Journal of Fluency Disorders xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

Journal of Fluency Disorders

ELSEVIER

The impact of threat and cognitive stress on speech motor control in people who stutter

Pascal van Lieshout[a,b,c,d,e,*], Boaz Ben-David[a,b,e,f], Melinda Lipski[a], Aravind Namasivayam[a]

[a] University of Toronto, Speech-Language Pathology, Oral Dynamics Lab (ODL), Canada
[b] Department of Psychology, Canada
[c] Institute of Biomaterials and Biomedical Engineering, Canada
[d] Graduate Department of Rehabilitation Science, Canada
[e] Toronto Rehabilitation Institute, Canada
[f] Interdisciplinary Center (IDC) Herzliya, School of Psychology, Communication, Aging and Neuropsychology Lab (CANlab), Israel

ARTICLE INFO

Article history:
Received 6 February 2014
Received in revised form 14 February 2014
Accepted 15 February 2014
Available online xxx

Keywords:
Stuttering
Anxiety
Emotional Stroop
Classical Stroop
Kinematics

ABSTRACT

Purpose: In the present study, an Emotional Stroop and Classical Stroop task were used to separate the effect of threat content and cognitive stress from the phonetic features of words on motor preparation and execution processes.
Method: A group of 10 people who stutter (PWS) and 10 matched people who do not stutter (PNS) repeated colour names for threat content words and neutral words, as well as for traditional Stroop stimuli. Data collection included speech acoustics and movement data from upper lip and lower lip using 3D EMA.
Results: PWS in both tasks were slower to respond and showed smaller upper lip movement ranges than PNS. For the Emotional Stroop task only, PWS were found to show larger inter-lip phase differences compared to PNS. General threat words were executed with faster lower lip movements (larger range and shorter duration) in both groups, but only PWS showed a change in upper lip movements. For stutter specific threat words, both groups showed a more variable lip coordination pattern, but only PWS showed a delay in reaction time compared to neutral words. Individual stuttered words showed no effects. Both groups showed a classical Stroop interference effect in reaction time but no changes in motor variables.
Conclusion: This study shows differential motor responses in PWS compared to controls for specific threat words. Cognitive stress was not found to affect stuttering individuals differently than controls or that its impact spreads to motor execution processes.

Educational objectives: After reading this article, the reader will be able to: (1) discuss the importance of understanding how threat content influences speech motor control in people who stutter and non-stuttering speakers; (2) discuss the need to use tasks like the Emotional Stroop and Regular Stroop to separate phonetic (word-bound) based impact on fluency from other factors in people who stutter; and (3) describe the role of anxiety and cognitive stress on speech motor processes.

* Corresponding author at: University of Toronto, Department of Speech-Language Pathology, Oral Dynamics Laboratory (ODL), #160-500 University Avenue, Toronto, ON M5G 1V7, Canada. Tel.: +1 4169788334; fax: +1 4169781596.
E-mail address: p.vanlieshout@utoronto.ca (P.v. Lieshout).

http://dx.doi.org/10.1016/j.jfludis.2014.02.003
0094-730X/© 2014 Elsevier Inc. All rights reserved.

1. Introduction

Speaking is a complex fine motor skill that requires mapping intended abstract linguistic structures to dynamic sequences of movements executed in a relatively fast pace. This makes the production of speech a very challenging motor task. As part of the phylogenetic development of the human species, the oral motor system has acquired specific adaptations to this relatively new behavioural repertoire (compared to chewing or swallowing) in terms of neural control (Lieberman, 2007) and changes to the physical/physiological characteristics of the structures involved in producing speech (Kent, 2004). It is no surprise then that learning a complex motor skill such as speaking typically takes time. Infants have to learn to control the many degrees of freedom involved in generating movement patterns that have acoustic consequences that can be interpreted by other humans as a (potentially) meaningful message. For some of these functions, it can take years before they reach the level of adult performance (Smith & Zelaznik, 2004).

For all motor tasks, some individuals will have a more suitable physical and neural makeup by genetic predisposition to become very efficient in motor performance while others may struggle. For most motor tasks, the latter is not a problem as one can simply discontinue them and focus on other tasks that may be more suitable. Hence, not everyone will become a professional tennis or soccer player, or a master concert pianist. For speech, so we argue, this is not different. Some infants will have the innate qualities to learn to speak in a very smooth and fast manner, without showing any obvious interruptions or breakdowns. Others however, will struggle and at best, are able to produce speech relatively fluent most of the time but with occasional problems especially when demands on speech motor control are high, such as when speaking fast and at the same time, in an intelligible manner. These are the basic premises of the Speech Motor Skill (SMS) theory, detailed further down (Namasivayam & Van Lieshout, 2011; Van Lieshout, Hulstijn, & Peters, 2004).

When applied to stuttering, the SMS theory claims that people who stutter (PWS) are at the low end of the speech motor skill continuum, similar to individuals who may be very bad at for example, playing tennis. Unlike those who are bad at playing tennis, children who struggle with speaking do not have the option to simply quit. They have to continue using a speech motor system that is presenting them with considerable difficulty controlling all these different degrees of freedom in producing sound patterns without interruptions. For some, their limitations are such that almost every attempt in controlling this complex system leads to failure and virtually every syllable is “stuttered”. For others, when demands are not too high and natural practice during development has allowed for achieving some level of performance, most of the time their speech is fluent. However, add some difficulty (e.g., increasing rate; more complex linguistic structure, complex clusters of sounds) and their ability to remain relatively fluent will be jeopardized. In essence then, according to the SMS theory, stuttering at its core is a problem in controlling the many degrees of freedom involved in producing speech in a relatively fast and stable way. If such problems become audible (as articulator movements often have acoustic consequences) they can perceptually become noticeable in the form of sound or syllable repetitions, sound prolongations or blocks.

1.1. The speech motor skill (SMS) theory

Developmental stuttering typically begins in childhood. From the perspective of the SMS theory, stuttering has its basis in how the speech motor system of these individuals learns to cope (or not) with demands posed by linguistic, motor, cognitive and emotional conditions. The notion that different factors play a role in stuttering is a common viewpoint of other theories proposed in recent years such as the Demands and Capacity model (Starkweather & Gottwald, 2000) or a similarly inspired model proposed by Zimmermann, Smith and colleagues (Kleinow & Smith, 2000, 2006; Smith, 2006; Zimmermann, Smith, & Hanley, 1981). The SMS theory is unique by not positing any need for deficits in any of these functions while proposing a very specific mechanism by which such factors influence speech motor control (Namasivayam & Van Lieshout, 2011; Van Lieshout et al., 2004). Specifically, the theory claims that all these factors impact on speech movements, in particular on their range of motion (amplitude). Within the SMS theory, movement amplitude is critical to the stability of the speech motor control system. It is presumed that kinesthetic feedback from speech articulators is used to stabilize the output of a coupled neural oscillatory system. Within such a system, larger amplitudes are thought to increase feedback gain which may result in an increase in the neural oscillator-effector coupling strength and system stability. Conversely, if certain conditions restrict the movement range, the theory assumes that it will reduce feedback gain to the neural oscillatory networks that control the effectors and if this feedback-gain reduction reaches a certain idiosyncratic threshold, the entrainment between the neural oscillator network and the speech effectors destabilizes (Atchy-Dalama, Peper, Zanone, & Beek, 2005; Peper & Beek, 1998; Peper, de Boer, de Poel, & Beek, 2008; Van Lieshout et al., 2004; Williamson, 1998). The end result of this is instability of the articulator movements and a possible breakdown in their coordination, and in a worst case scenario, it could lead to a cessation of the ongoing movements (aka a block). This particular mechanism was elegantly demonstrated in a robot model by Williamson at MIT (Williamson, 1998). Recent studies across different speech disorder populations, including stuttering individuals, have shown evidence for this mechanism to apply to speech motor control as well (Namasivayam & Van Lieshout, 2008; Namasivayam, Van Lieshout, McIlroy, & De Nil, 2009; Van Lieshout, Rutjens, & Spauwen, 2002; Van Lieshout, Bose, Square, & Steele, 2007). These studies have indicated that for bilabial closure gestures the amplitude of upper lip movements is a critical factor in maintaining stability. This does not mean that other effectors (e.g., jaw or tongue) will not show similar features, but the lips are so far studied most extensively.

Please cite this article in press as: Lieshout, P. v., et al. The impact of threat and cognitive stress on speech motor control in people who stutter. *Journal of Fluency Disorders* (2014), http://dx.doi.org/10.1016/j.jfludis.2014.02.003