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# Nonword repetition and phoneme elision in adults who do and do not stutter: Vocal versus nonvocal performance differences

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ABSTRACT

*Purpose:* The purpose of the present study was to enhance our understanding of phonological working memory in adults who stutter through the comparison of nonvocal versus vocal nonword repetition and phoneme elision task performance differences.
*Method:* For the vocal nonword repetition condition, participants repeated sets of 4- and 7-syllable nonwords ($n = 12$ per set). For the nonvocal nonword repetition condition, participants silently identified each target nonword from a subsequent set of three nonwords. For the vocal phoneme elision condition, participants repeated nonwords with a target phoneme eliminated. For the nonvocal phoneme elision condition, participants silently identified the nonword with the designated target phoneme eliminated from a subsequent set of three nonwords.
*Results:* Adults who stutter produced significantly fewer accurate initial productions of 7-syllable nonwords compared to adults who do not stutter. There were no talker group differences for the silent identification of nonwords, but both talker groups required significantly more mean number of attempts to accurately silently identify 7-syllable as compared to 4-syllable nonwords. For the vocal phoneme elision condition, adults who stutter were significantly less accurate than adults who do not stutter in their initial production and required a significantly higher mean number of attempts to accurately produce 7-syllable nonwords with a phoneme eliminated. This talker group difference was also significant for the nonvocal phoneme elision condition for both 4- and 7-syllable nonwords.
*Conclusion:* Present findings suggest phonological working memory may contribute to the difficulties persons who stutter have establishing and/or maintaining fluent speech.

***Educational Objectives***: (a) Readers can describe the role of phonological working memory in planning for and execution of speech; (b) readers can describe two experimental tasks for exploring the phonological working memory: nonword repetition and phoneme elision; (c) readers can describe how the nonword repetition and phoneme elision skills of adults who stutter differ from their typically fluent peers.



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## 1. Introduction

Stuttering is largely considered to be a multifactorial disorder (e.g., Bloodstein & Bernstein Ratner, 2008; Conture, 2001; Guitar, 2013; Smith, 1999; Yairi & Seery, 2011). There are significant data to suggest phonological encoding, the process of retrieving the sound segments in words prior to motor programming and execution (Levelt, 1989), is one of the many factors that contribute to the difficulties persons who stutter have establishing and/or maintaining fluent speech (e.g., Aboul Oyoun, El Dessouky, Shohdi, & Fawzy, 2010; Anderson, 2007; Anderson & Byrd, 2008; Bosshardt, 1993; Byrd, Conture, & Ohde, 2007; Byrd, Vallely, Anderson, & Sussman, 2012; cf., Bakhtiar, Ali, & Sadegh, 2007; Hakim & Ratner, 2004; Hennessey, Nang, & Beilby, 2008; Ludlow, Siren, & Zikria, 1997; Melnick, Conture, & Ohde, 2003; Nippold, 2002, 2012; Ntourou, Conture, & Lipsey, 2011; Pelczarski & Yaruss, 2014; Sasisekaran & Byrd, 2013; Sasisekaran & De Nil, 2006; Sasisekaran, De Nil, Smyth, & Johnson, 2006; Vincent, Grela, & Gilbert, 2012; Weber-Fox, Spencer, Spruill, & Smith, 2004). For example, of the disorders that co-occur with stuttering, disorders of phonology are among the most frequent (Arndt & Healey, 2001; Louko, Conture, & Edwards, 1999; Yaruss, LaSalle, & Conture, 1998; cf., Nippold, 2001, 2012). Researchers have also suggested that the phonological representations of children who stutter may be underspecified (e.g., Anderson, 2007; Anderson & Byrd, 2008; Anderson & Wagovich, 2010; Anderson, Wagovich, & Hall, 2006; Hakim & Ratner, 2004). Furthermore, the incremental processing abilities of children who stutter do not appear to develop within the same timeframe of their typically fluent peers (Byrd et al., 2007) and the phonological encoding of adults who stutter appears to be uniquely compromised by increased cognitive demands (e.g., Bajaj, 2007; Bosshardt, 1990, 1993; Jones, Fox, & Jacewicz, 2012; Sasisekaran & Weisberg, 2014; Weber-Fox et al., 2004). This reduced speed and accuracy in encoding seen in overt speech tasks have also been revealed during nonvocal speech tasks (e.g., Brocklehurst & Corley, 2011; Postma, Kolk, & Povel, 1990; Sasisekaran, 2013). Thus, together these results suggest that phonological deficits may extend beyond encoding to include other processes distinct to phonological working memory (see Bajaj, 2007 for review of phonological working memory and stuttering). In addition, among the studies that have been completed thus far, vocal indices of phonological working performance have been measured independently of nonvocal indices. The purpose of the present study is to enhance our understanding of the potential contribution of phonological working memory to stuttered speech by comparing nonvocal to vocal responses across tasks that, to date, have been explored with respect to vocal performance or nonvocal performance exclusively, as opposed to the two tasks in tandem.

### 1.1. Phonological working memory

According to Baddeley (2003) working memory is comprised of the central executive and the three supporting systems: (1) phonological loop, (2) visuospatial sketchpad and (3) the episodic buffer. The function of the central executive and that of the phonological loop are critical to the present study as we are focusing on phonological working memory. The visuospatial sketchpad with its distinct application to the manipulation of visual information is not relevant to the present study and will not be discussed further. Similarly, the episodic buffer will not be discussed as this particular system binds information from various distinct sources into chunks or episodes; an application that was not enacted in the present study. The central executive is thought to support the retrieval and transfer of information from long-term memory to short-term memory and vice versa. The phonological loop is one of the supporting systems to the central executive and is comprised of the following two critical components: a phonological store and a subvocal rehearsal system. The phonological store facilitates the ability to hold material to be remembered in a phonological code. This phonological code is vulnerable to decay over time (i.e., trace will last approximately 2 s), hence the need for the subvocal rehearsal system. The subvocal rehearsal system is a silent verbal repetition process that refreshes the phonologically encoded material, allowing it to be preserved in memory for a longer period of time (>2 s).

If persons who stutter demonstrate slowed initial encoding of phonological information, then the subsequent process of refreshing information would also be decreased as this process can only operate as quickly and efficiently as the information to be refreshed is provided. Alternatively, if there are distinct differences in the selection, programming and subsequent execution of speech (e.g., see Watkins, Smith, Davis, & Howell, 2008 for review of this perspective), then the covert articulatory rehearsal of words may be uniquely compromised in persons who stutter. Yet another consideration is that if persons who stutter have difficulty encoding phonological representations via short-term memory and/or accessing those representations via long-term memory, then perhaps differences reported in previous studies specific to phonological encoding may be reflective of central executive deficiencies.

### 1.2. Nonword repetition in adults who stutter

Relatively few investigations have been completed within the stuttering literature with respect to phonological working memory. Of the studies that exist, those that have employed nonword repetition in adults will be reviewed for two key reasons. First, this particular task is thought to allow valuable insight into phonological working memory in isolation with minimal influence from long-term storage of phonological as well as semantic and lexical information. Second, this present study is a systematic replication of a nonword repetition study that we completed with adults who do and do not stutter (i.e., Byrd et al., 2012). Nonword repetition has been shown to differentiate adults who do not stutter from adults who stutter in a few ways. Ludlow et al. (1997) examined the nonword repetition abilities of adults who do and do not stutter by having