Institution: Queen Margaret University
Unit of Assessment: UoA 28 Modern Languages and Linguistics
Title of case study: Electropalatography (EPG) to Support Speech Pathology Assessment, Diagnosis and Intervention
1. Summary of the impact

The impact is primarily in Public Health. It mainly concerns the adoption of and demand for a speech research technology, Electropalatography (EPG), for clinical diagnosis and treatment of speech disorders. Our continuing long-term and interdisciplinary research into EPG has increased our impact in this census period from the previous RAE2008, during which time the UOA had already been awarded a Queen's Anniversary Prize (2002) for working towards the clinical application of speech science.

Financial Support from the charitable sector and the NHS for the training of classroom assistants and SLTs in EPG therapy is highlighted, along with user testimonials, unmet demand, and small-scale provision of the therapy.

2. Underpinning research

The underpinning research overlaps the other case study. Here we focus on the phonetic, linguistic and clinically oriented research that underpins this case. CAPITALISED names are of individuals contributing outputs to this UOA in this REF, and other researchers named in this section were QMU staff (or RAs) at the time of producing the underpinning research.

QMU lecturing staff and researchers have undertaken research into EPG over two decades, since the appointment of Hardcastle (1991-2009) and Gibbon (1992-2009). Both led the strategic development of the therapeutic use of EPG, usually in a medical research context. It was decided to spin out Articulate Instruments Ltd. (in September 2003) from QMU to enable it to obtain a CE mark certification for non-research use of EPG as a clinical healthcare tool. CE marking of EPG for clinical (e.g. NHS) use was achieved by Articulate Instruments Ltd. in 2004, meeting stringent safety and quality-insurance regimes required by legislation. This was a crucial element in promoting the impactful use of EPG in the UK and EU that had previously been missing. This process also enabled Articulate Instruments Ltd. to exploit the freedom and flexibility of the commercial sector to tailor underpinning research to the needs of non-academic users. Nevertheless, a strategic synergy has been maintained between QMU and Articulate Instruments Ltd., and collaboration for research and impact have continued and prospered under WOOD.

The underpinning research is mainly applied or clinically related. Funding has been obtained through strategic internal investment and peer-reviewed competitive external grants. The latter clearly provides evidence of its quality, as does the selection of peer-reviewed outputs below.

The themes of the underpinning research highlighted in this case address the following questions:

1. How best can EPG be used in a clinical domain as a diagnostic and therapeutic tool, with what client groups and with what models of intervention? (Gibbon, WOOD, CLELAND);
2. What articulatory patterns, analysis variables, statistical comparisons and other phonetic characteristics of clinical speech are characteristic of disordered speech before, during, and after treatment? (Gibbon, WOOD, Timmins, Hardcastle);
3. Does EPG therapy improve the speech of children with speech disorders resulting from Down's Syndrome? (WOOD, CLELAND, Gibbon);
4. Does EPG therapy improve the speech of children with speech disorders resulting from Cleft Palate? (Gibbon, Roxburgh);
5. What are normal speech production patterns? (SCOBBIE, S.SCHAEFFLER, ZHARKOVA);
6. What are the psycholinguistic processes underlying real time visual biofeedback, and how best should the feedback be presented by software? (CLELAND, SCOBBIE, WRENCH).

It is important to note that the underpinning research has a long time base. It involves a broad set of QMU-based researchers and employs a variety of research methods, from electronic and software engineering, phonetics, laboratory phonology, psycholinguistics, speech technology, clinical linguistics. It addresses theoretical linguistic questions as well as clinical and methodological topics, and targets an increasing range of caseloads.

An MRC research project showed EPG could significantly improve the speech clarity of children and young people with Down's syndrome. The underpinning research by WRENCH prior to his departure from QMU to set up Articulate Instruments Ltd. in 2003 was to:

a. Develop an MS-Windows version of EPG, with a software environment called Articulate Assistant (AA) that enables the capture, storage, and analysis of client data with synchronised audio and articulatory patterns (at 200Hz). The software provides side-by-side therapist/client real time visual biofeedback and models of correct productions;
b. Develop a different, extendable, multi-channel EPG system ("AAA") which can be augmented with modules for other articulatory instruments. (Initially this was EMA, but later developments include video-based Ultrasound Tongue Imaging and high-speed Ultrasound Tongue Imaging, both of which are beginning to be applied in a clinical domain).

3. References to the research

We highlight here research into normative patterns, pathological patterns and clinical protocols. Evidence of 2* quality: peer-reviewed papers are [1], [3], [4], [5], [6]. **Bold** names were QMU staff at the time. In the case of Wrench, he was staff in 2002 and Category C in 2004 (cf. RAE2008).

[1] **Hardcastle** WJ and **Gibbon**, FE (1997) Electropalatography and its clinical applications. In: MJ Ball and C Code (eds.) *Instrumental Clinical Phonetics*. Whurr: London, pp. 149-193.
[2] **Wrench**, AA, **Gibbon**, FE, McNeill, AM, **Wood**, SE (2002) An EPG therapy protocol for remediation and assessment of articulation disorders. *Proc. ICSLP-2002*, pp. 965-968.
[3] **Scobbie**, JM, **Wood**, SE and **Wrench**, AA (2004) Advances in EPG for treatment and research: an illustrative case study. *Clinical Linguistics and Phonetics* **18** pp. 373-389.
[4] **Lee**, A, **Gibbon**, FE, Crampin, L Yuen, I and McLennen, G (2007) The national CLEFTNET project for individuals with speech disorders associated with cleft palate. *Advances in Speech Language Pathology* **9(1)** pp. 57-64.
[5] **Wood**, S, Hardcastle, WJ and Gibbon, FE (2011) EPG patterns in a patient with phonemic paraphasic errors. *Journal of Neurolinguistics* **24(2)** pp. 213-221.
[6] Pouplier, M, Hoole, P and **Scobbie**, JM (2011) Investigating the asymmetry of English sibilant assimilation: Acoustic and EPG data. *Journal of Laboratory Phonology* **2(1)** pp. 1-33.

4. Details of the impact

The impacts are in healthcare, public awareness, and quality of life. We detail how we attracted support to undertake impactful activity with EPG, how the media has presented our work, and the positive effect it has had on some clients. Its use has been seen in three main clinical areas:

a. speech disorders in children with cleft palate, in cleft palate centres in UK and Scandinavia;
b. speech disorders in children with hearing impairment, in Cornwall, as part of a pre-RCT;
c. speech disorders in children, with no known aetiology ("phonological disorders").

1. Charitable Funding Awards to provide clinical treatment with EPG

Project #1 – Cleftnet. The support from various charities (£20k in 2008-2012) maintained a national Cleftnet network linking EPG therapists in the cleft palate centres in the UK and linking to QMU for expert support for their caseloads.
Project #2 – Baily Thomas. This support (£37k in 2008-2010, for "Enhancing Speech Intelligibility in Children and Young People with Down syndrome") offered EPG therapy to 18 children who had volunteered for an MRC research project but had been allocated as controls for the research, therefore receiving either no treatment or conventional treatment. This donation was "to aid the care and relief of those affected by learning disability". In all, the MRC research project had given

EPG therapy to 8 children. We have generally not kept records of parental testimony nor taken quality of life scores as outcome measures, but we have speech analysis scores that show improved speech as evidence of impact. Evidence of impact on public awareness and quality of life of participants is provided by the Client D testimonial (below) from press coverage (06/12).

Project #3 – Nuffield. This award of £147k, from April 2012-May 2014, ("Improving the speech communication abilities of children with Down's syndrome: A new model of service delivery using electropalatography") was mainly for therapy. A component of applied research is also included, primarily to design therapy protocols that can be implemented by learning assistants in schools and to assess the level of improvement in speech. Treatment of 17 children is on-going. This award also attracted press and TV reports, quoting testimonials (04/13). The City of Edinburgh Council's Support to Children and Young People unit was very supportive in preparation and has provided the liaison, resourcing and support for the classroom assistants and teachers involved.

2. Uptake of training in EPG by therapists

NHS Education Scotland. A CSMEN award (£5k) was made during the census period to support WOOD to train therapists in EPG and to support a small clinical caseload of 3 children in Edinburgh, East Lothian and West Lothian. The actual intervention started after 31 July, so is detailed in our impact template as future activity. The Clinical Lead Community Services will corroborate the need for such treatment and associated training for NHS staff.

EPG workshops (QMU). Whole day workshops (2010, 2011, 2012) have attracted around 20 clinicians. (The 2013 workshop is a UTI workshop, associated with Ultrafest VI.)

EPG workshops (elsewhere). Workshops for clinicians have been run at other locations when QMU staff have been invited and funded to attend. This shows an on-going demand from professional organisations for training and discussion of clinicians. Notable events:

- 2008 Stockholm, Sweden, EPG workshop (WRENCH, CLELAND);
- 2009 Salzburg, Austria, EPG workshop (WRENCH);
- 2012 Osaka, Japan, EPG symposium (WRENCH);
- 2012 London, England, ASLTIP (Association of SLTs in Independent Practice) EPG & Ultrasound workshop (WRENCH, CLELAND);
- 2013 Linköping, Sweden, EPG workshop (WRENCH).

3. NHS trials

Though EPG is not routinely available, small-scale implementations of therapy associated with research in particular caseloads typically show improvements to speech.

4. Cleftnet UK

Prior to her departure in 2009, Gibbon coordinated a network of all 14 NHS cleft-palate centres in the UK, offering EPG in all locations to a small trial caseload.

5. Cornwall trial

There was a pre-RCT trial in Cornwall (2011-2013) of EPG therapy for children with severe and profound hearing impairment. It was supported by a Research for Patient Benefit grant (£250k) from the National Institute of Health Research. Again, this was a mixed research/impact activity, providing EPG therapy and evaluating the feasibility of a full RCT leading to improvements to delivery in non-academic contexts. Improvements in children's speech performance were observed and reported, providing evidence of impact.

6. Testimonials and public awareness via press coverage following EPG therapy

Client A. EPG therapy (and latterly some that was ultrasound-based) was given to a 10-year-old girl fitted in infancy with a cochlear implant, who had been referred by a CASL audiologist (White). Aged 15, A was keen for her testimonial to be featured in the press and in other publicity, because, in her words*: "The EPG helped me relearn how to speak. I didn't realise what I was doing wrong before but seeing the shapes my tongue made on a computer screen made it easy for me to learn how to change my words. People understand me so much better now and I don't have to repeat what I say nearly so much. And having better speech gave me the confidence to be a speaker at a*

conference for parents of deaf babies. I wanted to show how well their children could do when they grow up. Lots of the mums and dads were so moved they cried - even my mum." The article concludes that Client A: *"now wants more deaf people to benefit from the same techniques that helped her. "I'm the only one of all my deaf friends who has had EPG and that's not fair. Everyone should have an equal chance to improve their speech," she said."* (14/05/11)

Clients B and C, Parent, Classroom Assistant. After 3 months of the Nuffield project, a classroom assistant said: *"It's been very positive… [B, age 11] knows exactly how to produce sounds because she's seeing them on a screen and she really enjoys using the palate." "[C]… was also benefitting from the trial, with nine-year-old [X] also set to get on board."* Additionally, B's mother said*: "I think EPG has made her think about the sounds she's producing much more. The screen makes it easier to imagine the sounds and picture them, and I think the whole experience has just given her more confidence."* (09/04/13) (See also press coverage 05/02/13, 05/02/13.)

Client D. D (aged 8) was selected to meet H.M. the Queen when she opened QMU's new campus in 2008. In April 2012, she voluntarily contacted the BBC in response to a call for stories to illustrate "meeting the Queen" as part of the Diamond Jubilee. In 2012, aged 12, she reminisced: *"The Queen watched me doing speech therapy. She was in a room next door, looking through a window. I was using an electronic palate, which showed different patterns on the screen when I made different sounds. I met the Queen afterwards. I was excited, because she's a character in one of my favourite books - The BFG by Roald Dahl. I told my mum I would say 'Hello, your Majister', like the BFG, but my mum said I shouldn't. So I just said, 'Hello, Your Majesty'. The Queen asked me if I found it interesting working with the electronic palate. I said 'Yes, I did, your Majesty'."* (03/06/2012)

7. Un-met demand for EPG therapy from clinician workshops, self-referrals, etc.

The local model of integrating EPG into available care pathways, devised in collaboration with local SLT services, concentrates on clinical activity being targeted towards specific client groups, in small, manageable cohorts. We therefore discourage unsolicited referrals to QMU for EPG therapy. Even so, from 2008-2012 WOOD's records confirm we received 15 enquiries for therapy coming from word-of-mouth contacts of research participants. Following the February 2013 press stories about EPG, WOOD received 12 requests for therapy from clinicians and the general public. In association with calls for participants in therapeutic case studies, we receive many more referrals than we can satisfy. A brief 2008 call to SLTs for 2 cases to be the basis of a book chapter illustrating the methods and results of EPG therapy (Gibbon and WOOD, 2010) quickly drew 6 referrals. The CSMEN award (2013) to treat 3 children attracted 24 new referrals from local SLTs. After EPG workshops for about 6 SLTs, we predict a dozen or so referrals. As we unfortunately lack the resources and mandate to provide a therapeutic pathway of care and EPG is not yet available on the NHS, we have been careful not to create unmet demand. Nevertheless, the amount of pent-up demand revealed by spontaneous enquiries demonstrates impact in a way that also illustrates some of the ethical difficulties in aiming for impact in the first place.

5. Sources to corroborate the impact

These news coverage sources corroborate the quoted public testimonials selected for use

- Client A, *Scotland On Sunday / Scotsman Newspapers 14 May 2011* http://www.scotsman.com/news/girl-15-becomes-ambassador-for-ground-breaking-deafness-therapy-1-1630833
- Clients B. & C., Parent and Classroom Assistant.
  - *BBC Website, 5 February 2013* http://www.bbc.co.uk/news/uk-scotland-edinburgh-east-fife-21328998 is a general report that attracted self-referrals for EPG therapy.
  - *BBC TV news bulletins, 5 February 2013* featured an interview with WOOD on campus and clients in an extended segment positively evaluating the project http://www.bbc.co.uk/programmes/b01qfzwb (no longer available online).
  - *Evening News, 9 April 2013* http://www.scotsman.com/news/scotland/top-stories/speech-device-helps-down-s-pupils-learn-speech-1-2884509 or, an alternative URL http://www.edinburghnews.scotsman.com/news/speech-device-helps-down-s-pupils-learn-speech-1-2884509 is the source of the quotes given.
- Client D. *BBC Website, 3 June 2012* http://www.bbc.co.uk/news/uk-scotland-18148757