

RESEARCH DEPARTMENT OF SPEECH, HEARING AND PHONETIC SCIENCES, UCL

<http://www.ucl.ac.uk/psychlangsci/research/speech>

1 The department and its location

Phonetics and Speech Science at University College London (UCL) is based in the Research Department of Speech, Hearing and Phonetic Sciences (SHaPS) (<http://www.ucl.ac.uk/psychlangsci/research/speech>). This group is one of the largest in the field in the UK, and is part of a thriving research community with close links to many other departments and institutes within UCL, including particularly the UCL Ear Institute and the Institute of Cognitive Neuroscience. At the time of writing the department has 8 academic staff and 7 post-doctoral researchers. The department is part of the Division of Psychology and Language Sciences, which brings together researchers in a range of disciplines such as cognition, neuroscience, education, communication, medicine, and health, as well as phonetics and linguistics, within UCL's Faculty of Brain Sciences.

The present grouping was created in 2008 when the former department of Phonetics and Linguistics was relocated alongside the former department of Human Communication in Chandler House, about 1 km east from the main UCL campus. The Victorian building, once the site of the Royal Free Hospital Medical School for Women, was refurbished with an investment of £13M to house state-of-art research and teaching facilities for Language Sciences on all five floors, including the Language and Speech Sciences Library (LaSS), which is both a branch of the main UCL library and also the National Information Centre for Speech-language Therapy (NICeST), holding a unique specialist collection of materials in the field of human communication and its disorders, covering language and languages (written, spoken and signed), linguistics, phonetics, psychology, special education, speech science and voice.

Teaching facilities within Chandler House include two lecture theatres, each with a capacity of 90, three large teaching rooms seating 40 to 60, a 12-workstation computer cluster room, eight smaller meeting or seminar rooms, five rooms of a working speech-language therapy clinic, and a Teaching Laboratory suitable for groups of up to 40 students, with 18 computer workstations.

2 Research facilities and equipment

A dedicated ground floor laboratory is available for work with children, forming the UCL Infant and Child Language (ICL) Research Centre, while the basement houses the main Research Laboratory for phonetics and speech science, upon which approaching half a million pounds was invested during the refurbishment. It provides seven double-walled air-conditioned listening/recording rooms with ambient noise levels below the threshold of hearing. All are large enough to

accommodate 2-3 people, one being rather larger and equipped for audio-visual recording. One room is additionally constructed as an electrically and magnetically shielded Faraday cage to allow the measurement of very low level electrical signals reflecting neural activity. The seven rooms are reached from a lobby which houses ancillary equipment and services, and equipment storage and workshop facilities are nearby, together with a kitchen, and a waiting area for subjects. There are patch panels to each of the rooms for audio, video, computer network and other data; a dedicated server is located in the building.



Figure 1. In the lobby of the Research Laboratory, giving access to the seven sound-treated listening/recording rooms

High-quality microphones are available for audio recording, generally accomplished by direct digital capture to the networked computers. The shielded room houses a 64-electrode EEG (Electroencephalography) and ABR (Auditory Brainstem Response) facility installed in 2012. Several UCL-developed Laryngographs® are available for electro-glottographic recording (commonly made as a second channel along with speech), while the Teaching Laboratory separately has some 15 Laryngograph units. Though the main focus of work has recently been on speech perception rather than production, the laboratory is also equipped for aerodynamic studies, using Rothenberg masks and transducers from Glottal Enterprises, and for accelerometric studies of nasality.



Figure 2. Inside one of the recording rooms. The experimenter is using a Rothenberg mask to gather airflow data. On the bench are a portable Laryngograph, calibration equipment for the airflow unit, and a PC adapted for multi-channel acquisition.

In addition to the Research Laboratory at Chandler House, the department retains the use of an Anechoic Chamber adjacent to the prior location of the department in Gordon Square. This was originally completed in 1948, and has subsequently been refurbished to even higher standards of performance, providing a recording environment with very low ambient noise and reflected sound. The ambient sound pressure is below the threshold of hearing, and reverberation is controlled so that free-field conditions exist above 90Hz. The chamber is equipped with a Bruel and Kjaer 2231 Sound Level Meter and various recording systems. Signals are routed to an adjacent control room. This facility is made available for hire by outside agencies.

3 Students and courses

The Research Department of Speech, Hearing and Phonetic Sciences currently has 16 PhD students, and a dedicated SHaPS PhD work room with individual workstations is provided on the third floor; research students attached to the other Language Sciences research departments have similar facilities elsewhere in the building. The speech research facilities and teaching are also relevant to a range of postgraduate and undergraduate programmes. Courses include an MSc in Language Sciences with specialisation in Speech and Hearing Sciences, MRes in Speech, Language and Cognition, a long-established MA Phonetics, and the clinical MSc in Speech and Language Sciences, offering training in speech and language pathology and therapy. Phonetics is also an important component of the BA Linguistics. Almost all Language Sciences teaching takes place in Chandler House.

4 Research projects

Current SHaPS research foci are exemplified by the appended list of selected publications from 2011 and 2012. They include speech perception by learners of English (Iverson, Hazan) and by users of cochlear implants (Faulkner, Rosen); voice

transformation in therapy for schizophrenia (Huckvale); the adaptability of talkers to noisy and distorting communication channels (Hazan); accent change in English (Evans); models of the production and perception of intonation and tone (Xu). The department is a partner in a Marie Curie training network INSPIRE (2012-2016) that supports PhD and post-doctoral training addressing the perception of speech in non-optimal environments. Other funding comes from the Medical Research Council, the Economic and Social Science Research Council, the UK Home Office, and from three charities, the Wellcome Trust, Action on Hearing Loss and Deafness Research UK.

5 Publications

A complete listing of research publications from present members of the research department, covering more than 30 years, is available at:

<http://www.ucl.ac.uk/psychlangsci/research/speech/Research-Publications>.

A number of book-length treatments have been produced over the years by members of the department. Two of these are widely adopted teaching texts at present: *Signals and Systems* by Rosen and Howell (second edition 2011) and *Introducing Phonetic Science* by Ashby and Maidment (2005).

For much of the twentieth century, the IPA was sustained by an executive and administrative hub at UCL, where its journal *Le Maître phonétique* (later *Journal of the International Phonetic Association*, JIPA) and other publications, such as the chart of the alphabet itself, were produced and distributed. The journal *Language and Speech* was started in the department in 1958; both that journal and JIPA are now refereed journals produced by commercial publishers.

6 Software and resources

The department makes available the Speech Filing System, a free computing environment for PCs for conducting research into the nature of speech. It comprises software tools, file and data formats, subroutine libraries, graphics, special programming languages and tutorial documentation. It performs standard operations such as acquisition, replay, display and labelling, spectrographic and formant analysis and fundamental frequency estimation. It comes with a large body of ready made tools for signal processing, synthesis and recognition, as well as support for custom software development. SFS began as a tool created for a large UK collaborative research project in 1987 (Alvey). SFS was initiated by Mark Huckvale at UCL and has been maintained and developed by him continuously since that time. The department has for many years made available information on the use of phonetic symbols in computers, including the development of the SAMPA alphabet and the distribution of special fonts. With the almost universal use of Unicode, the department provides a freely-downloadable Unicode keyboard for Windows. SFS and many other resources can be obtained from <http://www.ucl.ac.uk/psychlangsci/research/speech/resources>, while recorded material

from the department, such as a CD of “Sounds of the IPA”, is sold via an online shop (<http://www.phon.ucl.ac.uk/shop/>).

The department also hosts and maintains the webpages of the International Phonetic Association (<http://www.langsci.ucl.ac.uk/ipa/>) and the proceedings of PTLIC (Phonetics Teaching and Learning Conference: <http://www.phon.ucl.ac.uk/ptlc/>) a biennial international conference which takes place at UCL.

7 Origin of the modern laboratory

From 1972 until its move to Chandler House in 2008, the Phonetics/Speech Science Laboratory was primarily in Wolfson House, a newly-built annex a little to the north of the main UCL campus. This was a period of intense development of the department’s experimental facilities; the two-room laboratory and anechoic room in the department’s original home at 21 Gordon Square were now extended by a purpose-designed air-conditioned ensemble comprising four doubly-isolated recording rooms, ten listening booths, a large laboratory equipped with in-house designed speech science teaching equipment, three computer/experimental rooms, a workshop, small library, seven staff office rooms, a small kitchen, a Common Room with kitchen area and two rooms for secretaries, all on the ground floor. The basement housed a large lecture theatre and a dedicated store-room. Funding came from the Wolfson Foundation, the Department of Health, and from UCL investment in the Phonetics and Linguistics Department’s initiative in the introduction of a new clinical BSc Speech Sciences degree, BSc Speech Communication, and the MSc in Speech and Hearing Sciences and also from a series of successful external grant applications.

The laboratory was also very active in research and was, for example: a pioneer with Cambridge University and Guy’s Hospital in electro-cochlear stimulation research with MRC programme grant support. A major contributor to the UK Alvey Spoken Language Engineering initiative in the mid 1980s; and the Coordinator of the EU flagship Speech Assessment Methods (SAM) project involving 26 Phonetics and Speech Science laboratories in eight European countries. This put the department to the fore in Europe and fostered considerable international collaboration and exchange. Research for some twenty successful PhD theses was completed, leading to the definition of a number of current research themes. The holders of some current senior research and teaching posts joined over this time: Stuart Rosen, Professor of Speech and Hearing Science, joined the department in 1977, initially to work on the cochlear implant project, Valerie Hazan, Professor in Speech Sciences and formerly Head of Department, came in 1980, and worked in the SAM consortium; Andrew Faulkner, currently Head of Department, joined in 1989, worked on and then led a series of UK and EU projects on hearing aids to support lipreading, while Mark Huckvale pioneered the Speech Pattern Audiometry research and initiated the MSc in Hearing and Speech Sciences.

From 1961 to 1972 the department’s laboratory facilities were in Gordon Square and this period saw: the first modernisation of the anechoic room, and the

construction, above it, of a speech science laboratory pneumatically isolated to curb the transmission of vibration; the introduction of the first flexible speech formant synthesis control system, copied by KTH (Kungliga Tekniska Högskolan) in Sweden and Bell Laboratories in the USA and used by government and university laboratories elsewhere in the UK (see Figure 6); and, for example, the first irrefutable experimental demonstration of the existence of central neuro-temporal pitch processing (Fourcin 1970); the invention and phonetic application of the Laryngograph (now in worldwide application) for language research, deaf voice training, voice therapy/pathology and the associated introduction of quantitative voice analysis based on connected speech (Fourcin and Abberton, 1971).

From 1961 until 1992, Adrian Fourcin, Professor of Experimental Phonetics, was the Head of the Phonetics/Speech Sciences Laboratory. An interview in which he describes aspects of his training and early career can be read here: http://americanhistory.si.edu/archives/speechsynthesis/ss_four.htm.



Figure 3. For more than 40 years, acoustics teaching has included hands-on lab practicals for every participant, with specially-developed apparatus. Here Speech Sciences students are introduced to the essential nature of formants by measuring the characteristics of an acoustic resonator. After confirming that the same laws govern mechanical, acoustic and electrical resonators, students are led to understand the use of electrical resonators in signal analysis.



Figure 4. Interactive speech perception testing in the mid-1990s at Wolfson House (Valerie Hazan and subject), using formant synthesis and a touch sensitive response box—before the advent of touch sensitive computer screens. Two spectrographs can be glimpsed in the background, on the left Houde’s real-time and on the right the drum of a Kay mechanical scanner.

8 History: the first fifty years

The history of phonetics at UCL extends back more than a century. Daniel Jones (1881-1964), who was to become Britain’s first professor of phonetics, began

lecturing at UCL in 1907. His career, and the development of the department he created, are documented in Collins and Mees (1998). Experimental work began from around 1912 with the appointment of Stephen Jones (1872-1942) who became the first superintendent of the laboratory (the two Joneses were unrelated). The laboratory techniques of his day included static X-ray photography (Jones, S., 1929), indirect palatography, the use of sensitive flames as sound detectors, and the measurement of voicing and duration by means of the kymograph. Stephen Jones supervised the construction of a kymograph with an unusually large electrically-driven drum, facilitating accurate measurements of speech sound duration and fundamental frequency, and the design was put into production by the firm of C. F. Palmer, and purchased for installation in other laboratories around the world (Figure 5). Film from 1928, showing Stephen Jones operating a kymograph of this type, has recently been discovered and restored (Ashby, 2011), and can be seen at: <http://youtu.be/cXp7jfgRNVA>.

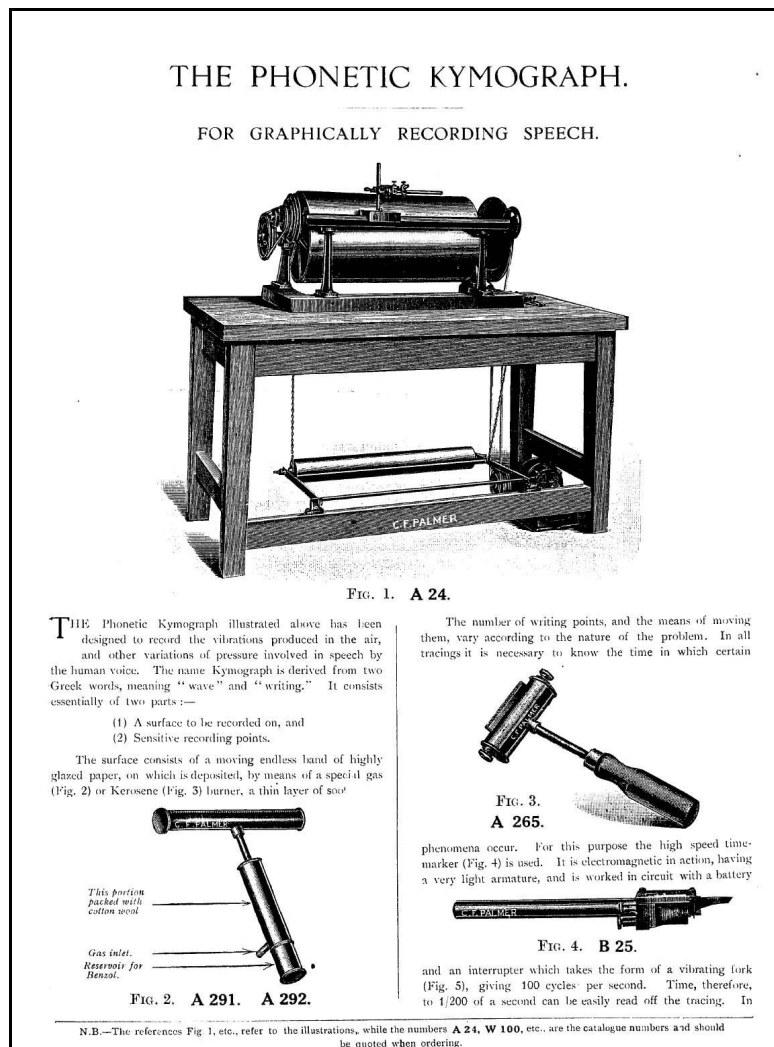


Figure 5. A page from the 1932 catalogue of C.F. Palmer, Ltd., showing the large horizontal kymograph developed by Stephen Jones, and some of its accessories.

UCL hosted the second International Congress of Phonetic Sciences in 1935 (Jones and Fry 1936), and though the department had by this stage become pre-eminent in the world, the basement laboratory remained relatively modest, serving a subordinate role to linguistic phonetic investigations.

Stephen Jones was succeeded as superintendent of the laboratory in 1937 by D. B. Fry (1907-1983) who additionally became Head of Department in 1949 when Daniel Jones retired, and Professor of Experimental Phonetics in 1958. He is best known for his widely cited experimental work on the perception of stress in English words, which showed that duration and pitch are much more powerful cues to stress than loudness. Fry recruited an engineer, Peter B. Denes (1920-1996), who worked in the department over the period 1946-1961, to assist in the energetic postwar expansion of experimental facilities and in the teaching of experimental phonetics. Fry and Denes worked together on the design and construction of a speech recognizer realized in analogue hardware, which had an unlimited vocabulary and incorporated “linguistic knowledge” in the form of phoneme transition probabilities. It can be seen in operation in a film which was shown at the fourth ICPhS in Helsinki in 1961, now available at: http://youtu.be/9IKf3Dm_pJA

Both Fry and Denes were effective teachers, and both produced successful foundation-level textbooks drawing on their experience. Denes was the co-author (with Pinson) of the popular book *The Speech Chain* published in 1963, shortly after he left UCL for Bell Laboratories, while after his retirement in 1975, Fry found time to write *The Physics of Speech* (1979).

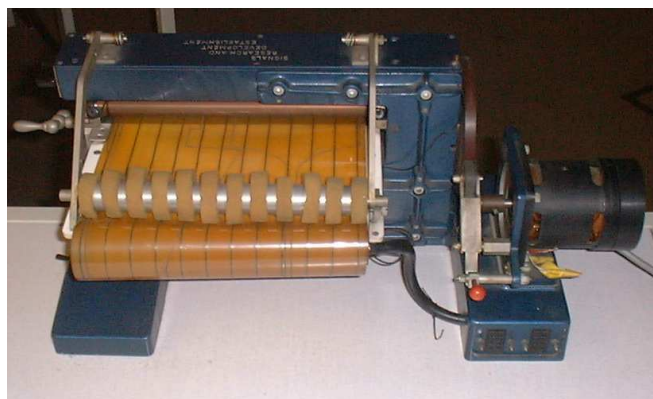


Figure 6. Hardware from the 1960s. In the interregnum between mechanical devices and computers, hybrid electronic equipment was used for experiments. The multi-function potentiometric speech synthesiser controller—familarly known as the “mangle”—employed conducting ink tracks drawn on a flexible printed circuit belt (Fourcin 1960). It was devised by A. J. Fourcin and developed collaboratively at UCL and the Signals Research and Development Establishment (SRDE). This example, one of nine made, is now in the Smithsonian Museum in Washington DC; another is in the Science Museum in London.

9 Links with linguistic phonetics and practical training

Through most of its history the laboratory was a harmonious part of a department, which also placed great emphasis on linguistic phonetic description and on practical training in sound recognition and production. Many of the department's most celebrated members, such as Daniel Jones himself, Harold Palmer, J. R. Firth, A. C. Gimson, J. D. O'Connor and J. C. Wells, were not primarily experimentalists, though all were ready to accord a place for measurement alongside the findings of the trained ear. It was also taken for granted that those working in the laboratory should have a good practical training and be thoroughly familiar with phonetic symbols and classification. Practical phonetic training remains a vital component of such programmes as the (clinical) MSc in Language Sciences, and the MA Phonetics. A number of pedagogical initiatives have sought to bring the phonetics laboratory into the practical phonetics classroom, reinforcing the training of skill with immediate acoustic analysis of teachers' and students' productions (Ashby 2008).

References

- Ashby, M. 2008. New Directions in Learning, Teaching and Assessment for Phonetics. *Estudios De Fonética Experimental* XVII, 19–44.
- Ashby, M. 2011. Film from a Phonetics Laboratory of the 1920s. In *Proceedings of the 17th International Congress of Phonetic Sciences*, 168–171. Hong Kong.
- Ashby, M., and Maidment, J. 2005. *Introducing Phonetic Science*. Cambridge Introductions to Language and Linguistics. Cambridge: Cambridge University Press.
- Collins, B. and Mees, I. 1998. *The Real Professor Higgins: The Life and Career of Daniel Jones*. Berlin: Mouton de Gruyter.
- Denes, P. and Pinson, E. 1993. *The Speech Chain: The Physics and Biology of Spoken Language*. New York, N.Y: W.H. Freeman.
- Jones, D. and Fry, D. 1936. *Proceedings of the Second International Congress of Phonetic Sciences: Held at University College, London, 22-26 July 1935*. Cambridge: Cambridge University Press.
- Jones, S. 1929. Radiography and Pronunciation. *British Journal of Radiology* 2, 149–150.
- Fourcin, A. 1960. A potential dividing function generator for the control of speech synthesis. *Journal of the Acoustical Society of America* 32 (11), 1501.
- Fourcin, A. 1970 Central Pitch and Auditory Lateralization. In Plomp, R., and Smoorenburg, G.F. (eds.) *Frequency Analysis and Periodicity Detection in Hearing*. Leiden: A.W. Sijthoff. Available at: <http://discovery.ucl.ac.uk/1330855/1/Fourcin%20Central%20pitch%20final.pdf>
- Fourcin, A. and Abberton, E. 1971. First applications of a new laryngograph. *Medical and Biological Illustration* 21, 172-182. Reprinted (1972) *Volta Review* 69, 507-518.
- Fry, D. 1979. *The Physics of Speech*. Cambridge Textbooks in Linguistics. Cambridge: Cambridge University Press.
- Rosen, S. and Howell, P. 2011. *Signals and Systems for Speech and Hearing*. 2nd ed. Bingley: Emerald.

Selected publications 2011/12

- Granlund, S., Hazan, V. and Baker, R. 2012. An acoustic-phonetic comparison of the clear speaking styles of late Finnish-English bilinguals. *Journal of Phonetics* 40, 509-520.
- Green, T., Faulkner, A. and Rosen, S. 2012. Variations in carrier pulse rate and the perception of amplitude modulation in cochlear implant users. *Ear and Hearing* 33, 221-230.

- Hazan, V. and Baker, R. 2011. Acoustic-phonetic characteristics of speech produced with communicative intent to counter adverse listening conditions. *Journal of the Acoustical Society of America* 130, 2139-2152.
- Hilkhuysen, G., Gaubitch, N., Brookes, M. and Huckvale, M. 2012. Effects of noise suppression on intelligibility: dependency on signal-to-noise ratios. *Journal of the Acoustical Society of America* 131, 531-539.
- Iverson, P., Wagner, A., Pinet, M. and Rosen, S. 2011. Cross-language specialization in phonetic processing: English and Hindi perception of /w/-/v/ speech and nonspeech. *Journal of the Acoustical Society of America* 130, EL297-EL303.
- Lehtonen, M., Hultén, A., Cunillera, T., Rodriguez-Fornells, A., Tuomainen, J. and Laine, M. 2012. Differences in word recognition between early bilinguals and monolinguals: behavioral and ERP evidence. *Neuropsychologia* 50, 1362-1371.
- Liu, F., Xu, Y., Patel, A. D., Francart, T. and Jiang, C. 2012. Differential recognition of pitch patterns in discrete and gliding stimuli in congenital amusia: Evidence from Mandarin speakers. *Brain and Cognition* 79, 209-215.
- McGettigan, C., Evans, S., Rosen, S., Agnew, Z., Shah, P. and Scott, S. 2012. An application of univariate and multivariate approaches in fMRI to quantifying the hemispheric lateralization of acoustic and linguistic processes. *Journal of Cognitive Neuroscience* 24, 636-652.
- McGettigan, C., Faulkner, A., Altarelli, I., Obleser, J., Baverstock, H. and Scott, S. 2012. Speech comprehension aided by multiple modalities: Behavioural and neural interactions. *Neuropsychologia* 50, 762-776.
- Messaoud-Galusi, S., Hazan, V. and Rosen, S. 2011. Investigating speech perception in children with dyslexia: is there evidence of a consistent deficit in individuals? *Journal of Speech, Hearing and Language Research* 54, 1682-1701.
- Pereira, V. J., Tuomainen, J. and Sell, D. 2011. The impact of maxillary osteotomy on speech outcomes in cleft lip and palate: an evidence-based approach to evaluating the literature. *The Cleft Palate-Craniofacial Journal*, in press, <http://dx.doi.org/10.1597/11-116>.
- Pinet, M., Iverson, P. and Huckvale, M. 2011. Second-language experience and speech-in-noise recognition: Effects of talker-listener accent similarity. *Journal of the Acoustical Society of America* 130, 1653-1662.
- Prom-on, S., Liu, F. and Xu, Y. 2012. Post-low bouncing in Mandarin Chinese: Acoustic analysis and computational modeling. *Journal of the Acoustical Society of America* 132, 421-432.
- Rosen, S., Wise, R., Chadha, S., Conway, E. and Scott, S. 2011. Hemispheric asymmetries in speech perception: Sense, nonsense and modulations. *PLoS One* 6, e24672.
- van Dommelen, W. and Hazan, V. 2012. Impact of talker variability on word recognition in non-native listeners. *Journal of the Acoustical Society of America* 132, 1690-1699.
- Wang, B. and Xu, Y. 2011. Differential prosodic encoding of topic and focus in sentence-initial position in Mandarin Chinese. *Journal of Phonetics* 39, 595-611.
- Xu, Y., Chen, S-W., and Wang, B. 2012. Prosodic focus with and without post-focus compression PFC: A typological divide within the same language family? *The Linguistic Review* 29, 131-147.

Michael Ashby, Andrew Faulkner, Adrian Fourcin
 Speech, Hearing and Phonetic Sciences, UCL
 London, UK
 e-mail: {m.ashby|a.faulkner|a.fourcin}@ucl.ac.uk