The Effect of Audiovisual Delays with Synchronous and Dyssynchronous Presentation on Stuttering Frequency

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Abstract

Introduction: Overt stuttering is significantly reduced when people who stutter (PWS) observe other speakers talking or are presented with recordings of their own speech that is fed back to them. Stuttering is typically reduced to greater extents when presented with an audio or audiovisaul speech signal.
Methods: Ten adults who stutter silently read and memorized 8-12 syllable length utterances then verbally recited them as they observed a feedback monitor. This procedure was repeated until the 300 syllable passage was completed for each condition.
Results: A one-factor repeated measures ANOVA revealed a significant main effect for stuttering by condition. Differences were revealed between baseline to auditory only feedback conditions (p =0.003).
Discussion: Findings of stuttering inhibition during auditory feedback supports prior evidence. Lack of differences for the other feedback conditions in contrary to previous findings and is likely due to the participants mild stuttering severity.

Introduction

Stuttering is an involuntary communication disorder that overtly manifests itself as repetitions, prolongations, and fixations of syllables and words, which disrupts the fluency of speech (Armson & Stuart, 1998). Stuttering is typically treated by using motoric alterations to one's speech output. Researchers have found that, choral speech reduces stuttering 90% to 100% and causes speech to sound natural and is effortless to produce (Cherry & Sayer, 1956; Kalinowski, Stuart, Rastatter, Snyder, & Dayalu, 2000; Silverman, 1996). Similar to choral speech, delayed auditory feedback (DAF), hearing one's own voice presented back to them with a slight delay, inhibits stuttering from 70%-80% (Saltuklaroglu et. al., 2009). Choral speech can also be presented in the visual modality. Visual choral speech decreases stuttering by approximately 80% (Kalinowski, et al., 2000). Results indicated that stuttering was inhibited up to 62% when presented delayed visual feedback (DVF) and there was no significant difference between the different amount of delay time (Hudock, et al., 2010).

As there are differential effects in stuttering from second speech signals that are presented via auditory, visual and audiovisual modalities simultaneously as compared to those presented with delays, it is relevant to explore the effect of other conditions that alters speech perception on stuttering frequency. One such condition is the McGurk effect, which occurs when a listener watches a speaker's lips and tongue movements of one syllable, but hears a different syllable (McGurk & Macdonald 1976; Galantucci, et al., 2006). When an auditory /ba/ is presented with a video of /ga/ 80% of people observe /da/ when observing the stimulus. This effect provides evidence that speech perception is a multimodal process integrating both visual and auditory information, which converge the percepts (Mai, 2009).

It is thought that the left superior temporal sulcus (STS) is the central location in the brain where audiovisual integration takes place during speech perception, indicating it as the place the McGurk effect occurs (Nath & Beauchamp, 2011). The STS is associated with a neurological system called the Mirror Neuron system (MNs). The mirror neuron system is thought to be the neurophysiological basis for the link between perception and production of biologically salient goal directed objectives (e.g., speech, grasping or walking) (Rizzolatti & Arbib, 1998). Mirror neurons are a particular class of sensorimotor neurons that activate both when an action is performed and when observing a similar action (Rizzolatti & Craighero, 2004). They have been discovered and give evidence to support that neural activity of the motor system is involved in the sensory integration during speech perception (Di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992). As described in the Gestural Model of Stuttering Inhibition (GMSI) (Hudock et al., 2010) or Max's inverse model of sensorimotor control (Max et al., 2004), it is possible that perceived altered auditory or visual feedback that is synchronous or dysynchronous may act on these sensorimotor systems to inhibit stutter.

Methods

Participants

10 individuals that stutter participated in the current study.

Instrumentation	Conditions
• Samsung 32-inch widescreen monitor • HD H23 AIPTEX digital video camera • Harman/Kardon AVR3600 digital audiovisual processing unit • Peavey 10 channel mixer • TC-Helicon Voice Rack	• Baseline- no feedback • Audiovisual feedback in realtime • DAF 200 millisecond (ms) • DVF 200 ms • DAF 60 ms with DVF 200 ms • DAF 200 ms with DVF 60 ms • 200 ms audiovisual feedback with a synchronous delay

Stimuli

The stimuli used in this study were 8-12 syllable length utterances taken from 300 syllable passages from Biographies: Skill-Based Story Cards (Remedia Publications, 2006). All passages are of similar linguistic complexity at a 3rd and 4th grade reading level. No utterance was used more than once in the study and all conditions and sequences were randomized. The stimuli was presented via PowerPoint from a 13-inch Macbook with a white background and black 28 point Arial font.

Procedures

A researcher verbally briefed participants prior to signing informed consent documents (*approved through Idaho State University's Human Subjects Committee)*. Before participating, a researcher demonstrated experimental procedures followed by a practice phase by the participant. Participants silently read then memorized the text then viewed the monitor as they recited the memorized passage. This procedure was repeated for all seven conditions to maintain consistency. Participants had a two-minute break including spontaneous conversation with the researcher between each condition to reduce carryover effects.

Analysis

Researchers calculated frequency of stuttering during each condition. Then proportional values were calculated for each condition. The number of stuttered syllables was divided by the total number of syllables per condition. Stuttering was defined as part-word repetitions, part-word prolongations, and inaudible postural fixations (i.e., "silent blocks) (Armson & Stuart, 1998). Stuttering episodes were then transformed into arcsine units to reduce end point weighting of proportion values during inferential statistical analysis (Cohen & Cohen, 1983; Viera & Garrett, 2005).

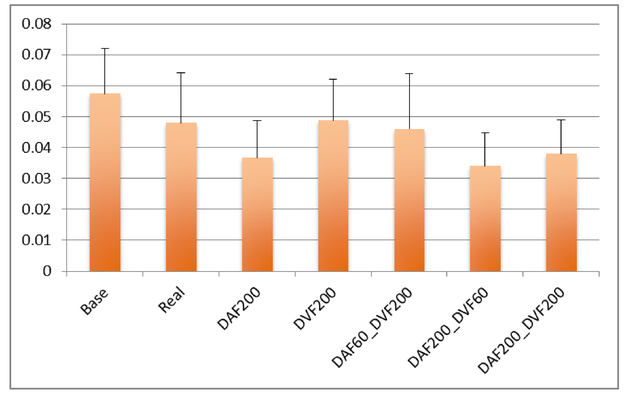

Figure 1: Average proportion of stuttering by condition

Results

A one-factor repeated measures analysis of variances (ANOVA; SPSS 21.0 for Mac) was conducted to examine the effect condition on stuttering frequency. A significant main effect was revealed *Greenhouse-Geisser* [F(3.340, 30.064) = 4.736, p = 0.006) η^2 0.345]. Bonferroni post hoc adjustments revealed differences between baseline to DAF200 conditions (p = 0.003)

Discussion

Stuttering was significantly reduced by 36% during the auditory only feedback condition. There was also a trend found in three of the other conditions; audiovisual feedback in real-time, 200ms DAF with 60ms DVF, 200ms audiovisual feedback with a synchronous delay, stuttering was reduced by 16%, 41%, and 34% respectively. It should be noted that these contrary findings not revealing differences between all feedback conditions as compared to the baseline are likely due to the severity of the participants stuttering. Most participants in the current study were very mild or mild as indicated by informal observation. A majority of studies on altered feedback and stuttering inhibition use participants that have moderate or severe classifications.

The finding that stuttering was significantly inhibited during auditory feedback supports the Gestural Model of Stuttering Inhibition (GMSI) (Hudock et al., 2010) and Max's Inverse Model of Sensorimotor Control (Max et al., 2004). The GMSI proposals that gestural cues are extracted from second speech signals simultaneously, which influences speech production by decreasing the frequency of stuttering (Hudock et al, 2010). This is based on motor involvement during speech perception. Simply put, when humans perceive speech there is neural motor involvement by the brain processing the auditory and visual speech gestures similarly to how it plan to produce the same movements. Therefore perception is activating production mechanisms and inhibiting overt stuttering from occurring. In Max's Model of speech production one generates a predictive motor plan for the timing and sequencing of the articulators prior to speech production (Max, et al., 2004). During and after these predictive command are executed the feedback system compares sensory (e.g., auditory and kinesthetic) information to the planned predictive model (Max, et al., 2004). Internal models must be updated and accurate because the neuromotor system in continually changing. If internal models are not being updated, it could make it impossible to create a motor plan and predict the sensory outcome of the planned movement resulting in dysfluent or incorrect production of speech.