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Evolvable Virtual Information Processing Architectures for Human-like Minds

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Five key words
Five key words, as requested, though they do not do justice to the breadth of the project!

Virtual machines
Evolvable Architectures
Conceptual Analysis
Mental concepts
Software tools

(a) The grant: a brief 'history'
Dates: The project started on 1st October 1999, and ended on 30th June 2003, though work is continuing, as this a phase in a very long term project.

Budget allocated: £ 104,340, for 36 months. All non-salary costs paid by Department.

Site: School of Computer Science, The University of Birmingham.

Researchers
Dr. Brian Logan (BL), original co-proposer, started Oct 1999 for one month, is now a lecturer at the University of Nottingham.
Dr. Matthias Scheutz (MS) arrived in June 2000, and returned to the University of Notre Dame at the end of July 2001.
Dr. Ron Chrisley (RC), on leave from the University of Sussex, from 1st October 2001 to 30th June 2003.
Prof. Aaron Sloman (AS), the principal investigator.
Collaboration with BL, MS and RC has continued since they left.

PhD students supervised by AS, though not funded by this project, gained enormous benefit from this project and contributed to it, including **Catriona Kennedy** (completed 2003) who worked on the use of mutual-meta-management in robust software security systems, now funded by DSTL, **Nick Hawes** (completed 2003, now at Media Lab Dublin) who worked on agents with 'anytime' planning capabilities in computer games; **Dean Petters** working on modelling development of attachment in infants, **Manuela Viezzer** working on development of ontologies (now working for DECIS Lab, Delft), and **Dave Gurnell** working on collaborative planning. Since leaving Birmingham, BL and MS have also been doing related work with PhD students at Nottingham and Notre Dame Universities, respectively.

(b) Objectives.

The project was an extension of the ongoing *Cognition and Affect* project led by A.Sloman at Birmingham.[1] It had diverse goals, including philosophy, cognitive science, and software development.

The main *philosophical* goal was to help to define and defend the thesis of "virtual machine functionalism" and demonstrate both its explanatory power (e.g. in architecture-based conceptual analysis) and its resistance to objections to standard functionalist theories. The main *scientific* goal was development of an architecture, of a type that could have been produced by evolution, which integrates many types of phenomena, including perception, learning, decision-making, problem-solving, personality development, pleasure, pain, emotions, planning, plan execution, reactive behaviour, motor control, reflex actions, etc. — topics that are usually studied separately by researchers in AI, psychology, neuroscience and other disciplines. We aimed to present the architecture in the context of a space of possible architectures (design space) related to a space of possible sets of requirements (niche space). An *engineering* goal was to develop tools to help with exploration of designs for architectures, and some demonstrations.

The overall vision was the need to re-unite various disciplines and sub-disciplines concerned with attempting to understand and model human minds. The vast majority of this research is currently fragmented and narrowly focused. We have tried to develop a framework, based on the notion of a virtual machine architecture, for uniting researchers who normally do not work together.

(c) Research activity

Sources and/or methods used, type of work involved

The bulk of the work was conceptual analysis, and theoretical design, starting from many sources, including previous developments in AI, robotics, cognitive science, recent work in psychology, evolutionary theory, and other relevant disciplines. In particular, AS has spent a considerable amount of time with developmental and cognitive psychologists.

The conceptual analysis and theoretical design work contributed to a book edited by MS (started before he joined the project), a tutorial plus booklet at a major conference, a collection of papers some already published, some accepted for publication, and some still incomplete.

Some of the work involved developing simple demonstration programs to help explain to others what we meant by the differences between different sorts of components in the architecture (e.g. reactive, deliberative meta-management components). More sophisticated programs were developed mainly by PhD students, and by MS, whose work led to production of his Simworld package[2] for research (and teaching) in connection with a certain type of evolutionary exploration. This work uses an unusual kind of evolutionary experiment in which particular types of pre-determined evolutionary steps (e.g. a certain kind of change in architecture) are explored and compared by seeing their consequences in simulations.

[1] Summarised in a longer draft report **http://www.cs.bham.ac.uk/research/cogaff/sloman-cogaff-03.pdf**

[2] Available at: **http://www.nd.edu/~airolab/simworld/**

All of this work helped to define new requirements for our SimAgent toolkit, and a number of enhancements were implemented by AS. This work has, as a side-effect, led to development of potentially useful teaching materials.

BS continued, after leaving, to work on developing requirements for tools in a collaborative EPSRC-funded project and in particular has been working on a distributed version of our toolkit, as well as helping to clarify architectural issues.

A considerable amount of work was done by responding to invitations to give talks. An expanding collection of presentations, mostly arising out of this project, can be found here: *http://www.cs.bham.ac.uk/research/cogaff/talks/*

Problems encountered

A practical problem arose because BL was offered a permanent post in Nottingham when the project was about to start. It took some time to find a suitable replacement (MS), and he was neither able to start immediately nor able to stay longer than 14 months. A further gap esured before the third person (RC) was in place.[3] RC was incapacitated for a time after an unprovoked attack by a thug caused serious injury. All the research fellows were mature researchers with ongoing research commitments, though fortunately they were all relevant to this project. Most of the problems were due to the sheer difficulty of the project, including the problem of clarifying the most general concepts to be used in specifying types of architectures and mechanisms. For instance our notion of how to define "belief-like" and "desire-like" states changed over time – the latest version being in a paper by AS, RC and MS to be published in a book on emotions in animals and robots.[4]

Changes in project once underway.

As a result of personnel changes, some changes came from changes in the central interests and abilities of the researchers employed on the project. All three were experienced, highly intelligent, independent researchers whose interests were closely related to the project, but from slightly different viewpoints. In particular, BL and MS were interested in building working models, whereas RC was more interested in pursuing the philosophical issues, though he is perfectly capable of developing software and we have some plans for work that could be done later.

(d) Conclusions and achievements

Shortcomings:

Less software development than hoped for. Less detailed architectural design and evolutionary analysis of architectural layers than hoped for. Many hard unsolved problems remain. Not enough detailed connections to empirical psychology developed (but continuing to grow). Several attempts to get further funding from EPSRC and Leverhulme to extend this work failed. (Though ESF funded a workshop in Sept 2003).

Objectives met:

Many concepts clarified, including ideas relating to notions of "information" (in the semantic sense) and "information user", critique of "symbol grounding theory", new concepts for describing architectures, clarification of "cluster concepts", elaboration of notions of "virtual machine", virtual machine functionalism, explanations of qualia and their "ineffability", and clarification of notions of affect and emotion. Further progress

[3] We are very grateful for the flexibility of the Leverhulme Trust in allowing these changes and extensions.

[4] Available here **http://www.cs.bham.ac.uk/research/cogaff/sloman-chrisley-scheutz-emotions.pdf**

on analysing supervenience, ontological levels[5] and causality. Diagnosis of "ontological blindness" as an obstacle to research in science and engineering.

We have clarified high level architectural design dimensions and some finer-grained architectural divisions. Work on perception and affordances with applications to modelling human vision and diagrammatic reasoning is still in progress.

We have devloped a new way of setting targets and evaluating progress in terms of combined scenarios and meta-scenarios. (Used in a large EC Cognitive Systems grant proposal.)

Fruitful collaboration with Marvin Minsky which may lead to sigificant funding for further work at MIT. (A joint paper with Minsky and Singh, reporting on a workshop held in 2002, will appear in the *AI Magazine*.)

Growing recognition

We have produced a new integrating vision for the scientific and philosophical study of mind, and this is now attracting increasing attention. E.g. in the last year AS was been involved in two DRAPA workshops and a DARPA consultation for research in this area, as well as consulting on EC Framework 6 plans for Cognitive Systms. We were asked to join a multi-site 8Meuro proposal, which is one of the few to have passed the first hurdle and reached the review stage. A UK "grand challenge" proposal is gaining momentum. See *http://www.cs.bham.ac.uk/research/cogaff/gc* We (RC and AS) co-organised with Ricardo Sanz (Madrid) an ESF-funded workshop on "Models of consciousness" and further collaborative work is under discussion.

BT Exact selected our work for inclusion in their 2003 Schools lecture (*http://www.btexact.com/aboutus/community/education*) including video interview with AS and software demonstration. The architectural framework we have been developing can be expanded and refined so as to fit more closely the available evidence from neuroscience, psychology and evolution, while raising new questions for empirical investigation. We expect that increasingly detailed and realistic implementations of the architecture can be demonstrated in a working form (subject to successful funding applications).

AS has been invited to give talks related to this work at a number of seminars, workshops or conferences in 2004, in the UK and overseas.

(e) Publications and dissemination: list actual and prospective publications and other means of disseminating results.

A list is appended to this report. Copies of all published papers and some incomplete drafts are enclosed. Additional materials can be found on our web site:

http://www.cs.bham.ac.uk/research/cogaff/	(Main paper repository)
http://www.cs.bham.ac.uk/research/cogaff/talks/	(Presentations)
http://www.cs.bham.ac.uk/ axs/cogaff/simagent.html	(Software tools)

Only a sample of the presentations have been included. All the software is freely available in open source format and help is available if necessary for installing it. E.g. if a Sun workstation or a PC running linux is available the software can be installed for

[5]Independent (unwitting) support for our arguments against *identity* of virtual and physical machines has turned up in a paper in *Mind* April 2003 by a well-known philosopher, Kit Fine

demonstrations or for use in research and teaching.

(f) Future research plans in this field.

Several attempts have been made to obtain funding in the UK to extend this work, so far without success, though one proposal was short-listed by the Leverhulme Trust.

We have been involved in in-depth discussions with leading researchers in the UK, Europe and the USA about how to pursue our very ambitious long term research ideas. AS was invited to several workshops in the USA, including one at IBM New York, a workshop organised by Marvin Minsky at St. Thomas Virgin Islands, two DARPA workshops, in Virginia and in California. Minsky has applied for funding from an American Financier and has pilot funds to develop the proposal.

AS was invited (in June 2003) to help the EC finalise their call for Cognitive Systems proposals and was later invited to join a multi-site consortium bidding for an integrated project. This has now reached the 'review' stage. If funded this will take our work forward in the context of a robotics project.

AS has been involved in discussions of the UK Computing Grand Challenges initiative of the UK Computing Research Committee, described here:

http://www.nesc.ac.uk/esi/events/Grand_Challenges/

He is also 'moderator' of one of the grand challenges *Architecture of Brain and Mind* described here:

http://www.cs.bham.ac.uk/research/cogaff/gc/.

Future research directions are described at that web site and one that grew out of the discussions with Minsky: *http://www.cs.bham.ac.uk/research/cogaff/manip/*

One of the key ideas, which appears to be novel is that the research should be based around a large number of scenarios each of which has associated meta-scenarios. In each scenario a working system, such as a robot, performs some task, whereas in the meta-scenarios it discusses the task, explains what it does how it does it, why it does not do it in another way, and perhaps advises someone else on how to do it. This requires a deep understanding of *affordances* as well as self-understanding. Most current AI systems are incapable of doing any of this because they lack the required kind of architecture.

If we get no new funding, progress will continue as before, though more slowly, leading to research papers, presentations, and software developed mainly by students.

PAPERS AND PRESENTATIONS

The papers listed below all involve one or more participants in the project and all are relevant to the project. Some involved work begun before the project started, and some were finished after one or more of the authors had left the project: as part of our on-going collaboration arising out of the project.

Some of the papers were sent with previous reports. The bundle attached to this report contains more recent publications.

Others can be provided on request, or fetched from our web sites.

Ron Chrisley:
http://www.cogs.susx.ac.uk/users/ronc/Ron%20Chrisley%20–%20Research.htm

Brian Logan:
http://www.cs.nott.ac.uk/cgi-bin/bsl/papers.cgi

Matthias Scheutz:
http://www.nd.edu/~mscheutz/publications/

Aaron Sloman and Project home:
http://www.cs.bham.ac.uk/research/cogaff/
http://www.cs.bham.ac.uk/research/cogaff/talks/
http://www.cs.bham.ac.uk/ axs/cogaff/simagent.html

Papers are grouped by year, and within a year by main author.

The presentations are listed in chronological order, after the papers.

Papers 2000

Led by Logan

Brian Logan, A design study for an Attention Filter Penetration architecture' in *Proceedings Symposium on How to Design a Functioning Mind AISB'00*, Birmingham, April 2000, pp 94-101.

Brian Logan and Georgios Theodoropoulos, Dynamic Interest Management in the Distributed Simulation of Agent-Based Systems, in *Proceedings of the Tenth Conference on AI, Simulation and Planning, AIS-2000*, pp. 45–50, Eds. J.S. Sarjoughian, F.E. Cellier, M.M. Marefat and J.W. Rozenblit, March, 2000, Society for Computer Simulation International,

Georgios Theodoropoulos and Brian Logan, A Unifi ed Framework for Interest Management and Dynamic Load Balancing in Distributed Simulation, in *Proceedings of the Twelfth European Simulation Symposium (ESS-2000)*, pp. 111–115, Ed. D. P. F. Moller, September, 2000,

Led by Scheutz

Matthias Scheutz, (2000) AI as a method? Commentary on Green on on AI-Cognitive-Science. *PSYCOLOQUY* 11(097)

Matthias Scheutz, Behavioral states: linking functional and physical descriptions, in *Proceedings Symposium on How to Design a Functioning Mind AISB'00*, Birmingham, April 2000, pp 117–123.

Matthias Scheutz, Aaron Sloman and Brian Logan 'Emotional states and realistic agent behaviour' in *Proceedings Game-on 2000* Eds. Philippe Geril et. al., Society for Computer Simulation, International", pp 81–88. Society for Computer Simulation International, 2000

Led by Sloman

Aaron Sloman, Models of Models of Mind, in *Proceedings Symposium on How to Design a Functioning Mind AISB'00*, Birmingham, April 2000, pp 1–9.

Aaron Sloman, Interacting trajectories in design space and niche space: A philosopher speculates about evolution, in *Parallel Problem Solving from Nature – PPSN VI*, Eds. Marc Schoenauer, et. al., Springer-Verlag, Berlin, Lecture Notes in Computer Science, No 1917, 2000, pp. 3–16,

Aaron Sloman and Brian Logan, Evolvable architectures for human-like minds, in *Affective Minds*, Eds. G. Hatano and N. Okada and H. Tanabe, pp. 169–181, Elsevier, Amsterdam, 2000,

Papers 2001

Led by Scheutz

M. Scheutz, (2001), What I am: "The Self as a Dynamic Data Structure Implemented within a Cognitive Framework by a Functional System". Review of: Gregory R. Mulhauser (1998). *Mind out of Matter: Topics in the Physical Foundations of Consciousness and Cognition.* in PSYCHE, 7(19), October 2001 http://psyche.cs.monash.edu.au/v7/psyche-7-19-scheutz.html

M. Scheutz, (2001), The Evolution of Simple Affective States in Multi-Agent Environments, in *Proceedings AAAI Fall Symposium* AAAI Press, 123–128. http://www.nd.edu/

M. Scheutz & B.S. Logan, (2001), Affective vs. deliberative agent control, in *Proceedings Symposium on Emotion, cognition and affective computing*, Ed. C. Johnson et al., AISB'01 Convention, York, http://www.nd.edu/

M. Scheutz & A. Sloman, (2001), Affect and Agent Control: Experiments with Simple Affective States, in *Intelligent Agent Technology: Research and Development*, Eds. Ning Zhong et al, World Scientifi c Publisher, New Jersey, pp. 200–209 http://www.nd.edu/

Scheutz, Matthias and Römmer, Brigitte (2001) "Autonomous Avatars? From Users to Agents and back". In *Proceedings of IVA-01*, Springer Verlag, 61-71. http://www.nd.edu/

Led by Sloman

A. Sloman, Diagrams in the mind, in Eds. Michael Anderson, Bernd Meyer and Patrick Olivier, *Diagrammatic Representation and Reasoning*, Springer-Verlag, Berlin, 2001,

A. Sloman, (2001), Varieties of Affect and the CogAff Architecture Schema, in *Proceedings Symposium on Emotion, Cognition, and Affective Computing*, Ed. C.G. Johnson, AISB'01 Convention, York, pp. 39–48,

A.Sloman, (2001) Beyond Shallow Models of Emotion, in *Cognitive Processing: International Quarterly of Cognitive Science*, 2, 1, pp. 177-198,

A. Sloman, (2001), Evolvable biologically plausible visual architectures, in *Proceedings of British Machine Vision Conference*, Ed. T. Cootes and C. Taylor, BMVA, Manchester, pp. 313–322,

A. Sloman, & M. Scheutz, (2001) Tutorial on philosophical foundations: Some key questions, *Proceedings IJCAI-01*, pp. 1–133, AAAI, Menlo Park, California,

Papers 2002

Led by Chrisley

Chrisley, R. and Sloman, A. (2002) "How Velmans' conscious experiences affected our brains"; invited commentary on Max Velmans' paper "How could conscious experiences affect brains?", in *Journal of Consciousness Studies*, Vol 9 No 11, pp 58-63.

Chrisley, R. (2002) “Some foundational issues concerning anticipatory systems”. *International Journal of Computing Anticipatory Systems*, Volume 11 pp 3-18.

Chrisley, R. (2002, in press) “Artifi cial intelligence”. In Gregory, R. (ed.) *The Oxford Companion to the Mind* (second edition)

Chrisley, R. & Ziemke, T. (2002) ”Embodiment”. In *The Macmillan Encyclopaedia of Cognitive Science*. London: Macmillan.

Led by Logan

Logan, B.. Lees, M., Theodoropoulos G., (2002) Simulating Agent-Based Systems with HLA: The case of SIM_AGENT *Proceedings of the 2002 European Simulation Interoperability Workshop (ESIW'02)*, Simulation Interoperability Standards Organisation and Society for Computer Simulation, June 2002, pages 285–293.

Led by Scheutz

Andronache, Virgil and Scheutz, Matthias (2002) “Contention Scheduling: A Viable Action-Selection Mechanism for Robotics?”. In *Proceedings of the Thirteenth Midwest AI and Cognitive Science Conference*, AAAI Press.

Scheutz, Matthias (2002) “Affective Action Selection and Behavior Arbitration for Autonomous Robots”. In *Proceedings of IC-AI 02,* CSREA Press.

Scheutz, Matthias (2002) ”Agents With or Without Emotions?”. In *Proceedings of FLAIRS 02*, AAAI Press, 89-94.

Scheutz, Matthias (2002), **[Book]** *Computationalism, New Directions* MIT Press. http://www.nd.edu/˜mscheutz/publications/scheutz02mitbook.html (Contains papers by AS, MS and several others.)

Scheutz, Matthias (2002) Computationalism-The Next Generation. In M. Scheutz (Ed.), *Computationalism: New Directions*. MIT Press: Cambridge, 1-17.

Scheutz, Matthias (2002) “The Evolution of Affective States and Social Control”. In *Proceedings of International Workshop on Self-Organisation and Evolution of Social Behaviour*, Monte Verita, Switzerland (forthcoming).

Scheutz, Matthias and Schermerhorn, Paul (2002) “Steps Towards a Systematic Investigation of Possible Evolutionary Trajectories from Reactive to Deliberative Control Systems”. In *Proceedings of Alife 8*, MIT Press (forthcoming).

Led by or involving Sloman

McCarthy, J, and M. Minsky, A. Sloman, L. Gong, T. Lau, L. Morgenstern, E.T. Mueller, D. Riecken, M. Singh, P. Singh, (2002), An architecture of diversity for commonsense reasoning, *IBM Systems Journal*, 41, 3, pp. 530–539,

A. Sloman, How many separately evolved emotional beasties live within us?, in *Emotions in Humans and Artifacts*, Ed. Robert Trappl and Paolo Petta, MIT Press, Cambridge MA, 2002.

A. Sloman, Architecture-based conceptions of mind, in *In the Scope of Logic, Methodology, and Philosophy of Science* (Vol II), (Synthese Library Vol. 316), Kluwer, Dordrecht, pp 403–427, 2002.

Sloman, A. (2002), The irrelevance of Turing machines to AI, in Ed. M. Scheutz, *Computationalism: New Directions*, MIT Press, Cambridge, MA, pp. 87–127,

Sloman, A and Chrisley, R (2002) “More things than are dreamt of in your biology: Information processing in biologically-inspired robots” in *Proceedings EPSRC/BBSRC International*

Workshop on Biologically-Inspired Robotics: The Legacy of W.Grey Walter August 2002, Bristol, pp 264–271 (Revised version in preparation.)

Sloman, A. and Scheutz, M. (2002) “A Framework for Comparing Agent Architectures”. In *Proceedings of UKCI’02*, pp 169–176

Papers 2003

Led by Logan

Michael Lees, Brian Logan, Ton Oguara, and Georgios Theodoropoulos (2003). ”Simulating Agent-Based Systems with HLA: The case of SIM_AGENT – Part II.” Proceedings of the 2003 European Simulation Interoperability Workshop.

Elizabeth Gordon and Brian Logan (2003). ”A Goal Processing Architecture for Game Agents.” Proceedings of the Second International Joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS 2003) (pp. 998-999).

Led by or involving Sloman

Sloman, A. & Chrisley, R. (2003) “Virtual machines and consciousness”. Invited submission to the *Journal of Consciousness Studies*, special issue on machine consciousness. http://www.cs.bham.ac.uk/research/cogaff/sloman-chrisley-jcs.pdf

Catriona M. Kennedy & Aaron Sloman, Autonomous Recovery from Hostile Code Insertion using Distributed Reflection In *Journal of Cognitive Systems Research*, 4, 2, pp. 89–117, 2003

Papers in preparation

RC: invited paper on non-conceptual content for the journal *Àgora*’s special issue commemorating the 20th anniversary of the publication of Gareth Evans’ *The Varieties of Reference* (Eds. Juan Jos Acero and Manuel de Pinedo Garcia).

RC: a review of *Principles of Cognition, Language and Action*, by Nini Praetorius.

AS,RC,MS: Invited contribution:
The Architectural Basis of Affective States and Processes. To be included in a book on emotions in animals and machines: *Who needs emotions?*, edited by Jean-Marc Fellous and Michael Arbib, Oxford University Press. Draft online here:
http://www.cs.bham.ac.uk/research/cogaff/sloman-chrisley-scheutz-emotions.pdf,

AS: Invited paper on diagrammatic reasoning for a new journal to be published by Kluwer. Draft online at http://www.cs.bham.ac.uk/research/cogaff/sloman-diag03.pdf

AS: Historical overview of the Cognition and Affect project. Draft online at:
http://www.cs.bham.ac.uk/research/cogaff/sloman-cogaff-03.pdf

AS and MS: A paper on cluster concepts and architecture-based analysis. Incomplete draft available on request

AS and RC: Revised version of paper on ontological blindness (‘More things than are dreamt of....’) Version online here: http://www.cs.bham.ac.uk/research/cogaff/sloman-chrisley-rs.pdf

AS: planning a book based on all this.

Online documentation

There is a lot of online documentation relating to our tools, including this overview *http://www.cs.bham.ac.uk/~axs/cogaff/simagent.html* and a large number of ‘help’ and ‘teach’ fi les included with the toolkit accessible in sub-directories here:

http://www.cs.bham.ac.uk/research/poplog/newkit/

PRESENTATIONS
Presentations 1999

Oct 1999, AS gave several invited lectures on this work at the University of the Saarland Saarbrücken, in their Autumn School on Cognitive Science.

Nov 1999, BL gave an invited talk on 'Teaching AI with the SIM_AGENT Toolkit', Department of AI, University of Ulm, Germany.

Nov 1999, AS was invited speaker on 'Deep and shallow models of emotion' at the EC conference on Information Society Technologies, IST99 in Helsinki, Finland. Abstract online at **http://www.ist99.fi**

Nov-Dec 1999, AS was invited speaker on 'Evolvable architectures for human-like minds' at 13th International Toyota conference, on Affective Minds, Japan. (Written up jointly with BL and published).

Presentations 2000

Jan 13 2000, AS gave invited talk at Exeter University, on 'How evolution of a metamanagement architectural layer supports social/cultural advances.'

Feb 15 2000, AS gave invited talk at Bristol University, on the same topic.

March 2000 BL talked on 'Distributed Simulation of Agent-Based Systems', School of Computer Science, University of Nottingham,

March 2000, BL presented a paper on 'Dynamic Interest Management in the Distributed Simulation of Agent-Based Systems', at the Tenth Conference on AI, Simulation and Planning, (AIS-2000), (co-authored with Georgios Theodoropoulos).

April 2000, AS gave invited plenary lecture on 'From intelligent organisms to intelligent social systems' at the AISB Convention in Birmingham.

April 2000, AS chaired and BL was on the organising committee of two day international symposium on 'How to design a functioning mind' (the DAM symposium, with web site, including papers and symposium programme, at **http://www.cs.bham.ac.uk/research/cogaff/dam00/**

April 2000, MS talked on 'Behavioral states: linking functional and physical descriptions' at the DAM symposium.

April 2000, BL talked on 'A design study for an Attention Filter Penetration architecture' at the DAM symposium.

May 2000, AS gave two invited talks, one on architectures and one on our SimAgent toolkit at ITC-IRST/University of Trento, Italy, in seminar series on 'Perspectives on Agents: Theories and Technologies'.

June-July 2000, AS, BL and MS presented a poster on 'Evolvable architectures for human-like minds' at the 4th conference of the Association for the Scientifi c Study of Consciousness in Brussels.

Aug 2000, AS was invited keynote speaker on 'What kind of virtual machine could be a mind?' at the European Summer School on Logic, Language and Information. Also presented a one week course on 'Architectures for intelligent language users'. The course notes are online at **http://www.cs.bham.ac.uk/~axs/esslli/**

Sept 2000, AS gave two invited talks at the Newcastle International Seminar on Computer Science, one on architectures and one on our toolkit.
http://www.cs.ncl.ac.uk/events/intl.seminars/

Oct 2000, MS gave a talk on ‘Thoughts on the Computational Power of Walls and Light-Switches’ to the departmental seminar, Birmingham.

Oct 2000, MS gave a talk on ‘Bi-simulation and the Notion of Implementation’ to a departmental seminar.

Oct 2000 AS gave a departmental research seminar talk on ‘What are virtual machines? Are they real?’

Oct 2000, AS gave an invited keynote talk on ‘Interacting trajectories in design space and niche space’ at conference on Parallel Problem Solving from Nature – PPSN VI, Paris. (Also published in proceedings.)

Nov 2000 MS presented a paper by MS, AS and BL, on ‘Emotional states and realistic agent behaviour’ at the Game-on 2000 conference on Simulation and AI in Computer Games at Imperial College London.

Nov 2000 MS gave invited talks at Sussex University and Nottingham University on ‘The Relation Between Virtual and Physical Machines’

Nov 2000 BL gave an invited talk on ‘Integrating Reactive and Deliberative Behaviours’, at the Department of Computer Science, University of Hull.

Presentations 2001

Jan 2001 AS: Invited Talk on Varieties of Evolvable Minds’, McDonnell Pew Centre for Cognitive Neuroscience, Oxford.

Jan 2001 AS: Invited Talk on SIM_AGENT Toolkit to Computer Laboratory, Oxford.

Mar 2001 MS: Presented paper by MS and BL, on Affective vs. Deliberative Agent Control, at York AISB conference.

Mar 2001 MS: Invited talk at University of Salzburg/Austria on philosophical issues concerning the relation between physical and virtual machines.

Mar 2001 AS: Presented paper on Varieties of affect and the CogAff architecture schema, at York AISB conference.

Mar 2001 AS: Invited talk to BBSRC/EPSRC workshop on Adaptive and interactive behaviour of animals, Abingdon.

Jun 2001: Invited talk on Architectures for human-like agents, at Nokia Research Centre conference Helsinki.

Aug 2001 AS&MS: *Tutorial on Philosophical foundations: Some key questions* at IJCAI01 Seattle. (Booklet for the tutorial is available.)

Sept 2001 AS: When is seeing (possibly in your mind’s eye) better than deducing, for reasoning? Departmental seminar. Online: http://www.cs.bham.ac.uk/research/cogaff/talks/#talk7

Sept 2001 AS: talk on Evolvable, biologically plausible visual architectures at (BMVC01), Manchester. Online: http://www.cs.bham.ac.uk/research/cogaff/talks/#talk8

Oct 2001 AS: Invited seminar at Philosophy Dept, Kings College London, discussing Cognitive Processing paper.

Oct 2001 AS: Invited talk on Varieties of Consciousness, Oxford Consciousness society.

Nov 2001 AS: ‘Supervenience and implementation’ at University of Nottingham, 29th Nov 2001.

Dec 2001 RC: ‘A conceptual overview of CogAff, or, What I’ve been doing since I’ve been away’, COGS Seminar Series, University of Sussex,

Presentations 2002
(Detailed information on talks by BL and MS not included.)

March 2002 AS: Four lectures on 'Architectures for Emotional Animals and Machines' at IK2002 Interdisciplinary College 2002, March 1 - 8, 2002 Gunne am Mohnesee, Germany http://www.cs.bham.ac.uk/~axs/ik2002

March 2002 AS: Two talks at IBM Watson Research Centre, March 13 and 14, at workshop on 'Architectures for common sense'. See publication with McCarthy et al. Slides are online http://www.cs.bham.ac.uk/research/cogaff/ibm02

March 2002 AS: Getting meaning off the ground: symbol grounding vs symbol attachment: A critique of concept empiricism including its modern descendant, symbol grounding theory. at MIT Friday 15th March 2002. Slides available http://www.cs.bham.ac.uk/research/cogaff/talks/#grounding

April 2002 AS: Contributions to workshop on architectures organised by M.Minsky at St. Thomas Virgin Islands April 14-16 2002.

April 2002, RC: 'Pre-objectivity in infants', Psychology Seminar series in the Department of Psychology at the University of Warwick, April 25th 2002.

May 2002 RC: 'Can there be a seems/is distinction for seemings?', NNCS1: Toward a Nordic Network for Consciousness Studies, University of Skovde, May 3-4, 2002.

June 2002 AS: 'Varieties of affect and the CogAff architecture schema', at University College London on 19th June 2002 (Gatsby Centre and Institute for Cognitive Neuroscience).

June 2002 RC: Invited talk for the First International Conference on Intelligent Computing and Information Systems http://asunet.shams.edu.eg/confs/icicis2002.html, Ain Shams University, Cairo, June 23-26, 2002.

July 2002 AS: 'Can we design a mind?' Keynote invited talk at AI in Design Conference, AID'02, Cambridge, 15th July 2002.

Aug 2002 Joint presentation AS & RC: at HP research labs for WGW02 conference August 2002, Bristol, UK "More things than are dreamt of in your biology: Information processing in biologically-inspired robots"

October 2002 AS: 'AI and the study of mind', Invited presentation (with three others) at Computer Conservation Society at the Science Museum, London, Symposium: Artifi cial Intelligence Recollections of the pioneers on 11th October 2002. Online here http://www.cs.bham.ac.uk/research/cogaff/talks/#talk17

October 2002 AS: 'What is science?' Presented at the meeting to launch Cafe Scientifi que in Birmingham, MAC, 25th October 2002. http://www.cs.bham.ac.uk/research/cogaff/talks/#science

Nov 2002 RC: 'In defense of physicalist accounts of consciousness' Center for Theoretical Study, The Institute for Advanced Studies at Charles University and the Academy of Sciences of the Czech Republic Nov. 7th 2002

Nov 2002 RC: 'In defense of physicalist accounts of consciousness' University of Kent at Canterbury, Philosophy Society Nov. 27th 2002.

Nov 2002, AS: Invited presentation on 'The Architecture of an Enduring, Perceiving, Learning Cognitive Agent' at DARPA workshop on Cognitive Systems (Nov 3-6, 2002) in Virginia USA Cognitive Systems Programme. http://www.dsic-web.net/meetings/oy8guwod/agenda.html

Nov 2002, AS: panelist UKRC Grand Challenges conference Edinburgh 24-26 Nov 2002, http://umbriel.dcs.gla.ac.uk/NeSC/general/esi/events/Grand_Challenges/

RC: Also gave two courses in Sweden during 2002.

Presentations 2003

Jan 2003, AS: Talk on ‘When will real robots be as clever as the ones in the movies?’ at Association for Science Education Conference, Birmingham, 4th Jan, 2003.

Jan 2003 AS: Talk on ‘Human vision — a multi-layered multi-functional system’ at BMVA Symposium on Reverse Engineering: the Human Vision System Biologically inspired Computer Vision Approaches, London http://www.cs.bham.ac.uk/research/cogaff/talks/#talk21

Feb 2003 AS: Invited seminar, at University of Kent on ‘How to design a functioning mind’

Feb 2003 AS: Invited talk, DAMTP, Centre for Mathematical Sciences, Cambridge ‘Why aren’t real robots as intelligent as the ones in the movies’ http://www.cs.bham.ac.uk/research/cogaff/talks/#talk20

March 2003 AS: Invited talk at University of Nevada Reno Graduate School and the Departments of Computer Science, Psychology, and Philosophy, on ‘The Irrelevance of Turing Machines to AI’ Online at http://www.cs.bham.ac.uk/research/cogaff/talks/#turing

March 2003 AS: Invited talk at University of Nevada Reno Graduate School and the Departments of Computer Science, Psychology, and Philosophy, on ‘What the brain’s mind said to the mind’s eye’

March 2003 AS: Invited talk at NSF/DARPA Symposium on Advances in Cognitive Architectures, Stanford University, March 22-23 2003, on ‘Varieties of affect and learning in a complete human-like architecture.’ Online at: http://www.cs.bham.ac.uk/research/cogaff/talks/#talk24

March 2003 AS: ‘Architecture-based philosophy of mind’, Invited Keynote speaker, at ECAP 2003, the fi rst European Computing and Philosophy Conference, Glasgow, March 27-29, 2003. (Talk revisd for presentation at Memphis later.)

April 2003 AS: Two Invited talks at University of Notre Dame, USA in April 2002 Computer science and Philosophy Departments.

May 2003 AS: Presentation to UK Foresight Seminar on ‘Architecture of Brain and Mind’ grand challenge http://www.cs.bham.ac.uk/research/cogaff/gc/

May-June 2003 AS: ‘What kind of virtual machine is capable of human consciousness?’ Invited talk at Seventh Conference of the Association for the Scientifi c Study of Consciousness (ASSC7), Memphis 30th May-2nd June 2002 http://www.cs.bham.ac.uk/research/cogaff/talks/#assc7

June 2003 RC: Invited talk on ‘The seems/is distinction: an(other) argument against the possibility of a science of consciousness’, at 7th CEP Conference on Consciousness, Oxford 27-29 June, http://www.warwick.ac.uk/cep/#Oxford

July 2003 RC: Invited talk for “Toward a Science of Consciousness 2003: Between Phenomenology and Neuroscience”, to be held in Prague, 6-10 July 2003.

August 2003, RC: On programme committee for IJCAI’03, Mexico, August 2003.

Sept 2003 AS & RC, with Ricardo Sanz (Madrid): Organised ESF-funded workshop on Models of Consciousness, Birmingham Sept 1-3.

Oct 2003, RC: Gave invited talk at ESF-funded workshop on Consciousness at Torino Italy. (A.Sloman also invited but unable to attend.)