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The role of temporal speech cues in facilitating the fluency of adults who stutter

Jin Park[a,*], Kenneth J. Logan[b]

[a] Department of Linguistics, Chungnam National University, Daejeon, Republic of Korea
[b] Department of Speech, Language, and Hearing Sciences, University of Florida, Gainesville, FL, USA

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ABSTRACT

Purpose: Adults who stutter speak more fluently during choral speech contexts than they do during solo speech contexts. The underlying mechanisms for this effect remain unclear, however. In this study, we examined the extent to which the choral speech effect depended on presentation of intact temporal speech cues. We also examined whether speakers who stutter followed choral signals more closely than typical speakers did.
Method: 8 adults who stuttered and 8 adults who did not stutter read 60 sentences aloud during a solo speaking condition and three choral speaking conditions (240 total sentences), two of which featured either temporally altered or indeterminate word duration patterns. Effects of these manipulations on speech fluency, rate, and temporal entrainment with the choral speech signal were assessed.
Results: Adults who stutter spoke more fluently in all choral speaking conditions than they did when speaking solo. They also spoke slower and exhibited closer temporal entrainment with the choral signal during the mid- to late-stages of sentence production than the adults who did not stutter. Both groups entrained more closely with unaltered choral signals than they did with altered choral signals.
Conclusions: Findings suggest that adults who stutter make greater use of speech-related information in choral signals when talking than adults with typical fluency do. The presence of fluency facilitation during temporally altered choral speech and conversation babble, however, suggests that temporal/gestural cueing alone cannot account for fluency facilitation in speakers who stutter. Other potential fluency enhancing mechanisms are discussed.

Educational Objectives: The reader will be able to (a) summarize competing views on stuttering as a speech timing disorder, (b) describe the extent to which adults who stutter depend on an accurate rendering of temporal information in order to benefit from choral speech, and (c) discuss possible explanations for fluency facilitation in the presence of inaccurate or indeterminate temporal cues.

* Corresponding author at: Department of Linguistics, Chungnam National University, Daejeon 305-764, Republic of Korea. Tel.: +82 42 821 6391.
E-mail address: gatorade70@cnu.ac.kr (J. Park).

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1. Introduction

1.1. Stuttering and speech timing

Many researchers have suggested that stuttering is a speech timing/motor sequencing disorder (e.g., Alm, 2004; Kent, 1984; MacKay & MacDonald, 1984; Packman, Code, & Onslow, 2007; Perkins, Kent, & Curlee, 1991; Smits-Bandstra & De Nil, 2007; Van Riper, 1982; Zimmerman, 1980). Within this relatively broad theoretical framework, the disorder has been examined in various ways: (a) as a disruption of the temporal coordination of the phonatory, respiratory, and articulatory systems that underlie speech production (e.g., Conture, Colton, & Gleason, 1988; Max & Gracco, 2005; Van Riper, 1982; Zimmerman, 1980), (b) as a breakdown in the temporal alignment of segmental and prosodic representations prior to speech initiation (Perkins et al., 1991), (c) as a temporal dyssynchrony between language and motor planning and its execution (Au-Yeung, Howell, & Pilgrim, 1998; Howell, 2004; Howell, Au-Yeung, & Sackin, 1999), (d) as an impairment in the capacity to generate temporal programs that underlie the sequential movements associated with spoken language (Kent, 1984; Max & Yudman, 2003; Smits-Bandstra & De Nil, 2007) and (e) as an impairment in the ability to execute speech motor plans once they have been generated (e.g., Kleinow & Smith, 2000; Packman et al., 2007; Packman, Onslow, Richard, & van Doorn, 1996; Smits-Bandstra & De Nil, 2007).

Despite the relatively large amount of empirical research and theoretical conjecture on matters such as these, the exact role of temporal factors in the speech fluency of speakers who stutter remains unclear. Consequently, one purpose of the present study was to investigate the role of temporal cueing as a means of fluency facilitation with adults who stutter. This was accomplished by examining changes in speech fluency during different types of choral speaking conditions.

1.2. Choral speech and fluency enhancement

It has been well demonstrated that speakers who stutter exhibit marked improvement in fluency when speaking chorally with others (Andrews, Howie, Dozsa, & Guitar, 1982; Barber, 1939; Bloodstein, 1950; Freeman & Armson, 1998; Guntupalli, Kalinowski, Saltuklaroglu, & Nanjundeswaran, 2005; Howell & Powell, 1987; Ingham et al., 2009; Ingham & Packman, 1979; Ingham, Warner, Byrd, & Cotton, 2006; Johnson & Rosen, 1937; Kiefte & Armson, 2008; Rami, Kalinowski, Rastatter, Holbert, & Allen, 2005). Early attempts at explaining the fluency enhancing effects associated with choral speech occurred within a psychological framework. For example, Barber (1939) proposed that choral reading is a novel condition that distracts speakers who stutter from their fluency difficulties, thus allowing them to talk more smoothly and with less effort. The distraction hypothesis subsequently was questioned by a number of researchers (e.g., Fransella, 1967; Fransella & Beech, 1965; Stuart, 1999; Wingate, 1969) as being overly vague and hard to verify empirically, and findings from several studies have not supported a strong form of the distraction hypothesis (see, for example, Arends, Povel, & Kolk, 1988; Fransella, 1967; Fransella & Beech, 1965; Mallard & Webb, 1980; Stuart, 1999). For instance, it has been shown that stuttering is not significantly reduced in certain dual task conditions that presumably involve distraction. These include discerning a pattern in an arrhythmic beat while reading aloud (Fransella & Beech, 1965), writing numbers while reading aloud (Fransella, 1967), and turning a light on and off while reading aloud (Mallard & Webb, 1980).

A second possible explanation for improved fluency under choral reading is that choral speaking leads speakers who stutter to focus on the action of speaking instead of focusing on aspects of communication. The attention-based hypothesis is essentially the opposite of the distraction hypothesis that was presented by Barber (1939) and others. That is, it may be that instead of taking one's mind *off* speaking, as would be the case with the distraction hypothesis, speakers who stutter, instead, focus their attention more often and/or more fully *on* speaking. Several neuro-imaging studies (e.g., Boberg, Yeudall, Schopflocher, & Bo-Lassen, 1983; De Nil, Kroll, Lafaille, & Houle, 2003; Kroll, De Nil, Kapur, & Houle, 1997) have shown that speakers who stutter exhibit post-treatment increases in left hemisphere activation in the auditory cortex relative to pre-treatment baseline levels. In such studies, the increased left hemisphere activity is associated with the use of newly learned methods of controlled fluency such as regulated speech rate, but not with increased activation of brain regions associated with attention (cf., De Nil et al., 2003; Neumann et al., 2003). In some studies with speakers who stutter (Neumann et al., 2003; Neumann et al., 2005), cortical regions associated with attention and error monitoring (e.g., the anterior cingulate cortex) seem to be "de-activated" during both pre- and post-treatment speech, while in others (e.g., De Nil, Kroll, Kapur, & Houle, 2000), areas that were overly active in a pre-treatment context show decreased activation following treatment.

A third possibility is that fluency-enhancing conditions like choral speech help speakers who stutter formulate key components of spoken messages and, in doing so, help speakers synchronize the various neural regions that are necessary for fluent speech (see Neumann et al., 2003 for additional discussion). For example, Kent (1984) proposed a motor modeling explanation for the choral speech effect. Essentially, he suggested that speakers who stutter monitor the choral speech signal and, in doing so, are able to generate the temporal patterns that are necessary for fluent speech. Kent argued that the mechanisms underlying choral speech are similar to those observed in metronome-paced speech (i.e., fluency inducement in response to an external rhythmic signal). In this view, speakers who stutter might use another speaker's voice as an external model from which they extract temporal information about ongoing speech. It was proposed that speakers then use the extracted information to generate utterances that are more fluent than they would be without such information.

In a similar vein, Saltuklaroglu, Kalinowski, and Guntupalli (2004) proposed that choral speech signals activate a speaker's mirror neuron system. In this view, the accompanying choral speech signal provides speakers who stutter with cues about