Institution: University of Westminster

Unit of Assessment: 4 Psychology, Psychiatry and Neuroscience

Title of case study: Susceptibility to, and treatments for, motion sickness and vestibular diseases producing vertigo.

1. Summary of the impact

Findings of Westminster research on motion sickness have been used by professionals working outside academia. Work on motion sickness susceptibility led to development of a screening questionnaire that has been used by the European Space Agency as a diagnostic tool, and the US military in development and evaluation of motion sickness countermeasures. Research done at Westminster underpins both British Medical Association best-practice guidelines and Continuing Medical Education / Professional Development for medical practitioners around the world. Improved desensitisation procedures for vertigo symptoms have been adopted as standard treatment for vestibular disease patients.

2. Underpinning research

Motion sickness can occur in nearly everyone with normal function in the vestibular apparatus of the inner ear if they experience unusual motion (e.g. when travelling on ships). Approximately 10% of the population are very susceptible. In more extreme motion environments such as agile military aircraft or Zero-gravity parabolic flights, the risk of motion sickness increases. **Vestibular disease** can also produce **vertigo** and other symptoms similar to motion sickness. Vestibular disease increases with age, and is experienced at some point in life by about 10-20% of the population.

Research by Professor **Golding**, conducted at Westminster since 1996, has incorporated three main strands. The first is development of a screening tool that substantively improved on previous measures of motions sickness susceptibility; the second is a programme of work enabling objective assessments of motion sickness treatments; the third is development of a new procedure for desensitisation training in vertigo patients. These strands combine to form a body of knowledge that has significantly enhanced professional practice around motion sickness.

(1) An important issue for motion sickness is how to identify those who are most susceptible, so that such individuals can then be targeted for suitable treatments. Susceptibility can be measured without putting people into motion sickness situations if there is a suitable questionnaire. Previous questionnaires were lacking in various ways, and this was the impetus for developing the Motion Sickness Susceptibility Questionnaire (MSSQ). It was validated using a mobile motion sickness chair that mimics natural motion sickness settings. The research took place from 1996 and the MSSQ was published in 2006. Compared to previous instruments the MSSQ is shorter and easier to complete and score. It is validated against several types of provocative motion (predictive validity was either lacking or very thin for previous instruments), has high reliability (internal and test-retest), and population norms with percentiles. It is also available in many language variants from French to Chinese, reflecting its widespread uptake and usage. The questionnaire was developed at Westminster by Golding alone.

(2) As there are various treatments for motion sickness, objective assessments were required to judge their efficacy and the optimal choices of drugs. This research established that choice of anti-motion sickness drugs should be based on efficacy cost-benefit trade-offs that will vary in any particular situation. This includes time course of action and side-effects. The research done at Westminster has been in collaboration with various European Universities, the European Space Agency, the US Military, and with Imperial College School of Medicine.

(3) For patients suffering vertigo and related vestibular disorders, desensitisation training was developed, based on knowledge acquired from experiments on habituation to motion sickness. Progressive and mild exposure to physical and visual stimuli, together with adjuncts such as controlled breathing exercises, was found to offer the most efficient route to desensitisation. Golding initially worked on this with Sang and Billar at Westminster and continued collaborating with them when they moved to Imperial. The research was carried out starting in 2000 with publications in 2003 and 2006.

3. References to the research

Golding's programme of research has produced a number of publications in international peer-reviewed journals. Many of these are highly cited. For example, Golding (1998) had 89 citations in Scopus in July 2013. Golding and Gresty (2005) was submitted to RAE2008. Publications underpinning impact in each of the three main areas are listed below.

Research on susceptibility:

- Golding, J. F. (1998). Motion sickness susceptibility questionnaire revised and its relationship to other forms of sickness. *Brain Research Bulletin, 47*(5), 507 - 516. doi:10.1016/S0361-9230(98)00091-4
- Golding, J. F. (2006). Predicting individual differences in motion sickness susceptibility by questionnaire. *Personality and Individual Differences, 41*(2), 237-248. doi:10.1016/j.paid.2006.01.012
- Golding, J. F. (2006). Motion sickness susceptibility. *Autonomic Neuroscience, 129*(1), 67-76. doi:10.1016/j.autneu.2006.07.019
- Golding, J. F., & Gresty, M. A. (2005). Motion sickness. *Current Opinion in Neurology, 18(*1), 29-34. doi:10.1097/00019052-200502000-00007

Research on objective assessments of motion sickness drugs:

- Golding, J. F., & Stott, J. R. R. (1997). Comparison of the effects of a selective muscarinic receptor antagonist and hyoscine (scopolamine) on motion sickness, skin conductance and heart rate. *British Journal of Clinical Pharmacology*, *43*(6), 633-637. doi:10.1046/j.1365-2125.1997.00606.x

Research on desensitization for vertigo:

- Sang, F. Y. P., Billar, J., Gresty, M. A., & Golding, J. F. (2005). Effect of a novel motion desensitization training regime and controlled breathing on habituation to motion sickness. *Perceptual and Motor Skills*, *101*(1), 244-256. doi:10.2466/PMS.101.5.244-256

Sources of funding:

Further evidence of the quality of the underpinning research comes from the fact that it has been supported by peer-reviewed funding from various sources ranging from Research Councils to charities and military research agencies. A list of funding sources for the overall research programme, covering the REF impact-underpinning research period, is shown below:

Funding for which Golding was principal/sole investigator:

- 1997 Ministry of Defence (MOD DERA) grant for Motion Sickness Research £8000.
- 1998 Wellcome Trust Research Travel grant on Motion Sickness £500.
- 2000 European Space Agency (ESA) grant with various participant collaborators (Univ. Tours France, lead institution, Univ. Tubingen Germany). Two year grant to max. £20,000 per year per participant. Used mainly for ESA parabolic flight 'Zero-G' research.
- 2005-2007 United States Navy, Travel grants to Navy Aerospace Medical Research Laboratory (NAMRL) Pensacola on four occasions to plan future research collaborations. Approx US $ 11,000.
- 2011 US Army: USAARL Fort Rucker USA "Warfighter Performance and Health Division at USAARL." US $11,000.

Other competitive, peer reviewed grants that have supported Golding's research programme are in association with Imperial College as lead:

- 2006-2013 Named co-investigator on **Medical Research Council** grant to Imperial College School of Medicine *'Factors determining chronic dizziness & vertigo'*. £1.8 million, duration 6 years.
- 2008-2013 Named co-investigator on **Meniere's Society** grant for *Effectiveness of Transtympanic Dexamethasone in Meniere's disease: a Randomised Controlled Double-blind Trial.* £130,000, duration 4 years.

4. Details of the impact

Golding's research impacts **Health and Welfare,** and **Practitioners and Services,** where professionals use his findings in their work.

Golding's Motion Sickness Susceptibility Questionnaire (MSSQ) predicts susceptibility to motion sickness. It has been translated into several languages (Chinese, Russian, Spanish) and used in a variety of contexts worldwide.

Since 2012, as a result of prior European Space Agency (ESA) awareness of Golding's work, all participants in Zero-gravity parabolic flights conducted by Novespace for the ESA have been screened for motion sickness risk using the MSSQ (9 flights involving 67 flyers to date; information not available for classified military flights). These put flyers (e.g. industrial researchers working on Zero-gravity microchip design) in a weightless environment and are highly nauseogenic. Those flyers whose MSSQ responses indicate they are at risk of motion sickness are prescribed appropriate medication.

The MSSQ has been used to evaluate military motion sickness countermeasures. This arose from Golding's role as invited visiting scientist at the US Naval Medical Aerospace Medical Research Laboratory (NAMRL). Scientists working for the US military used the MSSQ when evaluating the effectiveness of drugs at NAMRL (2008, 2009), and to screen participants when evaluating the effectiveness of stroboscopic illumination of military helicopter cabins during nauseogenic flight at the United States Army Aeromedical Research Laboratory (2011).

Other impact on **Practitioners and Services** is in medical treatment of motion sickness, where professional guidelines and training have been influenced.

The British Medical Journal (BMJ) Best Practice guidelines for Motion Sickness represent 'official advice' to doctors from the British Medical Association (BMA) on the disorder. Golding is author on 11 / 74 (15%) of the publications on which the guidelines are based. The BMJ reaches all 150,000+ doctors who are BMA members.

Golding's research also underpins professional training: Continuation Medical Education (CME) for practitioners. The BMJ commissioned a clinical review article from Golding and colleagues, informed by his work. This is the basis for a module on "Managing Motion Sickness" on the BMJ Learning site, which forms part of the CME offered by the BMA to clinicians in the UK. The module is also accredited for Continuing Professional Development / CME by professional bodies such as the Austrian Academy of Physicians, the Dubai Health Authority and others in Australia, Oman, South Africa, USA, and New Zealand for the period 1/12/11-1/12/13. Reviews from users (ranging from pharmacists to general practitioners) indicate its utility. The online version of the resource has been downloaded over 6,000 times, indicating a high level of user engagement with the module and a significant contribution to CME.

Some best practice recommendations result from work directly commissioned by users. Golding worked with the NAMRL, sponsored by the US Special Operations Command (USSOCOM), on objective evaluation of motion sickness medication. The 2009 report recommended considering scopolamine rather than USSOCOM's existing drug of choice.

The work on desensitisation therapy has impacted **Health and Welfare,** where outcomes for patients with vestibular disorders have improved. Throughout 2008-2013, desensitisation techniques arising from Golding's work have been used in clinical settings. The techniques involve graded exposure to vestibular or symptom-provoking stimuli, and controlled breathing exercises. The methods improve on previous treatments because graded exposure allows steady improvement in patients' tolerance and habituation to (particularly visual) stimuli, as opposed to intense stimuli from the start of treatment. The latter leads to overload, severe symptom increase and likely non-compliance with treatment. Controlled breathing works in a similar way, allowing patients to tolerate stimuli for longer periods. Over time this results in greater improvement.

The methods are mainly used by physiotherapists and cognitive behavioural therapists. Clinics where the techniques are used include Charing Cross Hospital and the National Hospital for Neurology and Neurosurgery, the National Ear Nose and Throat Hospital (Gray's Inn Road) and a number of vestibular clinics in the United States. At these clinics, all patients presenting with dizziness, vertigo, postural and/or gait instability due to a vestibular disorder have been treated with the techniques, which can be regarded as the standard treatment for these symptoms. Around 100-120 such patients are seen yearly at the London clinics listed above, with several hundred being treated across the UK as a whole.

All these patients receive customised graded exposure. Approximately 40% of such patients in these clinics and across the UK also receive controlled breathing exercise. This applies particularly to those with increased anxiety symptoms and avoidance behaviour.

Golding's techniques were demonstrated in a 2012 episode of the BBC's 'Bang Goes the Theory' where he worked with a lifeboat crewman to drastically reduce his symptoms.

5. Sources to corroborate the impact

(1) **Use of MSSQ in European Space Agency parabolic flights** can be corroborated by the European Space Agency medical officer for Zero-G flights (Corroborating Contact 1).

(2) **Use of MSSQ in US military evaluations of motion sickness countermeasures** at US Naval Aerospace Medical Research Laboratory and at U.S. Army Aeromedical Research Laboratory (USAARL) can be corroborated by a military scientist employed by the US federal government at USAARL (Contact 2).

*(*3) For **other work using the MSSQ at United States Aeromedical Research Laboratory** a non-classified version of technical *report "USAARL Report No. 2011-21 Motion Sickness Prevention by 8Hz Stroboscopic Environment during Actual Air Transport"* is available from http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA553665 and a copy is also held on file at University of Westminster.

(4) The **BMJ Best Practice guidelines** are available from http://bestpractice.bmj.com/best-practice/monograph/1034.html and a copy of the reference section of the website, showing the influence of Golding's research, is also held on file at University of Westminster.

(5) The **BMJ Learning module on Managing Motion Sickness** including details of accrediting bodies is available from http://learning.bmj.com/learning/module-intro/.html?moduleId=10030548 and a copy of this web page is also held on file at University of Westminster.

(6) **Download counts for the module's core clinical review article** can be seen at: http://www.bmj.com/content/343/bmj.d7430?tab=metrics A copy of these metrics (as of 18th July 2013) is also held on file at University of Westminster.

(7) For **objective evaluations commissioned by US Special Operations Command** a non-classified version of technical report "*Evaluation of Several Common Antimotion Sickness Medications and Recommendations Concerning Their Potential Usefulness During Special Operations*" is available at http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA511823 and a copy is also held on file at University of Westminster. Contact (2) can also corroborate this work.

(8) **Clinical use of desensitisation therapy for vertigo patients** can be corroborated via Contact 3, Guy's Hospital.

(9) **TV coverage of desensitisation techniques** was broadcast in the BBC's "*Bang goes the Theory*" Series 6, episode 7; Aired 30th April 2012. A copy of the subtitles is at http://tvguide.lastown.com/bbc/preview/bang-goes-the-theory-series-6/episode-7.html and a copy of these subtitles is also held on file at University of Westminster.