



The neurological underpinnings of cluttering: Some initial findings



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ABSTRACT

Background: Cluttering is a fluency disorder characterised by overly rapid or jerky speech patterns that compromise intelligibility. The neural correlates of cluttering are unknown but theoretical accounts implicate the basal ganglia and medial prefrontal cortex. Dysfunction in these brain areas would be consistent with difficulties in selection and control of speech motor programs that are characteristic of speech disfluencies in cluttering. There is a surprising lack of investigation into this disorder using modern imaging techniques. Here, we used functional MRI to investigate the neural correlates of cluttering.

Method: We scanned 17 adults who clutter and 17 normally fluent control speakers matched for age and sex. Brain activity was recorded using sparse-sampling functional MRI while participants viewed scenes and either (i) produced overt speech describing the scene or (ii) read out loud a sentence provided that described the scene. Speech was recorded and analysed off line. Differences in brain activity for each condition compared to a silent resting baseline and between conditions were analysed for each group separately (cluster-forming threshold $Z > 3.1$, extent $p < 0.05$, corrected) and then these differences were further compared between the two groups (voxel threshold $p < 0.01$, extent > 30 voxels, uncorrected).

Results: In both conditions, the patterns of activation in adults who clutter and control speakers were strikingly similar, particularly at the cortical level. Direct group comparisons revealed greater activity in adults who clutter compared to control speakers in the lateral premotor cortex bilaterally and, as predicted, on the medial surface (pre-supplementary motor area). Subcortically, adults who clutter showed greater activity than control speakers in the basal ganglia. Specifically, the caudate nucleus and putamen were overactive in adults who clutter for the comparison of picture description with sentence reading. In addition, adults who clutter had reduced activity relative to control speakers in the lateral anterior cerebellum bilaterally.

Eleven of the 17 adults who clutter also stuttered. This comorbid diagnosis of stuttering was found to contribute to the abnormal overactivity seen in the group of adults who clutter in the right ventral premotor cortex and right anterior cingulate cortex. In the remaining areas of abnormal activity seen in adults who clutter compared to controls, the subgroup who clutter and stutter did not differ from the subgroup who clutter but do not stutter.

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Conclusions: Our findings were in good agreement with theoretical predictions regarding the neural correlates of cluttering. We found evidence for abnormal function in the basal ganglia and their cortical output target, the medial prefrontal cortex. The findings are discussed in relation to models of cluttering that point to problems with motor control of speech.

Educational objectives: This paper reports findings on the neural correlates seen in adults who clutter, and offers hypotheses as to how these might map onto the behaviours seen amongst those who clutter. Readers will be able to (a) identify the structures that are implicated in the disorder of cluttering, (b) understand arguments relating these structures to the behavioural expression of the disorder, (c) understand some of the complexities in interpreting data pertaining to recovery from cluttering, (d) understand where future efforts in research into the neurological correlates of cluttering should be focussed.

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1. Introduction

1.1. A unified perspective of cluttering

Cluttering has been recognised and described as a communication disorder arguably as far back as stuttering (Van Riper, 1982), but rigorous scientific examination of the disorder has until very recently remained limited. The difficulty in some part has involved a certain circularity to the problem of identifying the significant features of cluttering. There is also a history of dispute as to the scope of the core behaviours of the disorder, with speculation as to whether cluttering is a motor speech disorder, a language disorder, both, or perhaps more to do with executive functioning than either (Daly, 1986; Preus, 1996; St. Louis, Myers, Bakker, & Raphael, 2007; Van Zaalen, Wijnen, & De Jonckere, 2009a; Ward, 2010; Weiss, 1964). These differences have led researchers to apply different criteria when defining their experimental groups. It has been helpful, then, that St. Louis and Schulte (2011) recently refined their working definition of cluttering, in what they call the ‘lowest common denominator’ (LCD) definition. As the name implies, this is conservative perspective, including only a limited number of core cluttering characteristics. They acknowledge that this definition may subsequently need to be revised and updated as more is known about cluttering, but it provides what is currently taken by clinicians and researchers alike as the standard definition of the disorder:

Cluttering is a fluency disorder wherein segments of conversation in the speaker's native language typically are perceived as too fast overall, too irregular, or both. The segments of rapid and/or irregular speech rate must further be accompanied by one or more of the following: (a) excessive ‘normal’ disfluencies; (b) excessive collapsing or deletion of syllables; and/or (c) abnormal pauses, syllable stress, or speech rhythm (St. Louis & Schulte, 2011, pp. 241–242).

St. Louis and Schulte (2011) qualify this definition further as follows: for example, that cluttering need not occur frequently but sufficiently often to exceed that seen in normal speakers; that the irregular speech rate may be described as “jerky” or “spurdy”; and, that collapsing of syllables can include excessive shortening, “telescoping,” or “over-coarticulating” various syllables, especially in multisyllabic words.

1.2. Recent considerations on the aetiology of cluttering

Cluttering behaviour, even when constrained under the LCD definition, might still be caused by a wide range of factors. For example, the hesitations and normal non-fluencies cited in the LCD could be language based, motor based, or reflect a more generalised problem with organisation, or planning as Weiss (1964) first speculated. Ward (2011a) argued that cluttering symptoms are seen at all levels of Van der Merwe's (2008) four-level model of speech processing. This starts with linguistic planning levels, but then involves motor planning, motor programming, and finally, motor execution. Relatedly, Ward (2006, 2011a, 2011b) identified two possible subcomponents of cluttering: those which affect what he termed ‘motoric fluency’, relating to aspects such as overcoarticulation, and those which impact on ‘linguistic fluency’, for example filled pauses, part word repetitions, unnatural pausing and phrase revisions. Recently, Van Zaalen, Wijnen, and De Jonckere (2009a, 2009b) have argued that, unlike stuttering, cluttering is a language-based disorder. In their view, the disorder can be split into two subtypes: ‘syntactic cluttering’, which somewhat equates to Ward's concept of linguistic cluttering, and ‘phonemic cluttering’ which covers areas Ward considered to be motoric. It is possible that an investigation into the brain and the functional abnormalities associated with cluttering may go some way to helping resolve these fundamental questions.

1.3. The neural basis of cluttering

Very little is known about the neural basis of cluttering. Earlier speculation aligned the disorder with deficits in motor speech control, with Seeman (1970) suggesting that cluttering results from a disturbance of the basal ganglia circuitry.

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