under DAF and non-altered feedback (NAF) [3] and compared the rate of occurrence of disfluent speech between AWS (mild) and ANWS. We hypothesized that a comparison of speech disfluency between AWS (mild) and ANWS would reveal the function of auditory attention processing in AWS with mild severity when they produce speech.

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DAF, auditory dual NAF, auditory dual DAF, tactile dual NAF, and tactile dual DAF.

Each of these six conditions was performed thrice by each participant while alternating between the NAF and DAF setting. The sentences, the order of stimulus modality (single, auditory, or tactile), and the order of feedback condition were counterbalanced among the participants.

2.4. Data analysis

We calculated the disfluency rate of each participant under each condition by calculating the proportion of disfluent speech (disfluent phrase/all phrases × 100). For each (single, auditory, or tactile) conditions, we performed a 2 (feed-back: NAF and DAF) × 2 (participant: AWS and AWNS) two-way ANOVA to compare the disfluency rate among different conditions. Generalized eta squared ($\eta_G^2$) was calculated to confirm the effect size among three conditions (single, auditory, or tactile) under DAF.

Based on the work by Sakai et al. [10] and Ishida et al. [3], we divided disfluency symptoms into nine classifications: “sound repetition,” “part-word repetition,” “word and phrase repetition,” “prolongation,” “break,” “distortion,” “syllable repetition,” “revision,” and “error.” SPSS version 25.0 was used for statistical analysis.

3. Results

Stuttering severities of AWS participants were as follows: very mild (13), mild (2), mild to moderate (2), and moderate (3). We report the results of disfluency rates in both groups under NAF and DAF in single (Fig. 1), auditory (Fig. 2), and tactile (Fig. 3) conditions.

In the single condition, there were significant interaction between feedback and group ($F[1, 38] = 7.97, p = 0.008, \eta_G^2 = 0.066$). By the simple main test, we found that in the DAF condition, the disfluency rate of the AWS group was significantly higher than that of the AWNS group ($p = 0.009, \eta_G^2 = 0.165$), whereas there was no group difference in the NAF condition ($p = 0.529, \eta_G^2 = 0.011$). Both the AWS and AWNS groups showed a significantly higher disfluency rate in the DAF condition than in the NAF condition (AWS group: $p < 0.001, \eta_G^2 = 0.439$; AWNS group: $p < 0.001, \eta_G^2 = 0.324$).

In the auditory dual condition, there were significant interaction between feedback and group ($F[1, 38] = 6.37, p = 0.016, \eta_G^2 = 0.061$). By the simple main test, both the AWS and AWNS groups showed significantly higher disfluency rate in the DAF condition than in the NAF condition (AWS group: $p < 0.001, \eta_G^2 = 0.491$; AWNS group: $p < 0.001, \eta_G^2 = 0.426$). We found that in the DAF condition, the disfluency rate of the AWS group was significantly higher than that of the AWNS group ($p = 0.023, \eta_G^2 = 0.129$), whereas there was no group difference in the NAF condition ($p = 0.847, \eta_G^2 = 0.001$).

In the tactile dual condition, an interaction between feedback and group were marginally significant ($F[1, 38] = 3.09, p = 0.087, \eta_G^2 = 0.029$). There were significant main effects of feedback ($F[1, 38] = 26.90, p < 0.001, \eta_G^2 = 0.208$) but the main effect of group did not reach a significant level ($F[1, 38] = 2.41, p = 0.129, \eta_G^2 = 0.038$). The effect size between AWS and AWNS under DAF conditions was “medium” ($\eta_G^2 = 0.071$).

4. Discussion

In the present study, we compared the disfluency rate between AWS (mild) and AWNS groups using the dual task.
paradigm of Ishida et al. [3] to examine the mechanism of disfluency occurrence of AWS (mild) under DAF. There were no significant differences of disfluency rate across all tasks (single, auditory, and tactile) in the NAF condition between groups. As the stuttering severities of participants in the AWS group were mostly mild, it can be assumed that the AWS group could speak as fluently as the AWNS group under the NAF condition.

In contrast, we found that the AWS group showed an increase in speech disfluency under any DAF condition compared with the AWNS group, with a “medium” to “large” effect size. Over-monitoring of the speech plan [11] and overreliance on the auditory feedback-dominated motor speech control [6] have been suggested to be associated with the speech disfluencies among AWS. In a magnetoencephalography study, it was reported that AWS have impaired auditory sensory gating system that “gate out” irrelevant information [7]. Based on these studies, we speculate that the AWS participants in our study over-monitored their auditory feedback, making it hard for them to ignore their delayed speech under DAF. Thus, their attention was “captured” more to the auditory modality under DAF whether the task condition was single or dual, resulting in the increased variability of disfluencies among the AWS group compared with those among the AWNS group.

The important findings of the present study were the increased variability of disfluencies during DAF in the AWS group. Our results suggest that the mechanism of disfluency occurrence in AWS (mild) and AWNS could be different, even though the baseline disfluency rates were similar for both groups, i.e., the NAF conditions. Thus, the occurrence of speech disfluency under DAF in AWS (mild) could be a “state” rather than a “trait” of speech control.

A further implication of the finding was that we analyzed the participants of AWS with mild stuttering severity and whose disfluencies increased under the DAF condition. Conversely, it is reported that speech disfluencies could decrease among severe AWS [12]. Further investigations are necessary to elucidate the mechanism of disfluency occurrence among severe AWS and find an association between researches of sever AWS and our present findings.

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