Nonword repetition and nonword reading abilities in adults who do and do not stutter

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A B S T R A C T

Purpose: In the present study a nonword repetition and a nonword reading task were used to investigate the behavioral (speech accuracy) and speech kinematic (movement variability measured as lip aperture variability index; speech duration) profiles of groups of young adults who do (AWS) and do not stutter (control).

Method: Participants were 9 AWS (8 males, *Mean age* = 32.2, *SD* = 14.7) and 9 age- and sex-matched control participants (*Mean age* = 31.8, *SD* = 14.6). For the nonword repetition task, participants were administered the Nonword Repetition Test (Dollaghan & Campbell, 1998). For the reading task, participants were required to read out target nonwords varying in length (6 vs. 11 syllables). Repeated measures analyses of variance were conducted to compare the groups in percent speech accuracy for both tasks; only for the nonword reading task, the groups were compared in movement variability and speech duration.

Results: The groups were comparable in percent accuracy in nonword repetition. Findings from nonword reading revealed a trend for the AWS to show a lower percent of accurate productions compared to the control group. AWS also showed significantly higher movement variability and longer speech durations compared to the control group in nonword reading. Some preliminary evidence for group differences in practice effect (seen as differences between the early vs. later 5 trials) was evident in speech duration.

Conclusions: Findings suggest differences between AWS and control groups in phonemic encoding and/or speech motor planning and production. Findings from nonword repetition vs. reading highlight the need for careful consideration of nonword properties.

Educational objectives At the end of this activity the reader will be able to: (a) summarize the literature on nonword repetition skills in adults who stutter, (b) describe processes underlying nonword repetition and nonword reading, (c) summarize whether or not adults who stutter differ from those who do not in the behavioral and kinematic markers of nonword reading performance, (d) discuss future directions for research.

1. Introduction

Stuttering is a fluency disorder characterized by disruptions in the smooth flow of speech. A few theories have been proposed to account for stuttering within a motoric framework with a speculated core deficit in speech motor planning and/or production (e.g., Neilson & Neilson, 1991; Webster, 1990; Zimmermann, 1980). Evidence for such theories is available from

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studies of speech and limb motor performance in persons who stutter, primarily adults, that have reported delayed initiation and slower productions, higher movement variability, poor timing and coordination of intra- and inter-gestural synergies, delayed acquisition and poor retention of skilled movement sequences (Brown, Zimmermann, Linville, & Hegmann, 1990; Cross & Luper, 1979; Kleinow & Smith, 2000; Loucks, De Nil, & Sasisekaran, 2007; Max & Gracco, 2005; Namasivayam & Van Lieshout, 2008; Smits-Bandstra, De Nil, & Rochon, 2006; Zelaznik, Smith, & Franz, 1994). Furthermore, the interactions between speech motor and other processes, including stages of linguistic processing, and their implications for stuttering have resulted in explanations of stuttering within a multidimensional framework. For instance, Smith and colleagues (*Multifactorial model*; Smith, 1999; Smith and Kelly, 1997) identified stuttering as an emerging, dynamic motor disorder with complex interactions between multiple systems (including linguistic, cognitive, and emotional) that eventually destabilize the speech motor system. In the present study, a nonword repetition task and a nonword reading task were used to investigate the underlying processes in adults who stutter (AWS) with specific focus on the functioning of the speech motor system and its response to increased task complexity.

1.1. Norwood repetition vs. reading: underlying processes

The ability to repeat novel phonetic sequences is a critical skill underlying word learning. Gathercole's (2006) framework of nonword repetition involves various stages, including auditory processing (when the nonwords are presented aurally), phonological analysis, phonological storage and retrieval, speech motor planning and execution. In the present study, in addition to the traditional nonword repetition task, a nonword reading task was employed. Presumably, nonword reading involves some of the same underlying processes involved in nonword repetition, including phonological storage and retrieval, speech motor planning and execution. However, this task also eliminates some of the steps involved in the nonword repetition task while introducing a few additional steps. For instance, in contrast to the focus on auditory processing of the input in nonword repetition, nonword reading involves deciphering the orthographic code. Furthermore, the reading task shifts the focus from phonological working memory to other stages, including encoding the phonemic units from orthography and speech motor planning and execution. This task also offers an opportunity to study underlying speech motor output processes as well as the plasticity at the motor level with progressive acquisition of novel phonetic strings. Measures of speech kinematics provide a sensitive index of speech formulation and implementation (e.g., Goffman and Smith, 1999), and supplement the information provided by speech errors and/or reaction time data. Therefore, the investigation of speech kinematics associated with nonword reading performance in speech disorders, such as stuttering, will provide critical insights into the role of the speech planning and production processes involved in its causation and maintenance.

1.2. Nonword repetition skills in adults who stutter

Several studies have employed nonwords to investigate cognitive – linguistic and motoric processing in AWS. Some of these studies have reported behavioral measures (Byrd, Vallely, Anderson, & Sussman, 2012; Ludlow, Siren, & Zikria, 1997), while some others have reported kinematic measures of task performance (e.g., Namasivayam & Van Lieshout, 2008; Smith, Sadagopan, Walsh, & Weber-Fox, 2010).

1.2.1. Behavioral studies of nonword repetition in adults

Ludlow et al. (1997) tested the speech learning abilities of adults who stutter (AWS) in a nonword repetition task. Five AWS and five typically fluent speakers repeated two lengthy nonwords multiple times. Both groups improved in production accuracy with repeated nonword production thereby showing a practice effect. However, AWS did not appear to benefit much from practice as their percentage of consonants correct was still lower than that of control participants after repeated production of the two novel words. The authors interpreted the difference in practice effect to support the assumption that AWS have phonological encoding deficits. Despite limited sample size, the Ludlow et al. study was the earliest to report of difficulties in nonword repetition in AWS.

Byrd et al. (2012) explored the phonological working memory of AWS through the use of a nonword repetition and a phoneme elision task. Participants were 14 AWS and 14 age and gender matched control participants. For the nonword repetition task, the participants had to repeat a set of 12 nonwords across four syllable lengths (2, 3, 4, and 7 syllables). For the phoneme elision task, the participants repeated the same set of nonwords at each syllable length, but with a designated target phoneme eliminated. AWS were significantly less accurate than adults who do not stutter in their initial attempts to produce the longest nonwords (i.e., 7 syllables). The groups were comparable in nonword repetition performance across the other syllable lengths. AWS also required a significantly higher mean number of attempts to accurately produce 7-syllable nonwords than adults who do not stutter. For the phoneme elision task, there was no significant interaction between group and syllable length. The authors interpreted the group differences in repeating the 7-syllable nonwords to suggest phonological working memory deficits in AWS.

1.2.2. Kinematic studies of nonword repetition in adults

Namasivayam and Van Lieshout (2008) investigated the spatial and temporal variability of cyclic patterns of upper lip, lower lip, and jaw trajectories associated with multiple repetitions of two simple bisyllabic nonwords—/bapi/ and /bipa/—in three sessions spanning several days in five AWS and five typically fluent speakers. The aim of the study was to investigate