Testing hypotheses about the underlying deficit of apraxia of speech through computational neural modelling with the DIVA model

Hayo Terband, Joe Rodd & Edwin Maas

To cite this article: Hayo Terband, Joe Rodd & Edwin Maas (2020) Testing hypotheses about the underlying deficit of apraxia of speech through computational neural modelling with the DIVA model, International Journal of Speech-Language Pathology, 22:4, 475-486, DOI: 10.1080/17549507.2019.1669711

To link to this article: https://doi.org/10.1080/17549507.2019.1669711
Testing hypotheses about the underlying deficit of apraxia of speech through computational neural modelling with the DIVA model

HAYO TERBAND¹, JOE RODD² & EDWIN MAAS³

¹Utrecht Institute of Linguistics-OTS, Utrecht University, Utrecht, The Netherlands, ²Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands, ³Department of Communication Sciences and Disorders, Temple University, Philadelphia, PA, USA

Abstract
Purpose: A recent behavioural experiment featuring a noise masking paradigm suggests that Apraxia of Speech (AOS) reflects a disruption of feedforward control, whereas feedback control is spared and plays a more prominent role in achieving and maintaining segmental contrasts. The present study set out to validate the interpretation of AOS as a possible feedforward impairment using computational neural modelling with the DIVA (Directions Into Velocities of Articulators) model.

Method: In a series of computational simulations with the DIVA model featuring a noise-masking paradigm mimicking the behavioural experiment, we investigated the effect of a feedforward, feedback, feedforward + feedback, and an upper motor neuron dysarthria impairment on average vowel spacing and dispersion in the production of six/bVt/speech targets.

Result: The simulation results indicate that the output of the model with the simulated feedforward deficit resembled the group findings for the human speakers with AOS best.

Conclusion: These results provide support to the interpretation of the human observations, corroborating the notion that AOS can be conceptualised as a deficit in feedforward control.

Keywords: apraxia of speech; computational modelling; vowel acoustics; feedback masking

Introduction

Apraxia of Speech (AOS) is a neurogenic motor speech disorder that is defined as an impairment in the planning and/or programming of speech movements (Deger & Ziegler, 2002; Duffy, 2005; Van der Merwe, 1997). The speech of people with AOS is characterised by slow speech rate, abnormal prosody, abnormal speech sound and syllable segmentation, speech sound distortions, and speech errors that are inconsistently present but relatively consistent in type and location (Duffy, 2005; Maas et al., 2008). AOS typically results from brain lesions to the left cerebral hemisphere, but more specific lesion locations reported in the literature diverge. Most reports indicate lesions in left inferior frontal regions (e.g. Dronkers, 1996; Graff-Radford et al., 2014; Hickok et al., 2014; Hillis, et al., 2004; Itabashi et al., 2016; Richardson, Fillmore, Rorden, LaPointe, & Fridriksson, 2012), however, other regions have also been reported, including the parietal cortex (e.g. Hickok et al., 2014; McNeil, Weismer, Adams, & Mulligan, 1990), basal ganglia (Seddoh et al., 1996), and right frontal cortex and basal ganglia structures (Balasubramanian & Max, 2004). The precise location of the lesion responsible for AOS thus remains subject of debate. Likewise, the precise nature of the disorder remains poorly understood.

One of the main difficulties in isolating the underlying deficit(s) is diagnostic circularity. The ability to investigate the characteristics underlying AOS requires pure cases of AOS selected on the basis of clear-cut criteria, which are only available as a result of research. As lesion inducing medical accidents such as strokes, brain injuries, or tumours rarely produce isolated and one-dimensional deficits, pure cases are rare and symptom profiles show considerable variation between individuals as well as a large overlap in symptomatology with other speech disorders. Additionally, when confronted with a partial breakdown, the

Correspondence: Hayo Terband, Utrecht Institute of Linguistics-OTS, Trans 10, room 1.24, 3512JK Utrecht, The Netherlands. Email: h.r.terband@uu.nl

ISSN 1754-9507 print/ISSN 1754-9515 online © 2019 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group
This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives License (http://creativecommons.org/licenses/by-nc-nd/4.0/), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited, and is not altered, transformed, or built upon in any way.
DOI: 10.1080/17549507.2019.1669711