Assessment of Working Memory in Normal Children and Children Who Stutter

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By

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Abstract

The aim of this study is to assess working memory abilities in normal children and Children Who Stutter (CWS), 30 normal children and 30 children who stutter were subjected to Working Memory (WM) recall abilities test and nonword repetition task. The WM recall tests included recall of word sets different in length and rhyming, digit span, letter sequences and picture-number test. The nonword repetition test was used to assess phonological encoding through measuring number of phonological errors produced on repeating the task, and to measure the reaction time. The children who stutter (CWS) had performed poorly on some working memory tests. Conclusion: Children who stutter may have diminished ability to recall nonwords and some of working memory abilities and that further investigation into this possibility may shed light on the emergence and characteristics of childhood stuttering.

Key words: working memory, children who stutter nonword repetition, phonological encoding, phonological errors, reaction time.

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List of abbreviations

Abbreviation	Description
BNWR	Bisyllabic nonwords repetition
BRT	Bisyllabic Reaction Time
CA	Chronological age
CRH	Covert Repair Hypotheses
CWS	Children who stutter
CWNS	Children who do not stutter
DAF	Delayed Auditory Feedback
EXPLAN	Acronym stands for execution and planning
IQ	Intelligence Quotient
LRT	Laryngeal reaction time
NWs	Nonwords
PEs	Phonological errors
PLA	Psycholinguistic age
SD	Standard deviation
SM	Sequential memory
SMC	Theories of speech motor control
SPA	Suprasegmental Sentence Plan Alignment

STM	Short Term Memory
PWS	Persons Who Stutter
TNWR	Trisyllabic nonword repetition
TRT	Trisyllabic Reaction Time
WM	Working memory
WS	Word sets

Introduction

Stuttering has been described as a speech motor disorder that disrupts the timing and/or coordination between the respiratory, laryngeal, and vocal tract symptoms of speech (***Van Lieshout et al., 2004)***. Evidence consistent with impairment or disruption to speech motor control in stuttering comes from studies showing differences between People Who Stutter (PWS) and fluent speaking controls in measures of articulation during fluent and disfluent speech ***(Logan, 2003 and Max et al., 2003).*** For example, investigations using verbal reaction time (RT) paradigms have found PWS to be slower than normally fluent speakers in the initiation of speech movements ***(Logan, 2003)***. Acoustic and Kinematic analyses of speech in PWS have also provided evidence for difficulties in the timing of speech movements, such as the lip and the jaw ***(Kleinow and Smith, 2000)***.

However, from a theoretical point of view, research has so far failed to identify a specific locus of deficits in speech motor planning ***(Venkatagiri,2004)***, muscle command preparation and/or execution ***(Petres et al., 2000)***, or in integrating segmental plans with the prosodic requirements of speech ***(Packman et al., 1996)***. Some authors have proposed that PWS are less skilled in their speech motor ability, as reflected in normal variation in any motor skill ***(Van Liesout et al., 2004)***; therefore, the underlying deficit may not be localizable to a specific component of speech motor control. However, the disrupted motor processes responsible for stuttering may be a consequence of

deficiencies in control or planning process external to speech motor system. One dominant hypothesis of this type is that deficiencies in linguistic processing may provide inadequate or delayed input to speech motor control system, and stuttering results as a consequence of the motor control system attempting to cope with that impoverished input ***(Bosshardt, 2006 and Newman and Bernstein- Ratner, 2007)***.

Recently working memory has been implicated in the development of stuttering. Working memory is universally recognized as neurocognitive system that provides temporary storage and processing of incoming information. ***Baddeley (2003)*** envisioned working memory as a multicomponent neurocognitive system that includes a central executive, visuospatial sketchpad and phonological loop. The phonological loop includes short term storage and rehearsal of incoming verbal information to enable comprehension. Phonological encoding during speech planning involves retrieving phonological material from storage to build articulatory plans ***(Levelt, 1989)***. Such encoding relies essentially on phonological loop operations. Working memory is considered critical to phonological encoding ***(Gathercole and Baddeley, 1993)*** and vital to higher level cognition ***(Rosen and Engle, 1997)***

One prominent theory which is the covert repair hypothesis of ***Postma and Kolk (1993)*** assumes that stuttering arises because inefficient or slow phonological encoding leads to an increase in covert repairs to the phonological plan, particularly when the individual is

intent on speaking at a rate exceeding the compliance of the phonological encoding mechanism. Phonological encoding may be delayed for a number of reasons, ranging from delay in higher level semantic activation to inefficiencies in the encoding mechanism itself ***(Postma and Kolk, 1993).***

There is also mounting evidence implicating a role for linguistic deficits in the etiology of stuttering ***(Hall et al., 2007).*** Some several studies have shown children who stutter tend to perform more poorly on assessments of language, particularly expressive language, than normally fluent controls ***(Karniol, 1995)***. In addition, studies have shown that stuttering frequency measures of articulatory stability in PWS are related to linguistic variables such as grammatical complexity (***kleinow and Smith, 2000 and Dayalu et al., 2002)*** and word frequency ***(Anderson, 2007)*** . The increased levels of linguistic complexity may also be associated with increased motoric complexity or simply increased demands on cognitive resources available to the speech motor control system ***(Kent, 2000)***.

If stuttering originates because the speech motor control system must deal with asynchronies or inefficiencies in pre-motor linguistic planning, then differences between PWS and controls should be observed in tasks that are sensitive to those linguistic processes. Cognitive models of speech production, such as that proposed by Levelt and colleagues ***(Levelt et al., 1999)***, provide a useful framework to consider the linguistic processes that might be deficient in stuttering. A