**Institution:** Queen's University Belfast

**Unit of Assessment:** 4

**Title of case study:** Connecting Emotionally With and Through Computers

**1. Summary of the impact** (indicative maximum 100 words)

Emotional signals – obvious outbursts, or more often subtle changes in tone of voice, or facial expression – play a key part in human communication. Psychology researchers at Queen's have made fundamental contributions to 'affective computing', which enables automatic systems to use those signals. The team's work has influenced a new computing language for describing these signals and the states that they reveal: EmotionML (Emotion Markup Language). The language has been recommended as a standard by the World Wide Web Consortium, to define how software describes emotions.

The language is used by multinational corporations in a range of applications in a rapidly expanding field. Queen's expertise in emotion led Dr Gary McKeown to found a start-up company, Adoreboard (previously known as Mediasights) along with entrepreneur Chris Johnston, which specifically uses EmotionML in opinion and sentiment analysis in marketing. Its product, Adoreboard, lets companies track consumers' emotional responses to their products. The company has agreed funding of £470,000, partnerships with three multinational corporations, and was recently selected to take up residence at Google's campus in London.

**2. Underpinning research** (indicative maximum 500 words)

Psychologists in the Perception, Action and Communication Research group at Queen's are pioneers in the field of affective computing, which allows computer systems to register emotion in human behaviour and communication, and to give appropriate signs in return. This technology describes and interprets the signals that drive everyday human interactions: changes in the tone and rhythm of speech, facial expressions or posture that indicate how someone feels about a topic or interaction, and which we pick up on in order to respond appropriately. The Queen's group has made major contributions to the theory and evidence which allows technology to make use of these emotional cues.

The research, led by Professor Roddy Cowie since the 1990s, has centred on databases, which bring together details of the visible and audible signs that convey everyday emotional 'colouring', and systematic descriptions that capture the emotional meaning of the signs [2, 3, 4], in a variety of cultures [6]. The team pioneered ways to record apparent emotion [1], and to analyse relationships between the signals that humans give out and the emotional states that they correspond to [1].

Most of this work was done in international and interdisciplinary collaborations funded by the European Commission, with the Queen's group playing a leading part. Eight of these European projects have run consecutively since 1998, with total funding of over £1.5 million to Queen's alone.

One of these projects, HUMAINE (FP6, Network of Excellence), which began in 2004 and was led by the Queen's group, started the process of trying to understand emotion oriented computing. This interdisciplinary group set out to establish a standard language that could be used to describe everyday emotions, and the non-verbal signals that convey them, in computing related contexts. Subsequently the standard that was developed as a result of the research carried out by this interdisciplinary network has now been recommended by the World Wide Web Consortium, and is called EmotionML.

From 2007 the team provided the psychological input to the SEMAINE project [4], which confirmed that human-computer conversation could make use of emotional signals picked up from cameras and microphones. The SEMAINE project developed avatars which talked to a real person and made appropriate responses to the person's emotional signals. This kind of ability has applications in emerging areas such as computer-aided teaching systems, or computer-mediated therapy.

Related research from Dr Gary McKeown (Research Fellow; 2006 – present) identified a different application for research on emotion. Building on research into risk communication [5], he developed software to help experts communicate risk to lay people, and was led to recognise the role emotion plays within risk communication. The system uses a novel agent based modelling approach to opinion and sentiment analysis [5], where software sends messages to social networks as if from an individual and the response to these interactions can then be assessed. These approaches are now being commercially implemented by the start-up company Adoreboard. Along with fellow Queen's researcher Ian Sneddon (Senior Lecturer, Psychology), McKeown has also studied how emotional responses change geographically and over time. [6]

**3. References to the research** (indicative maximum of six references)

1. Cowie, R., Douglas-Cowie, E. Tsapatsoulis, N., Votsis, G., Kollias, S., Fellenz, W., & Taylor, J.. (2001). Emotion recognition in human-computer interaction. *IEEE Signal Processing Magazine*, *18*, 32-80.

2. Cowie R., & Cornelius, R. (2003) Describing the emotional states that are expressed in speech *Speech Communication*, *40*, 5-32.

3. Douglas-Cowie, E., Campbell, N., Cowie, R., & Roach, P. (2003). Emotional speech: towards a new generation of databases. *Speech Communication*, *40*, 33-60.

4. McKeown, G., Valstar, M., Cowie, R., Pantic, M., & Schröder, M. (2011). The SEMAINE Database: Annotated multimodal records of emotionally coloured conversations between a person and a limited agent. *Proceedings of the IEEE International Conference on Multimedia and Expo 2010,* 1079-1084. doi:10.1109/T-AFFC.2011.20

5. McKeown, G., & Sheehy, N. (2006). Mass media and polarisation processes in the bounded confidence model of opinion dynamics. *Journal of Artificial Societies and Social Simulation*, 9(1).

6. Sneddon I., McKeown, G., McRorie, M., & Vukicevic, T. (2011) Cross-cultural patterns in dynamic ratings of positive and negative natural emotional behavior. PLoS ONE 6(2): e14679. doi:10.1371/journal.pone.0014679

**4. Details of the impact** (indicative maximum 750 words)

The team's influence on affective computing has an international reach both within the world of software and also commercially.

The World Wide Web Consortium (W3C) recommended EmotionML as a standard in April 2013. W3C is the body that regulates the web and sets standards for all internet-based applications (a familiar standard is HTML, used to code all web pages). As a standard, EmotionML is more than a

research instrument: it defines a policy that has major implications for the web. Most immediately, using the standard ensures that any computer programme that describes or uses emotion will be compatible with another.

The need to develop suitable descriptions for everyday emotions was highlighted by Cowie and Cornelius in 2003 (see section 3). The process of translating the academic analysis into a working standard was initiated during the Queen's-led HUMAINE project, which began in 2004. Former Queen's research fellow Marc Schroeder steered the project until 2012, leading an incubator group that included academics, companies and W3C representatives. The specifications for describing emotions combine ideas and tools from many sources. In particular the project made use of Queen's development of 'trace' methods to describe emotions that change with time, and the vocabularies needed to describe everyday emotion. The formal defining documents for EmotionML (cited below) acknowledge the input from Queen's researchers in developing the standard.

A W3C standard is a policy statement by a transnational body, and influencing such a standard is an impact in its own right. A second level of impact comes from applications of the language. In W3C terminology these are 'use cases', and establishing that such cases exist is part of the approval process. In the 2013 implementation report, nine cases where the standard has now been implemented are listed, and they demonstrate the next level of impact. The commonest use of EmotionML is as an interface that allows different components to communicate. Deutsch Telekom implemented it to describe the output of their speech analysis software; Swiss-based emotion technology company nViso integrates EmotionML into market research software that infers emotion from facial expressions; the widely used open-source MARY text-to-speech system developed at the German Research Centre for Artificial Intelligence uses it to describe the emotional colouring that speech should express; and the WASABI simulation of central emotion processes, used in the artificial museum guide Max, uses EmotionML to let WASABI interface with other software.

In a local development, that directly uses QUB's expertise and research, a start-up company, Adoreboard was founded in collaboration with Dr Gary McKeown in 2011 to build on the research into opinion dynamics, affective computing, and emotion. The company has secured funding of £470,000 so far. This includes £310,000 in private funding, £60,000 from a Knowledge Transfer Partnership and up to £100,000 from InvestNI–the regional business development agency. It currently has four employees and Dr Gary McKeown serves as Chief Scientific Officer. Adoreboard is working with a number of multinational companies who are interested in using their sentiment analysis software to assess the emotional response that consumers have to their products, based on their news, media and blogs, as well as online comments on sites such as twitter, forums, chatboards and review websites. Adoreboard was recently selected from UK start-ups by Google to take up residence at its Google Campus in London.

**5. Sources to corroborate the impact** (indicative maximum of 10 references)

***W3C documentation*:**

Recommendation for EmotionML http://www.w3.org/TR/emotionml/

Use cases and incubator group membership http://www.w3.org/2005/Incubator/emotion/XGR-emotion/#AppendixUseCases

Implementation report: http://www.w3.org/2002/mmi/2013/emotionml-ir/

**Applications of EmotionML (brief descriptions are in the W3C Implementation report)**
**Deutsch Telekom**: Burkhardt, F (2012) Fast Labeling and Transcription with the Speechalyzer Toolkit http://www.lrec-conf.org/proceedings/lrec2012/pdf/110_Paper.pdf

**nViso**: https://developer.nviso.net/

The **MARY text to speech system**: http://mary.dfki.de/

**WASABI**: Becker-Asano, C., & Wachsmuth, I. (2010). Affective computing with primary and secondary emotions in a virtual human. *Autonomous Agents & Multi-Agent Systems 20*, 32-49.

Schuller B, Baron-Cohen S., Robinson P., Golan O., Newman S., Camurri A., Baranger A. (2012) Integrated Internet-Based Environment for Social Inclusion of Children with Autism Spectrum Conditions deliverable D9.2 http://geniiz.com/wp-content/uploads/2012/12/Deliverable-289021-D9.2-Annual-report-year-1_updated.pdf

**Verification of Queen's input to W3C standard**
Director of Research, CNRS at LTCI, Telecom-Paris Tech, 37/39, rue Dareau, 75014 Paris, France. (Senior member of W3C group).

**Adoreboard (formerly known as Mediasights)**
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Investment Executive, QUBIS Ltd, 63 University Road, Belfast, BT7 1NF. Verification of the relationship between Adoreboard and the School of Psychology QUB.