Institution: University of Sheffield

Unit of Assessment: 3A - Allied Health Professions, Dentistry, Nursing and Pharmacy: Dentistry

Title of case study: Improved treatment of post-stroke speech disorders with self-administered computer therapy

1. Summary of the impact

Stroke and other forms of brain injury often result in debilitating communication impairments. For example, patients with acquired apraxia of speech (AOS) experience difficulties that affect their capacity to verbally express thoughts and needs. Such individuals have benefitted from the development of a **novel computerised treatment** - "Sheffield Word" (SWORD). Patients who took part in clinical trials showed **improvements in aspects of speech** that were impaired after stroke. SWORD is now used by healthcare teams worldwide, providing benefits to a large patient population. The SWORD computerised treatment is **convenient to use at home**, **fosters users' autonomy, and delivers higher treatment doses** than possible through traditional clinical sessions. Clinicians who treat AOS have also benefitted through education, training and access to online materials about SWORD which were provided by the research team.

2. Underpinning research

The underpinning research was initiated in 1994 at the University of Sheffield's Department of Human Communication Sciences (HCS) as part of an ongoing programme of work led by Dr Sandra Whiteside (Sheffield 1992-present) and Professor Rosemary Varley (Sheffield 1991-2012). They developed a new theory of speech encoding and applied it to the study of apraxia of speech [R1-R2]. Apraxia of speech occurs in adults as a result of stroke and brain injury. These individuals exhibit speech characterised by reduced intelligibility, fluency and speed which can significantly impair their capacity to communicate and thus reduces quality of life.

Before Whiteside and Varley's work, the conceptualisation and clinical management of apraxia of speech were dominated by theories that speech output was assembled sound-by-sound. These theories were influenced by linguistic science, but made little attempt to address the neurobiological mechanisms of movement control in speech articulation. Usual therapies for apraxia of speech involved relearning individual articulatory actions (e.g., lip rounding). The evidence-base for such interventions was limited and in particular, there was no evidence for generalised improvement in speech production following treatment (West et al., 2005, Cochrane Review).

Whiteside and Varley's alternative model of speech control proposed that speech encoding depended on stored plans for words and whole utterances, rather than on segment-by-segment computations [R1-R4]. This theory is consistent with neurobiological principles underpinning sensory-motor systems and was subsequently used to explore the behavioural impairments observed in AOS. The research attracted funding from major healthcare charities to test the theoretical model through the development of a novel treatment approach to AOS [Varley & Whiteside. 2001-2002. The PPP Foundation. £52,004; Varley, Whiteside & Windsor. 2002-2004. The Health Foundation. £80,218].

Results from this initial phase (2001-2004) were promising and encouraged further development of a linked therapeutic intervention aimed at improving speech through rebuilding access to whole word and utterance plans. The group also developed an innovative method of treatment delivery for people with post-stroke speech/language impairments using a software program that allowed intensive therapy delivery in a cost-effective manner. This treatment gave patients access to the high-intensity stimulation necessary to initiate reorganisation of their damaged neural systems. It incorporated neurobiological principles that underpin sensory-motor learning. The project represents one of the first attempts to root speech and language interventions firmly in these concepts [R6].

Funding was subsequently obtained from The BUPA Foundation's specialist research programme 'New roles for health professionals in addressing public health needs' [Varley, Whiteside, Cowell, Blank & Young. 2007-2010. £251,834] to determine the outcomes of the software intervention on a larger scale. At that stage, the project team had been widened to include specialist statistical support [R5] from Professor Patricia Cowell (HCS, 1996 to present), wider NHS patient recruitment (Dr Catrin Blank, Consultant Neurologist, NHS, Sheffield, 2003-present) and health economic analysis by Dr Tracey Young (School of Health & Related Research at the University of Sheffield, 2004 to present). The research design was innovative in that a two-period cross-over design, with active and sham interventions, was applied to a complex behavioural therapy. The associated innovations in study design and statistical methods represent a contribution to the field of treatment evaluation research. This project constituted one of the largest intervention studies of its kind, and at the time of this report it represents the largest treatment trial of AOS which employed a single, full therapeutic software program.

The research is significant in its development of new theory that introduced explicit neuroscience principles into the domain of speech control and management of speech production disorders. The outcomes of the intervention research showed significant improvement in the ability of patients with chronic post-stroke speech impairments to accurately and fluently say words [R5-R6]. For the first time, evidence of therapeutic generalisation was demonstrated, and word forms which had not been treated also showed improvements. The application of principles of sensory-motor processing to higher order cognitive abilities such as speech and language represents a paradigm-shift that will stimulate further theoretical advances and development of evidence-based therapies for speech and language impairment [R4].

3. References to the research

R1. **Whiteside**, S. P. & **Varley**, R. A. 1998. A reconceptualisation of apraxia of speech: a synthesis of evidence. *Cortex*, **34**, 221-231. doi: 10.1016/S0010-9452(08)70749-4 (44 citations)

R2. **Varley**, R. A., **Whiteside**, S. P. **Luff**, H. 1999. Apraxia of speech as a disruption of word-level schemata: some durational evidence. *Journal of Medical Speech-Language Pathology,* **7**, 2, 127-132. (22 citations)

R3. **Varley**, R. A. & **Whiteside**, S. P. 2001. What is the underlying impairment in acquired apraxia of speech? *Aphasiology,* **15**, 39-49. doi: 10.1080/02687040042000115 (Invited target paper, with international peer commentaries, 50 citations).

R4. **Varley**, R., **Whiteside**, S.P., **Windsor**, F., & Fisher, H. 2006. Moving up from the segment. *Brain and Language*, **96**, 235-239. DOI: 10.1016/J.BANDL.2005.04.008

R5. **Cowell** P.E., **Whiteside**, S.P., **Windsor**, F., & **Varley**, R.A. 2010. Plasticity, permanence and patient performance: study design and data analysis in the cognitive rehabilitation of acquired communication impairments. *Frontiers in Human Neuroscience*. **4,** 213. doi: 10.3389/fnhum.2010.00213 (Since publication, the "paper received 1190 total views, making it among the highest-performing articles in Frontiers," excerpt of email from Carina Paraiso, Journal Manager, 9 January 2013)

R6. **Whiteside**, S.P., **Inglis**, A. L., **Dyson**, L., **Roper**, A., **Harbottle**, A., **Ryder**, J. **Cowell**, P.E. & **Varley**, R. (2012). Error reduction therapy in reducing struggle and grope behaviours in apraxia of speech. *Neuropsychological Rehabilitation, 22, 267-294.* Special Issue on Errorless Learning and Rehabilitation of Language and Memory Impairments. doi: 10.1080/09602011.2011.639614

4. Details of the impact

The research findings of Whiteside, Varley and colleagues led to the theoretical conceptualisation, technical production, and clinical testing of the software program "Sheffield Word" (SWORD) [*http://www.propeller.net/sword.htm*]. SWORD allows patients to self-administer the high intensity therapy required to stimulate neural reorganisation and speech recovery. The impact summary highlights the commercialisation of the SWORD treatment software and its benefits for patients, patient families and clinicians achieved since January 2008.

Commercialisation and deployment. The project evolved through a series of phases: from theory development and testing, through design of pilot software and a preliminary clinical trial, to design of market-ready software and the completion of a major intervention study. All these stages were completed at the University of Sheffield. The software development was supported by commercial development teams within the University, and then evaluated by Fusion IP, the University of Sheffield´s commercialisation partner. Fusion IP led the subsequent commercial negotiations with a SME partner, Propeller Multimedia Ltd. The software is available in two versions – SWORD Professional and SWORD Home. The software was licensed to Propeller and since its market launch in October 2008, over 200 units have been purchased. This includes direct sales to 47 NHS Trusts across the UK, which incorporates 72 NHS hospital-based speech-language therapy teams and 27 community-based rehabilitation teams. The Professional version is available at a cost of £435 for a single user licence. This version is largely used by practitioners who can then refer patients to the Home version. The Home version is available at the lower cost of £150 and allows people with stroke illness to directly access high quality speech rehabilitation. A 'Community USB Dongle' version can also be purchased for £765. This version incorporates three 'Community' Home licenses and one 'Admin' license with full functionality of the Professional version. The 'Community USB Dongle' allows the remote administration of speech therapy to several clients simultaneously. Program sales to date have been across the UK, Ireland and India [S1].

Patient beneficiaries. Stroke rehabilitation is an NHS priority. Every year, an estimated 150,000 people in the UK have a stroke and it is a leading cause of severe adult disability. A recent Care Quality Commission report (2011) indicated that although there had been improvements in services for the treatment of acute stroke, there was a need for improvement in longer term care and support services. Furthermore, inequities were recorded in the provision of care across regions. The AOS project and the resulting SWORD software are targeted at improving longer term care following stroke. It is a full speech intervention programme that enables high quality, equitable services to be provided to people with post-stroke speech disorders. Evidence shows that people with stroke illness were positively and directly impacted by the research [R5, R6]. Participants in the clinical efficacy study demonstrated significant gains in speech fluency and intelligibility that were maintained after the withdrawal of the program [R6]. The project included a group of users who were engaged in the research process at the University, and had the opportunity to inform the content and course of the research. Furthermore, this model of service delivery, and the availability of a home version of the software, allows users to self-administer therapy at times and locations convenient to them, without the need for a therapist to be present or to travel to a hospital or clinic. The software was designed so that the user (who could be a computer novice) self-administered the intervention. This in turn reduces the speech and language therapists' role to one of monitoring the progress of intervention. As a result, service users gain considerable control of their own treatment, contributing to regaining autonomy after stroke illness. The SWORD program has been well received by patients and carers, and continues to be used in speech and language therapy adult services [S2]. Health economic analysis of the clinical trial indicated that health and social gains from the treatment were cost effective within NICE guidelines (below the £20,000 threshold per Quality Adjusted Life Year (QALY) gained). This analysis showed that improvements in patient communication were associated with physical and psychosocial enhancements to quality of life [S3].

Professional beneficiaries. Linked to the release of the software, the research group has provided consultancy and education services to clinicians and also educational materials on the design and use of the program on the SWORD website (e.g., http://www.propeller.net/sword.htm). Training consultancy has been provided to clinician special interest groups (e.g., South West England Motor Speech Special Interest Group, Bath, October 2010; West Hertfordshire NHS PCT, June 2010) and via invited keynote addresses at clinician-led conferences (e.g., British Aphasiology Society Conference, Reading, September 2011; Irish Association of Speech and Language Therapists, Dublin, November 2011). Initial reporting of pilot study outcomes attracted international interest in the clinical speech pathology community, with reference to the work in an American Speech-Language-Hearing Association report [S4], and a Cochrane Review of the related post-stroke impairment aphasia [S5]. Development of SWORD Version 2 with updated interfaces and additional program features (e.g., audio-visual samples representing a North American Accent) is underway.

5. Sources to corroborate the impact

S1. The Managing Director of Propeller Multimedia Ltd. can corroborate the SWORD sales information and the sales contract renewal to 2016.

S2. The Joint Clinical Leads for Adult Speech and Language Therapy Services at Rotherham Foundation NHS Trust can corroborate the professional benefits of the software to speech therapists.

S3. The Health Economics Analysis Report: Young, T., Dyson, L., Whiteside, S., & Varley, R The cost-effectiveness of self-administered computer therapy for acquired apraxia of speech. *International Journal of Language and Communication Disorders (*submitted manuscript, which is under review). This manuscript corroborates that the treatment is cost effective within NICE guidelines, and that improvements in patient communication were associated with physical and psychosocial enhancements to quality of life.

S4. American Speech-Language-Hearing Association. Ballard, K.J. et al. 2010. Promising Approaches to Treatment of Apraxia of Speech: Preliminary Evidence and Directions for the Future. *Neurophysiology and Neurogenic Speech and Language Disorders*, October 2010; 20: 87 - 93. http://div2perspectives.asha.org/cgi/reprint/20/3/87

S5. Cochrane Review. Kelly, H., Brady, M.C., & Enderby, P. 2010. Speech and language therapy for aphasia following stroke. *The Cochrane Library*, 2010, 7, 1-170. (page 11)