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Does Excessive Attention to Speech Contribute to Stuttering? A Preliminary Study With a Reading Comprehension Task

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Abstract

People who stutter (PWS) presumably pay excessive attention to monitoring their speech, possibly exacerbating speech fluency. Using a reading comprehension task, we investigated whether or not PWS devote excessive attention to their speech.

Methods: *Eleven PWS and 11 people who do not stutter (PNS) read passages in silent and oral reading conditions with and without noise masking, then answered comprehension questions. For PWS, auditory noise masking and silent reading would presumably divert their attention away from their speech.*

Results: *The comprehension performance of PWS was lower in the oral-no-masking condition than the oral-masking and silent-no-masking conditions. In contrast, there were no significant differences in the comprehension performance of PNS between the four conditions.*

Conclusions: *PWS had poor comprehension when listening to their speech, suggesting excessive attention to speech and limited attention to concurrent cognitive tasks.*

Developmental stuttering is a fluency disorder characterized by involuntary repetitions, prolongations, and silent blocks, especially in the initial parts of utterances (e.g., Guitar, 2006; Van Riper, 1971, 1982). Numerous conditions or situations influence stuttering frequency among people who stutter (PWS). Variability in stuttering frequency could be partly explained by attention during speech production. Stuttering frequency tends to co-vary with the amount of attention PWS devote to their speech (Bloodstein & Ratner, 2008). Some argue that PWS attend excessively to monitoring their speech (e.g., Civier, Tasko, & Guenther, 2010; De Nil, Kroll, & Houle, 2001; Fukawa, Yoshioka, Ozawa, & Yoshida, 1988; Kamhi & McOsker, 1982; Tourville, Reilly, & Guenther, 2008). Based on Levelt's psycholinguistic theory of speech perception (Levelt, 1989; Levelt, Roelofs, & Meyer, 1999), there are two distinct speech monitoring loops. External (post-articulation) monitoring is mainly based on auditory feedback, whereas internal (pre-articulation) monitoring is based on inner linguistic representations. Here, as in previous research, we use "speech monitoring" or "attention to one's speech" to refer to external monitoring via auditory feedback.

In general, people who do not stutter (PNS) seem to devote adequate attention to both verbal and nonverbal information during speech. During speech monitoring, they hear their voice and modify tone, volume, intonation, speech content, and so on, based on auditory feedback, and allocate limited attentional resources to those processes. However, PWS could have problems appropriately allocating attention during speech (Bosshardt, 2006; Metten et al., 2011). This is supported by results from dual task experiments that include a speech task. In dual task experiments, participants are engage in two tasks concurrently, such as finger tapping while reading aloud. Previous studies have shown that concurrent tasks have a greater effect on task performance in PWS than PNS (Arends, Povel, & Kolk, 1988; Bosshardt, 1999, 2002, 2006; Bosshardt, Ballmer, & De Nil, 2002; Caruso, Chodzko-Zajko, Bidinger, & Sommers, 1994; De Nil & Bosshardt, 2001; Vasic & Wijnen, 2005). Presumably, this is because PWS are not able to properly allocate attention to the task and devote too much attention to speech monitoring, which influences their performance on concurrent tasks (Metten et al., 2011).

Previous dual task experiments suggest that PWS allocate excessive attention to their voices and less attention to cognitive processes. While some studies have shown an increase in stuttering while performing concurrent tasks (Bosshardt, 1999, 2002; Caruso, et al., 1994; Metten et al., 2011), other studies have shown that concurrent tasks reduce stuttering (Arends et al., 1988; Vasic & Wijnen, 2005). Arends et al. (1988) found that PWS showed fewer stuttering disfluencies when simultaneously speaking and performing a tracking task than when performing only speech tasks. Vasic and Wijnen (2005) instructed PWS and PNS to retell the content of a reading passage while playing a computer game or monitoring their speech for a target word. They found a decrease in stuttering frequency among PWS in dual-task conditions, and suggested that distracting secondary tasks divert attentional resources from speech monitoring. Allocating less attention to speech monitoring reduces speech disfluency in PWS.

In addition, the alleviation of stuttering with altered auditory feedback may support the hypothesis that PWS devote excessive attention to speech. Previous studies have shown a decrease in stuttering with delayed auditory feedback (DAF), frequency altered feedback (FAF), and masking auditory feedback (MAF; e.g., Antipova, Purdy, Blakeley, & Williams, 2008; Cherry & Sayers, 1956; Howell, El-Yaniv, & Powell, 1987; Kalinowski, Armson, Stuart, & Gracco, 1993; Kalinowski, Stuart, Sark, & Armson, 1996; Kalinowski, Stuart, Wamsley, & Rastatter, 1999). Furthermore, shadowing (Andrews, Howie, Dozsa, & Guitar, 1982; Healey & Howe, 1987) and chorus speech (Kalinowski & Saltuklaroglu, 2003; Saltuklaroglu, Kalinowski, Robbins, Crawcour, & Bowers, 2009) also reduce stuttering disfluencies. There are many theories about why these conditions enhance fluency in PWS. In particular, Bloodstein and Ratner (2008) hypothesized that these conditions create an artificial or unnatural speech pattern that diverts attention away from stuttering. A recent speech production model, DIVA (Civier et al., 2010; Guenther, Ghosh, & Tourville, 2006), suggests that speech motor control relies heavily on auditory feedback (i.e., attention) in PWS. This model seems to support Bloodstein and Ratner's (2008) distraction hypothesis. Based on the results of a neuroimaging study investigating speech-induced suppression and response latency, Beal et al. (2010) proposed that there may be compensatory neural changes in engaging the right-earlier-than-left hemisphere of the auditory cortex in PWS. This compensatory activation of the right hemisphere may imply abnormal auditory feedback processing, and, consequently, abnormal attention involvement to speech in PWS.

Although the studies reviewed above mainly focused on speech fluency, stuttering behavior, as well as non-speech task performance (Bajaj, 2007; Lincoln, Packman, & Onslow, 2006), they may be insufficient for determining other factors that potentially contribute to distress among PWS. Therefore, in the present study we propose a new research direction. The central point is that because attentional resources are limited, the allocation of excessive attention to speech monitoring in PWS could require the use of a relatively large amount of attentional resources, resulting in disadvantages in speech communication, such as comprehension. However, to our knowledge little is known about this possibility (Kamhi & McOsker, 1982; Weber-Fox, 2001). Here, we hypothesize that abnormal speech monitoring would hinder comprehension of speech content in PWS, because comprehension requires the attentional resources allocated to speech and/or stuttering disfluency. Thus, if PWS pay excessive attention to speech monitoring, they are less likely to devote adequate attention to speech comprehension. Consequently, PWS might show poor speech comprehension. This would be problematic for speech communication, as well as overt speech disfluency.

We evaluated reading comprehension in PWS as a preliminary study to estimate speech comprehension. Note that reading comprehension is slightly different from speech comprehension. The former reflects reading skills and concurrently comprehending a visually presented passage, whereas the latter additionally includes comprehension of one's own spontaneous speech and speech produced during conversations with others (see Discussion). Because it is difficult to control the content of spontaneous speech and compare it between participants in an experimental setting, we evaluated reading comprehension during reading of prepared passages. Although comprehension is a complex mental process that includes cognitive processes other than attention, we assumed that reading comprehension performance can index the amount of attention devoted to one's reading voice, as suggested by Kamhi and McOsker (1982) who stated that attention-demanding tasks could influence reading comprehension.

In the present study, we investigated reading comprehension in PWS under several conditions. Based on Kamhi and McOsker's (1982) oral reading comprehension experiment, a reading passage was displayed to participants. Participants were instructed to read the passage and understand the content. To perform this dual task, participants had to allocate sufficient attention toward both reading and comprehension. According to our hypothesis, reading comprehension performance would be lower in PWS because excessive attention to their speech (i.e., passage reading) prevents sufficient attention to comprehension. PWS may be better able to focus on comprehension if their attention is diverted away from their speech. To this end, we included two attention-distracting conditions: silent reading and exposure to noise masking. Silent reading includes subvocal rehearsal or inner speech (Weber-Fox, 2001), so participants do not need to direct attention toward overt speech monitoring. In the noise masking (MAF) condition, auditory noise was presented to participants' ears. In contrast to DAF or FAF, in which participants can hear their delayed or frequency-altered voice, MAF prevents participants from hearing their voice when speaking, so that they cannot attend to overt speech monitoring. Thus, noise masking may divert attention away from speech monitoring. We tested these hypotheses by comparing comprehension performance between normal oral reading, oral reading with noise masking, silent reading, and silent reading with noise masking conditions.

Materials and Methods

Participants

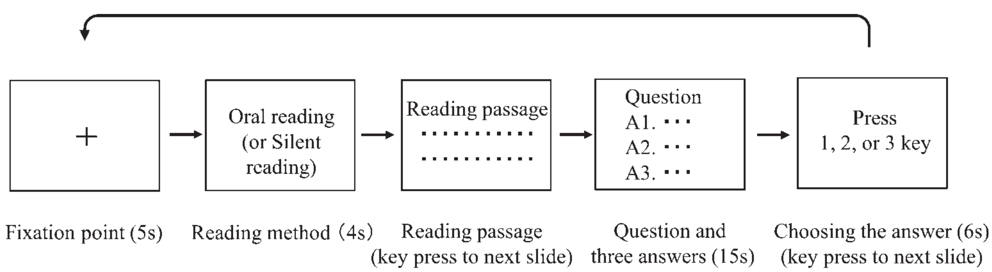
The PWS group consisted of 11 adults (nine male and two female) aged 21–29 years (mean age=23.9±2.8 years), and the PNS group consisted of 11 adults (nine male and two female) aged

21–27 years (mean age=23.6±2.4 years). The PWS participants were recruited from a self-help group in Japan, and all showed symptoms of developmental stuttering. All participants were right-handed and none had any history of neurological problems or chronic hearing loss. The ethics committee of Kyoto University approved the experimental procedures in advance, and the experiment was conducted in accordance with the Declaration of Helsinki.

Experimental Setup and Procedure

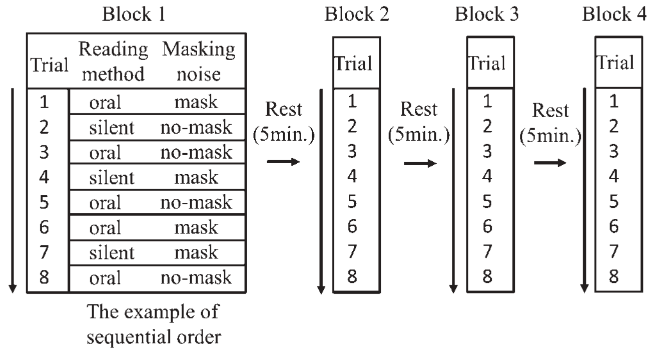
As in Kunita, Yamada, Morita, and Chujo (2008), 34 reading passages (190±23 syllables) and comprehension questions were extracted from five workbooks used in a Japanese language proficiency test (32 passages were used in experimental trials and two passages were used in practice trials). Participants read passages orally or silently and then chose the correct answer to a comprehension question from three choices. Figure 1 shows the sequence of visual stimuli in the experiment. Participants viewed the display monitor (G225HQ, ACER, Taiwan) while wearing a headset (MM-HSUSB14GY, SANWA SUPPLY INC., Japan). Presentation of visual stimuli was controlled by software (LabVIEW 8.5, National Instruments, Japan). Participants' right hands were positioned on a table, which enabled them to press keyboard buttons when required (spacebar, 1, 2, and 3). In each trial, a fixation cross appeared for 5 seconds. During this period, participants were required to look at the center of the cross. Then, visual instructions for reading method (oral or silent) were presented for 4 seconds, followed by a reading passage. Participants were instructed to read the passage orally or silently (as per the instructions) at a comfortable pace. When they were finished reading the passage, participants pressed the spacebar with their right hand as quickly as possible. We measured reading duration (time interval between passage presentation and when participants pressed the spacebar). We did not tell participants that reading duration was being measured, as this could influence their reading pace. Then, a question about the passage content was presented with three possible answers for 15 seconds. Finally, a visual stimulus instructing participants to answer the question appeared for 6 seconds. Participants responded immediately by pressing a button with their right hand.

Figure 1. Time Course of One Trial in the Experiment.



There were two independent variables: reading method (oral or silent) and auditory masking (masking or no-masking). In the masking condition, pink noise of 85 db SPL was presented through the participants' headphones during reading to mask the participant's voice. We asked participants if they could hear their own voiced speech via air conduction while receiving pink noise. Before the study, we confirmed that the noise completely masked participants' voices. In the no-masking condition, no sound was presented. Two practice trials preceded the experimental trials. There were 32 experimental trials divided into four blocks of eight trials (see Figure 2). Each block included two trials for each of four conditions: oral-masking, oral-no-masking, silent-masking, and silent-no-masking. Condition order was randomized, and reading passages for each condition were randomly assigned. We measured the percentage of correct answers on the comprehension questions and reading duration. In addition, speech samples in PWS were recorded with a video camera and voice recorder so that two speech therapists could evaluate speech disfluency in the oral condition.

Figure 2. Time Course of the Experiment for One Participant.



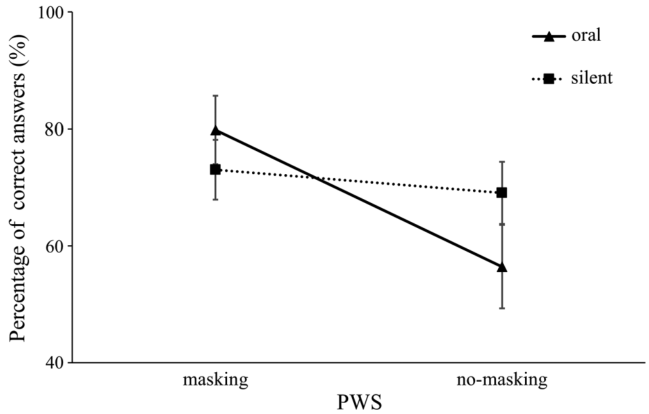
Data Analysis

Although we controlled for age and gender between the two groups, we did not take reading experience into account. Therefore, we asked participants at a later date to complete a five-question questionnaire (5-alternative forced-choice) about daily reading habits (extracted from Sawasaki, 2012) and to send it back. We received completed questionnaires from eight PWS and six PNS participants. A *t*-test revealed a significant difference in reading experience between PWS and PNS [$t(11)=2.30$, $p=.042$]. Therefore, the two groups did not have comparable reading experience. This prevents group comparisons, so behavioral data were analyzed for each group separately. In PWS, comprehension performance (percentage of correct answers) and reading duration were analyzed using two-way repeated-measures analyses of variance (ANOVAs), with reading method (oral/silent reading) and auditory masking (masking/no-masking) as factors. In addition, we calculated stuttering frequency (stuttered syllables/all syllables) based on the recorded speech samples. We then compared stuttering frequency between the oral-masking and oral-no-masking conditions. A Spearman correlation analysis was performed between stuttering frequency and comprehension performance in both conditions. A qualified and trained speech-language pathologist (SLP) calculated stuttering episodes in all recorded passages. Stuttering was defined as part-word repetitions, part-word prolongations, and silent blocks. To ensure intrajudge reliability, the same speech therapist recalculated stuttering episodes among 10% of randomly selected samples. To ensure interjudge reliability, a second SLP calculated stuttering episodes of another 10% of randomly selected samples. We confirmed reliability of these evaluations (Cohen's Kappa; intrajudge=0.85, interjudge=0.76). One participant was excluded from the analysis because his stuttering behavior was markedly more severe than the other PWS participants. Notably, this participant's reading durations were extremely long, and he exhibited considerable disfluency. Both of these measures exceeded two standard deviations of the PWS mean. In the PNS group, comprehension and reading duration were also analyzed using two-way repeated-measures ANOVAs. Statistical analyses were conducted using Statistical Package for the Social Sciences (SPSS) version 12 for Windows.

Results

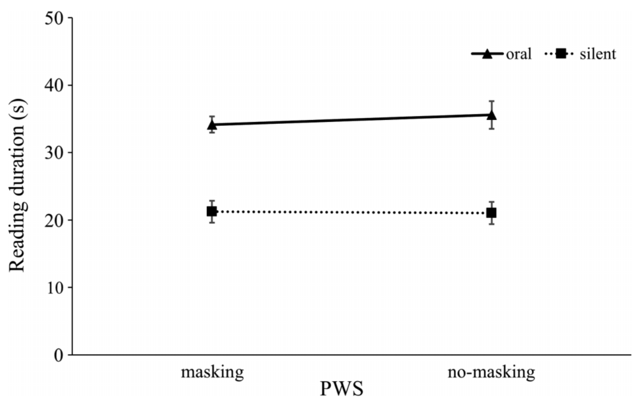
For comprehension performance in PWS, there was a significant interaction between reading method and masking [$F(1, 9)=6.55$, $p=.031$, $\eta_p^2=.421$]. There was also a significant main effect of masking [$F(1, 9)=9.05$, $p=.014$, $\eta_p^2=.501$], but no significant main effect of reading method [$F(1, 9)=0.49$, $p=.503$, $\eta_p^2=.051$] (see Figure 3). Because there was a significant interaction between factors, we examined simple main effects (reading effect in the masking condition, reading effect in the no-masking condition, masking effect in the silent reading condition, and masking effect in the oral reading condition). Comprehension performance was significantly higher in the oral-masking than oral-no-masking condition [$F(1, 9)=14.42$, $p=.004$, $\eta_p^2=.616$], and in the silent-no-masking than oral-no-masking condition [$F(1, 9)=7.04$, $p=.026$, $\eta_p^2=.439$]. Moreover, there was a significant main effect of reading method on reading duration [$F(1, 9)=75.32$, $p<.001$, $\eta_p^2=.893$] (see Figure 4). The main effect of masking and the interaction between reading method and masking were not significant [masking: $F(1, 9)=0.71$, $p=.421$, $\eta_p^2=.073$; interaction: $F(1, 9)=0.86$, $p=.377$, $\eta_p^2=.089$]. Thus, PWS took longer to read during oral reading than silent reading. Figure 5 shows stuttering frequency in the masking and no-masking conditions and the PWS group means. Mean stuttering frequencies were 0.62±0.55% (masking) and 0.79±0.2% (no-masking). A *t*-test showed no significant difference between the two conditions [$t(9)=-0.80$, $p=.441$, $d=.409$]. The correlation between stuttering frequency and comprehension performance was not significant ($r=-.19$, $p=.412$).

Figure 3. Mean Percentage of Correct Answers for the Four Conditions in PWS (*n*=10).



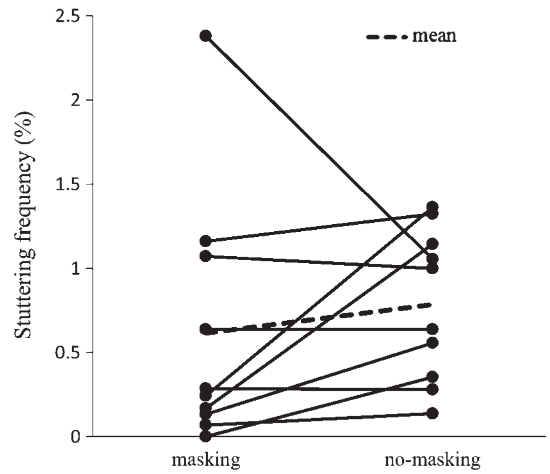
Error bars represent one standard error of the mean (SEM).

Figure 4. Mean Reading Duration for the Four Conditions in PWS (*n*=10).



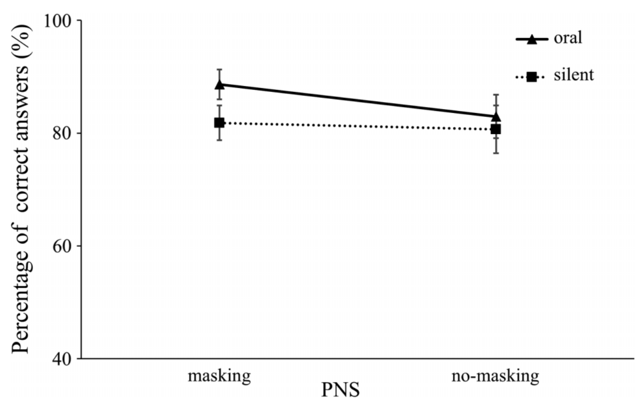
Error bars represent one standard error of the mean (SEM).

Figure 5. Stuttering Frequency for Each PWS (Solid Lines) and Means (Broken Line) in Masking and No-Masking Conditions.



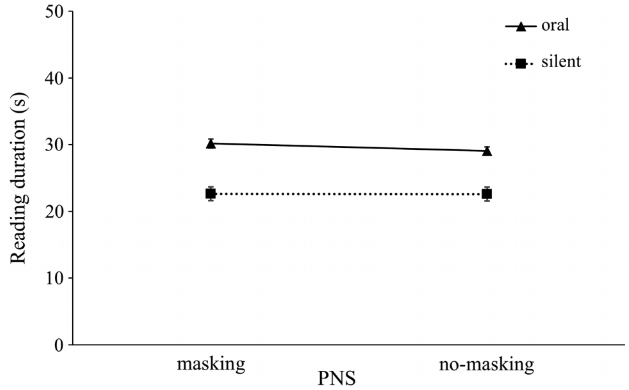
For comprehension performance in PNS, the main effects of reading method [$F(1,10)=1.38$, $p=.267$, $\eta_p^2=.121$] and masking [$F(1,10)=0.731$, $p=.412$, $\eta_p^2=.068$] were not significant, and there was no significant interaction between factors [$F(1, 10)=0.42$, $p=.531$, $\eta_p^2=.040$] (see Figure 6). Thus, performance on the comprehension task did not differ between the four conditions. There was a significant main effect of reading method on reading duration [$F(1, 10)=71.71$, $p<.001$, $\eta_p^2=.878$] (see Figure 7). The main effect of masking and the interaction between reading method and masking were not significant [masking: $F(1, 10)=1.85$, $p=.203$, $\eta_p^2=.156$; interaction: $F(1, 10)=1.63$, $p=.231$, $\eta_p^2=.140$].

Figure 6. Mean Percentage of Correct Answers for the Four Conditions in PNS ($n=11$).



Error bars represent one standard error of the mean (SEM).

Figure 7. Mean Reading Duration for the Four Conditions in PNS (*n*=11).



Error bars represent one standard error of the mean (SEM).

Discussion

We investigated whether or not PWS allocate excessive attention to speech monitoring, and whether or not they devote insufficient attention to the content of their speech when reading passages orally. We manipulated the participants' attention toward their speech by using two variables (reading method and auditory masking) while they read passages and answered comprehension questions. We hypothesized that PWS pay excessive attention to auditory feedback; therefore, their reading comprehension performance should be lower in the oral-no-masking condition compared to the other conditions.

Results showed that PWS had low comprehension performance, particularly in the oral-no-masking condition, suggesting that PWS do not devote sufficient attention to speech comprehension. In other words, PWS may devote excessive attention to their speech. PWS had higher comprehension performance in the silent-no-masking and oral-masking conditions. Based on our hypothesis that PWS devote excessive attention to their speech, this suggests that these conditions distracted PWS from speech monitoring, so they could use those attention resources for comprehension. Kamhi and McOsker (1982) also investigated the amount of attention allocated by PWS to their speech in dual tasks, including reading comprehension. They reported that comprehension performance was lower in PWS than PNS. Kamhi and McOsker's experimental condition was similar to the oral-no-masking condition in the present study. However, we further demonstrated that the amount of attention allocated to speech is variable in PWS. We showed that PWS could pay attention to reading comprehension when attention was shifted away from speech monitoring by noise masking or silent reading. Thus, although PWS allocated excessive attention to their speech in the oral-no masking condition, they could use attention diversion tactics to divert attention away from speech monitoring to focus on speech content. Overall, the results suggest that PWS pay excessive attention to their speech when they are reading and are exposed to auditory feedback. As a result, PWS may not be able to devote sufficient attention to reading comprehension, resulting in reduced comprehension for the content of their speech.

In PNS, who do not seem to pay excessive attention to their speech, performance on the comprehension did not vary across the four conditions. These results are consistent with previous studies showing no differences between oral and silent reading in PNS (Kunita et al., 2008; Miller & Smith, 1985).

A fluency-enhancing effect of MAF was not observed in this study. This is inconsistent with previous studies (e.g., Cherry & Sayers, 1956; Howell et al., 1987; Kalinowski et al., 1993). However, it has been suggested that the fluency-enhancing effect of noise masking is less robust in MAF than in FAF and DAF (Howell et al., 1987; Kalinowski et al., 1993). In addition, in the current study the PWS participants exhibited more variability (i.e., larger standard deviation). These factors might lead to a failure to find a significant difference in stuttering disfluency between masking and no-masking conditions. Furthermore, contrary to our expectations, we did not find a significant correlation between stuttering frequency and comprehension performance. This may be because stuttering severity was mild (most participants showed less than 1% disfluency, see Figure 5), and there was a ceiling effect in comprehension performance.

The fact that PWS performance on the comprehension task decreased in the oral-no-masking condition may represent a disadvantage in their speaking ability. PWS may have fewer attentional resources available for comprehending the content of their speech when reading passages. This could add to the stress of stuttering disfluency. Consequently, insufficient speech comprehension may produce negative reactions and emotions, such as fear or anxiety, in relation to speech content. Speech comprehension in PWS is not directly related to speech fluency, but could be an important factor in attention-demanding communication.

It is important to note the difference between reading comprehension and speech comprehension. As mentioned in the Introduction, reading and speech comprehension are not the same. However, according to one speech monitoring model (Levelt, 1989; Levelt et al., 1999; Postma, 2000), auditory feedback during speech production is sent through one's "speech comprehension system" for speech monitoring. Thus, at the level of speech monitoring, we comprehend our own speech during speech production. In addition, our results showed that comprehension performance in PWS increased in the no auditory feedback conditions (reading silently or masking auditory feedback). This could indicate that PWS generally devote excessive attention on their speech via auditory feedback, and devote relatively little attention to reading comprehension. Considering that both spontaneous speech and reading passages rely on auditory feedback monitoring, attention may also be involved in speech comprehension. Thus, although reading comprehension is somewhat different from speech comprehension, the common link between reading and speaking could be comprehension of the speech content.

We consider the present study to be a preliminary investigation, so there are several limitations that should be mentioned. First, as we stated in the paragraph above, we evaluated reading comprehension, but not speech comprehension. Therefore, although similar cognitive processes may be involved in oral reading and spontaneous speech, it is unclear whether PWS use the same strategies during speaking and reading. Second, some participants obtained a perfect comprehension score. Consequently, a ceiling effect could have affected the statistical results. We should have taken comprehension task difficulty into account. In future studies, participants' reading experience and reading comprehension task difficultly need to be considered and controlled (e.g., the difficulty of the reading passage and/or the answers could be modified). Third, in addition to attention, short-term memory could also influence reading comprehension. Short-term memory, which is used to hold a sentence in mind while an answer is being chosen, is likely involved in comprehension. The relationship between short-term memory and stuttering has not been fully investigated (A rong na, Mori, Sakai, & Ochi, 2014; Bajaj, 2007) and should be considered in future studies. Finally, it remains unclear if long reading duration in oral reading in PWS is due to stuttering disfluency or reading ability. Despite these limitations, the present study provides insight into the nature of stuttering, and further supports previous suggestions that PWS differ in attentional control and availability of cognitive resources when speaking. Our experimental paradigm could be widely applied in future studies investigating attentional control of speech in PWS and other speech disorders.

Conclusions

We found that PWS had low comprehension performance during oral reading. PWS devote excessive attention to listening to their speech, and therefore struggle to devote attention to other cognitive tasks (e.g., reading comprehension). PWS can increase attention to concurrent tasks using alternative reading methods (i.e., reading silently or masking auditory feedback). Allocating minimal attention to speech content while speaking may reflect other related issues in PWS, such as unsatisfactory communication.

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