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Proceedings of the
AISB’99 Workshop on Issues in Teaching
Cognitive Science to Undergraduates
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The AISB’99 Convention

The AISB’99 Convention has provided an opportunity to focus on one of the Cinderella’s of the AI world – the study of human creativity. The form of the event – a set of short symposia and workshops running concurrently – has made it possible to bring together a significant number of researchers interested in themes which, though normally considered different areas of AI and Cognitive Science, have in common the theme of creativity.

This, coupled with the contribution of invited speakers of the highest international calibre – Prof. Margaret Boden (Creativity and Evaluation), Dr. Ian Cross (Musical Creativity), Prof. Harold Cohen (Creativity in Visual Art) and Prof. Mark Turner (The Literary Mind), not to mention the many speakers invited to the individual symposia and workshops – has made the Convention an exciting and worthwhile event, as can be clearly seen from the quality of the work presented in this volume.

The Convention included symposia on Musical Creativity, Creativity in Entertainment and Visual Art, Creative Language, Creative Evolutionary Systems, Scientific Creativity, Imitation in Animals and Artifacts, and finally Metaphor, AI and Cognition. Alongside the explicitly creative focus, we are pleased to include in the Convention the 6th Workshop on Automated Reasoning, a Workshop on Reference Standards for NLP, and a Workshop on Teaching Cognitive Science to Undergraduates. The proceedings of all these events are published by AISB, whose Web site can be found at http://www.cogs.susx.ac.uk/aisb/.

The organising committee would like to thank Edinburgh Projects, the research wing of Edinburgh College of Art, and the Division of Informatics, University of Edinburgh for their generous support of the event. Our sincerest thanks also go out to the symposium chairs and committees, without whose hard work and careful cooperation there could have been no Convention. Finally, and by no means least, we would like to thank the authors of the contributed papers – including those which were regretfully not eventually accepted.

Andrew Patrizio, Geraint A. Wiggins & Helen Pain

The AISB’99 Workshop on Issues in Teaching Cognitive Science to Undergraduates

A number of universities in the UK now teach Cognitive Science at the undergraduate level, either as part of a stand-alone degree course, or as an identified option within Psychology or Computer Science. Contributions often come from different departments, with Psychology and Computer Science/AI playing a leading role and with support from philosophy, linguistics, and other allied departments. Various issues arise when trying to do this kind of teaching, and indeed it appears that despite the growing relevance of Cognitive Science to several different disciplines and the increasing number of places where it is taught, some of the universities are experiencing problems with their Cognitive Science courses. We suspect that many of the problems encountered at one university are also experienced at others. It therefore seemed to us to make sense to gather together a group of people engaged in the enterprise, in order to exchange experiences, discuss problems, and share the lessons learned.

The workshop will include three main kinds of activities. Firstly, two distinguished cognitive scientists will be presenting invited talks, one at the beginning and one at the end of the workshop. Secondly, six of the participants will be giving short talks, reporting on particular experiences and ideas. Thirdly, and importantly, there will be two rounds of parallel discussion groups, charged with mulling over specific topics and reporting back to the plenary workshop.

The last similar meeting (that we know of) in the UK was also held under the auspices of AISB, in January 1987, organised by Nigel Shadbolt and Richard Young, under the title of Teaching AI in Psychology Departments (Shadbolt, 1987). There have been a couple of similar meetings in the USA. One at Vassar in 1985 led to an unpublished but widely circulated and influential report on Teaching Cognitive Science to Undergraduates (Kelley, 1985), but is now of course seriously out of date. A later meeting in 1987 at Hampshire College, Massachusetts had sessions led by the contributors to the book Teaching Cognitive Science: An Introduction (Stillings et al., 1987), which formed the basis for the workshop. More recently, at the 1994 annual conference of the Cognitive Science Society, at Georgia Tech in Atlanta, there was a Workshop on Cognitive Science Education, an "idiosyncratic view" of which is available on the WWW (Kolodner, 1994). A more recent workshop was held at New Hampshire, sponsored by NSF, in 1993. The final report by Stillings is available on the web (http://hamp.hampshire.edu/~nacCS/nssfreport.html).

We bid you welcome to this workshop, and wish you many fruitful hours of discussion.

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References


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The Computing Component

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1. Introduction

In this paper we discuss the way the computational aspects of Cognitive Science are taught at the University of Hertfordshire, a degree course that is now in its eighth year. Computing constitutes over a third of the material in the first two years of the degree and students can choose a predominantly computational program of study in their final year. The degree consists of 24 modules studied over 3 years. A 2-module project in an area of the student's choice is undertaken in year 3.

Our approach in the degree has been governed by two principles: firstly that the computational material should be integrated and directly relevant to Cognitive Science, and secondly that the students should develop practical and useful computing skills.

2. Year 1

2.1 Foundations of Computing and Artificial Intelligence (3 modules)

At 3 modules, this is the largest computing course the students will take, and underpins all later courses. We take Lisp as our first programming language; Lisp is a functional programming - and therefore formal - language. This immediately begs questions about students' understanding of the notion of a formal language or indeed a function which is, after all, a mathematical object. Ideally we should like them to have some understanding of both these concepts before they start to write programs, though we have to remember that most of our students come from non-technical backgrounds. It is important that students recognise the need for languages which humans and machines both 'understand', in some sense, and the power and limitations of such languages. And in order to appreciate fully what a functional language can do for them they need to know what a mathematical function is. We cannot teach both of these concepts first, and we certainly do not have time to postpone the start of practical sessions until both are learned. We opt, then, to start the theoretical side of the course with a study of formal languages;
this always seems more natural and indeed, kinder, than plunging students into discrete mathematics as soon as they arrive. There is no ideal way and we have found this one to be less frightening and baffling to them at what is a vulnerable stage in their learning.

A large part of the theoretical side of the course is taken up with a study of Symbolic Logic. Students learn elementary Propositional and Predicate Logic and learn to symbolise natural language arguments and use truth tables to validate them. Following on from this, we used to teach natural deduction which was then used to derive proofs of validity, but most students found this very hard and truth tables make the point well enough for year 1. They learn the rudiments of resolution/refutation theorem proving in predicate logic and this leads naturally on to the language Prolog, which they usually take to quite well, perhaps because it is motivated by what they have learned and so they do not come to it cold, so to speak.

In parallel with the theoretical side of the course, the students learn Lisp and have weekly practical sessions. In a perfect world we would arrange for the two aspects of the course to run in lockstep so that, for example, when they were learning propositional logic they would be building Lisp models of compound propositions and truth tables. In practice this is hard to achieve all the time; progress is made at different speeds at different times in each part of the course, so we sacrifice our ideals to some extent in the interests of a better overall understanding.

3. Year 2

3.1 Artificial Intelligence and Neural Networks (2 modules)

The way that computational Cognitive Science has been delivered in the second year changed quite radically two years ago when the number of modules in each year was cut. In our original model symbolic and connectionist modelling were taught in the context of the psychological phenomena that they modelled, for example a large course that covered Knowledge Based Problem solving included both cognitive psychology and AI.

The current course structure puts both traditional AI and connectionism in one course. Here the students extend their programming skills by writing a LISP search engine, and by tackling a knowledge representation exercise using the LISP based CLASSIC language. Almost all the students gain some level of competence in programming. No programming is used in the connectionism material, rather a simple neural network tool is used, currently TLEARN.
3.2 Cognitive Modelling (1 module)

This introduction to cognitive modelling is explicitly integrational, and aims
to start to pull together the two main strands that students have been exposed
to so far, from Psychology on the one side and from Computing on the other.
It has two parts, connectionist and symbolic, both of which build on the
earlier-starting course on AI and neural networks. Practical work with
connectionist modelling continues with TLEARN, though a number of other
architectures are also discussed. The symbolic side draws heavily on
production systems, which in turn show up in later courses (e.g. Knowledge
Engineering in the 3rd year). Practical work makes use of the COGENT
modelling environment, which also incidentally provides students with
their first taste of Unix.

4. Year 3

4.1 Knowledge Engineering (1 compulsory module)

This course integrates material from earlier in the degree: elements of
cognitive psychology and knowledge representation. The students engineer
and implement a small expert system, using CLASSIC as the implementation
vehicle. The course also puts Knowledge based systems in the context of
information systems in general and includes a discussion of data and process
modelling. This gives the course an additonal vocational element.

4.2 Further Programming (1 optional module)

This course has a strong vocational element. By the third year many students
have come to see themselves as falling naturally on to either the Psychology
side of things or else the Computing side. We feel we have a responsibility to
the latter group to help them equip themselves for a career in the computing
industry and so we offer a course on C running under Unix, two skills that
never do any harm on a CV. Whilst there is not time to turn Cognitive
Scientists into Software Engineers in one term, we can and do give them a
grounding in good procedural programming and design principles. The
course is assessed by coursework only, in which the students are asked to
build a neural net (a Hopfield net, in fact) in C. Although the students have
met the Hopfield net in year 2, this is their first encounter with, so to speak,
its inner workings. Many computer scientists measure their understanding
of a concept in terms of their ability to write a program to simulate it. By the
time the students have built a Hopfield net in C, they have gained a good
understanding of it. This is a very pleasing side effect of this course.
4.3 Computer Processing of Natural Language (1 optional module)

The approach to this is twofold. Students learn the traditional AI approach of prescriptive grammatical analysis, due largely to Chomsky. They construct simple Definite Clause Grammars in Prolog and soon learn the inherent difficulties involved in trying to capture the notion of êcorrectê English for anything beyond the simplest declarative sentences. They also study a corpus-based approach to natural language processing. This approach is empirical, by contrast; regularities in language are found by examining large corpora. The approach has become computationally feasible because of the huge storage capacity of modern computers. It is also of great interest to industry, particularly in the areas of speech recognition and automated translation (of such things as product manuals).

4.4 Topics in symbolic Cognitive Modelling (1 optional module)

Drawing on material first introduced in the 2nd-year course on cognitive modelling, this module takes a more advanced approach. Actual computational work centres on a detailed exploration of the ACT cognitive architecture, for which a recent (and excellent) textbook and an on-line tutorial are available, as well as a wealth of other web-based introductory and research material. Half the class time is spent in lab sessions using ACT. A number of other architectures are covered more lightly, including Soar, CAPS, and EPIC.

5. Conclusion

We attempt, within the degree, to provide all the students with a reasonable level of computational sophistication both in simple programming and modelling. We also provide the opportunity for interested students to gain further skills and expertise in computing.

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THE DESIGN OF AN UNDERGRADUATE PROGRAM BASED ON A VIEW OF COGNITIVE SCIENCE AS A SOCIETY WITH THREE METHODOLOGICAL ‘CULTURES’

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Abstract
A alternative view of cognitive science as neither one unified cognitive science, nor just a multidisciplinary field of a number of sciences (psychology, AI, linguistics, philosophy, neuroscience etc.) is presented. It is argued that cognitive science is best described as a matrix of two dimensions: a content or domain dimension (e.g., language, problem solving etc., and subsets of these) and a methods dimension, comprising of three basic approaches to research: empirical, formal, and model building. The latter are seen not only as methods per se, but rather as scientific ‘cultures’; carriers of differing explicit and implicit views of what constitutes ‘good research’. Since cultural knowledge to a large extent can be acquired only by ‘living’ in the culture, the Linköping Cognitive Science program is built on the assumption that the students should early in their studies learn all three scientific traditions, both theoretical and methodological aspects, on an equal footing, before specializing in a particular sub-field. The paper presents the ‘three cultures’ view of cognitive science, how this has influenced the general design of the program, and describes two courses, one theoretical and one applied, which illustrates our approach to supporting the students acquiring their own perspective of the multi-cultural but still unified field of cognitive science.

1 Introduction
For all undergraduate programs, but especially so for interdisciplinary ones like Cognitive Science, it is important to base them on a coherent view of the subject area or areas under study. For a large field like ours, with many different sub-areas and different perspectives, we need criteria for deciding what to include and what to exclude from the curriculum. If not, there is a risk that the students will be presented with a rather haphazard collection of courses that reflect the research interest of the present faculty more than anything else. Ten years ago, when the computational theory of mind was the dominant one within cognitive science, this was probably an easier task than it is today. The aim of the present paper is to present the underlying views of the field of cognitive science behind the Linköping Cognitive Science undergraduate and Master’s program, and illustrate how this has influenced the design of the curriculum.

2 Defining Cognitive Science
Cognitive science is often described in textbooks and elsewhere as ‘the science of mind’, and presented as comprising of five or six disciplines or sciences (philosophy, psychology, AI, linguistics, neuroscience and anthropology). The standard introductory presentation often also points to the representational or information processing view of mind as central to cognitive science. An on-going discussion in the field, ever since its start, has been whether it will develop into one unified science of cognition, or if it will remain an interdisciplinary meeting ground for the different sciences of mind mentioned above, and possibly others.

One problem with the traditional taxonomy of the sub-fields of cognitive science is that it conflates methods and topic areas. All the different cognitive sciences not only have a core study object, but also a methodological tradition associated with it. Linguists study language, but so do psychologists and others. Psychology has a strong empirical tradition, but also anthropologists, neurologists and linguists run empirical studies, while some psychologists write computer programs, just like workers in AI. But there are AI researchers who never write any programs, but instead develop mathematical and logical models, as do philosophers and linguists – and the circle is closed.

Another problem with the ‘standard view’, is that the selection of what to include as relevant seems somewhat arbitrary. The listing in the journal Cognitive Science of which disciplines belong to the field has changed over the years (Schunn, Crowley, & Okada, 1998), and (Simon & Kaplan, 1989) have pointed out that other disciplines, e.g. economics, could belong there.

I believe, however, that there are alternatives to the ‘standard’ views. One such viewpoint, originally presented in
(Dahlbäck, 1991), is that Cognitive Science is better described by a matrix of two dimensions; a content or domain dimension (language, memory, problem solving, etc., and subsets of these), and a methods dimension, comprising of three basic approaches to research; empirical, formal, and model building, and subsets of these. The first defines the study object of cognitive science, the second describes the major different scientific traditions in the field.

In this paper I will concentrate on the methodological dimension, but first a few words on the content dimension. An approximate definition of the subject field of cognitive science could be something like "the information processes of the person's interaction with the physical and social environment". It is admittedly loose, but delimits cognitive processes (information processing, in its widest sense) from emotive, volitional and other aspects. Furthermore it sets an 'upper' boundary towards sociology and similar 'macro' social sciences, and a 'lower' boundary towards the genetic information processes. The definition is purposely vague in the view of the relationship between cognitive and neurological aspects, as well as of the relationship between how much of the individual's cognitive processes are taking place 'in the head' or 'in the world'. It includes those aspects of e.g. neurological processes that have a direct bearing on the organism-environment interaction, but leaves it open where this border actually is. Likewise it includes tool-based external support of these processes, but leaves it open where this border actually is.

As a final note on this topic, I would like to add that it is my impression that there is a tendency in today's cognitive science community to cluster into two major sub-divisions of the field; one connecting cognition 'proper' with its underlying strata (neuroscience, sub-symbolic computation), and another connecting to the physical and social environment (situated cognition etc).

3 Cognitive Science as three methodological 'cultures'

The reason that we find the methods dimension important is that it, in a sense, is not about research methods, and definitely not about methods only. Associated with these methods are different views on science and theory, not the least the view of what constitutes 'good scientific work' etc., like which of the two criteria of internal coherence and correspondence between theoretical concepts and empirical data is the most important one. They are therefore in important respects different scientific 'cultures', or different ways of 'doing science', rather than just different methodological traditions.

The empirical-formal distinction has a long tradition, and can perhaps most clearly be illustrated by work on logic and thinking by logicians and psychologists. The work of the psychologists is descriptive and empirically based, and the correspondence between theory and data is the major evaluative criterion. The work of the logicians is on the other hand prescriptive, there is a limited interest in the empirical base, and coherence or correctness from a formal point of view is the major evaluative criterion. The important point is of course that there is no 'right' and 'wrong' here, but while the study object in some sense is the same, the scientific traditions are different.

The third category here, the constructive or model building (sometimes called design science, or science of the artificial) is best exemplified with AI within cognitive science, but seems in many respects to share features with much of engineering science in general. It shares with the formal tradition a concern with the suitability of formalisms, but the emphasis is rather on 'external' criteria, such as a particular formalism's suitability for a particular task, rather than its soundness, completeness, and other similar evaluative criteria. It shares with the empirical tradition the concern with and interest in studying some kind of 'external reality', but in contrast with traditional empirical science, the objects studied are not given by nature but constructed by man.

There are of course also important different traditions also within the different major classes. These are often more discussed, e.g. the difference between quantitative and qualitative empirical methods.

There is one interesting difference between classical empirical research and design oriented research, which perhaps is most clearly seen in applied areas of cognitive science, e.g. HCI, which concerns the relationship between theory and empirical data. In traditional empirical science there is a tight connection between the theory and the empirical data, which means that the latter will have a more or less clear-cut bearing on the theory. In design oriented research, on the other hand, the connection between the theories and the evaluation of the designed artefact is much looser. Consequently, the consequences of the results of the empirical evaluation for the theories that inspired the design will not be as clear-cut in this case. Let me illustrate this point with examples from two different field, cinema and clinical psychology.

Imagine a director creating a movie, which he claims, is inspired by Jung's theories of the collective unconsciousness. It is then a rather pointless review, which concentrates on whether this movie is really a true interpretation of what Jung actually meant. First, because it is obvious that being inspired by something is not the same as deriving hypotheses from a theory into predictions that can be tested in an empirical study. Second, because the value of the movie is primarily not in how good a reflection of Jung's theories it is, but how good it is as a piece of art.
Behavior therapy is another illustration of this. One can of course debate whether behaviorism is an accurate and adequate theory of human behavior, and likewise one can certainly debate whether e.g. Wolpe (Wolpe, 1958) made correct interpretations of the basic theories he based his work on, and whether he made reasonable additional assumptions in the derivation of a therapeutic approach from these basic assumptions, but that is of course not the most important issue from a clinical point of view. The important issue is instead whether the therapy works. And conversely, a study showing that it works cannot of necessity be seen as a validation of standard behaviorist theories.

Getting back to the basic issue of the three scientific cultures, I do not want to claim that the present formulation of these three scientific traditions is all that clear cut and well developed as it stands today. But even in its present form, it has a useful heuristic value for the design of a cognitive science curriculum. The argument here is that one of the central characteristics of cognitive science, and which perhaps makes it unique among established scientific fields of study, is that it encompasses all three of these methodological traditions/cultures. And that this need to be reflected in the cognitive science curriculum, since any competent cognitive scientist in academia or industry, needs some basic knowledge in all three areas. This in contrast with many educational programs in cognitive science which, in taking a leap from the computational theory of mind, has a course or two in programming as a requirement for the exam, but no such requirements for e.g. experimental methods and design, or logic.

There are a number of reasons for our emphasis on the plurality of methods. The most obvious is of course that it is a valuable knowledge in itself. Other reasons for this is that this kind of knowledge has a longer life (theories change, methods remain), and furthermore that it is easier to teach yourself about theoretical developments than about programming, experimental design, or formal logic. But the most important reason for our emphasis on this, is that 'hands-on' knowledge of the methods used in a piece of research will give the student a deeper understanding of the results obtained and the conclusions possible to draw from it. You cannot really understand a Cookery book if you cannot cook, you will never really understand what sailing is like by only reading about it, etc, and I take this to be true also for knowledge areas involving an important amount of practice. Which programming, experimental design etc seems to belong to too.

Another reason for our emphasis on this is the accumulating research on what characterizes successful scientific work, e.g. (Dunbar, 1995), (Schunn et al., 1998). Two of these factors are multidisciplinarity, and within this diversity some commonality of perspective. The latter probably is important because it provides the common ground for successful communication and collaboration. Our cognitive science students will most likely work in multidisciplinary work environments, whether at universities or in industry. Consequently, it seems important for us as teachers to prepare them for the requirements of work in such environments, by, among other things, giving them some first hand experience of the different perspectives or cultures that they will encounter in their professional lives. And we know, of course, that there is no substitute for living in a culture if you want to understand it from within, rather than from without (pace Simon’s travel theorem).

4 Design of a program based on these views

To put what I will describe below in context, I will first say a few words about the Swedish undergraduate education in general. All countries have their differing university traditions. One aspect of the Swedish system that makes it differ from most other countries, is that the Master’s level is a part of the undergraduate and not the graduate level. Another, and in the present context more important, is that much of the undergraduate teaching takes place within pre-defined three to four year educational programs, often with a strict progression of courses to be taken during the years, and especially the initial ones. There are certainly both pros and cons with this, but one advantage is that it makes it possible for us as teachers to control the order in which courses are taken, and let theoretical and pedagogical reasons influence these decisions. We have tried to make active use of this possibility in our design of the cognitive science program.

There are two aims underlying the design of the program, related to the view of cognitive science described above. First, to give the students some first hand experience with all three scientific traditions or cultures we have defined, while at the same time letting them specialize in at least one of these to a level of proficiency and professional competence that makes it possible for them to perform independent first class work within that tradition. Second, to provide opportunities for the students to integrate the different sub-parts into a coherent view of cognitive science where the whole is something more than the sum of its constituent parts.

These two goals are obviously conflicting, at least on a surface level, since the first is about learning what char-

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1 “Anything that can be learned by a normal American adult on a trip to a foreign country (of less than one year’s duration) can be learned more quickly, cheaply, and easily by visiting the San Diego Public Library.” (Simon, 1996), p 306.
characterizes 'pure' empirical cognitive science etc, whereas the second is about merging these into a larger whole.

Since both research in cognitive science and educational experience tell us that students' world view will be most strongly influenced by the very first courses taken, we have deliberately structured the sequence of the first two years of courses to give an as balanced as possible mix of the different methods and domains. Our program has an emphasis on the 'higher' levels of cognitive science, and in the three subjects psychology, linguistics/communication, and computer science/AI. Consequently, almost the entire first one and a half years have the focus on basic courses in psychology, linguistics, and AI, and in courses in empirical research design and statistics, logic and discrete math, and programming. Ten-week courses for the three theoretical subjects, and five-week courses for the methodological ones. By this we want the students to get an early first-hand knowledge of the different scientific traditions associated with our three topic areas, hoping thereby to avoid having e.g. students with a deep background in psychology viewing the later AI course through their 'psychological glasses', and seeing AI as some kind of inferior psychology (speculative and too weak empirical evidence, based on toy examples and simplified views on cognitive processes etc). Or making them to view everything they learn about psychology through their AI and programming glasses, just because that was what they first studied.

The first two years of courses taken follow a pre-described obligatory path. After these two years the students can branch out into different specializations. This does not, however, mean that the students specialize into one sub-discipline. They must continue to take courses in all disciplines and also courses in cognitive science that integrates the perspectives, but they emphasize and specialize in one or more sub-area of cognitive science. This specialization is strengthened by the students first-hand experience with other scientific traditions, since this helps them seeing the strength and weaknesses of their own sub-field by being able to view it from also an outside position. This is in a sense similar to the traveler who gains a deeper understanding of his own country and culture by encounters with the other countries and cultures he has traveled through.

Our aim is to make the students knowledgeable enough in the fields they to not specialize in to be able to do smaller 'standard' tasks in all of them, and, more importantly, to be able to successfully interact in their future work-places with experts in the other fields, with an understanding of not only the possibilities and limitations of their own fields, but as importantly with an implicit understanding of the 'thinking style' of programmers, experimental scientists, etc.

This is based on our belief from our own careers in the evolving field of cognitive science, that the major stumbling block for successful communication between e.g. computer scientists and psychologists, is not lack of knowledge of the theories in the different fields; most academics can, after all, read books. Instead, the culture clash comes, as we also could expect from cognitive science research, from the unspoken, non-verbalized (and perhaps non-verbalizable) underlying 'taken for granted' assumptions of the different scientific traditions. As pointed out above, we believe that you can never really learn what it is like to live in another culture by reading about it, you have to live there. Likewise, we believe that the only way for our students to understand the different scientific cultures of cognitive science, is to live them. And to do it early on in their university years.

5 Integrating the Diversity

But we are hopefully teaching cognitive science, and not just psychology + linguistics + computer science, with some add-ons of philosophy, neurology and anthropology. The students need a cognitive science perspective on their studies. The courses mentioned above are therefore preceded by an introductory course in cognitive science, which is the first course taken by the students. The aim of this course is to give the students a historical-philosophical background to today's cognitive science, and also to introduce the central questions and research issues in cognitive science. Another aim is to introduce them to applied cognitive science (e.g. cognitive engineering, HCI, etc). The focus is more on elaborating the questions than giving the answers. The students' knowledge in the different branches is not enough as yet, and after all, they have four years to find the answers. The aim here is 'only' to give them good questions to seek answers to during the coming years. (Yes, it is great fun to teach this course!).

All through the four years of study, but with increased emphasis after the first one and a half years of studies, we try to help the students forming a coherent view of the field of cognitive science as a whole. The emphasis here is on making the students finding their own perspective on this, not presenting them with ours. There is no longer one dominant view of cognition or cognitive science, as it was in the hey-days of information-processing psychology, symbolic AI, and functionalism in philosophy of mind. But even if this means that we cannot tell the students how everything fits together, we shouldn't leave it to them alone the task of creating a structure of the field at large. Instead we try to provide courses that serve as vehicles for their work on this. I will here give examples of two such courses, one applied and one theoretical.
5.1 The Applied Projects Course

In the project course, where the students work in groups of 6-7 students, the aim is to give them an opportunity to use their theoretical and methodological knowledge in working on an applied problem. As our students are eager to practice their knowledge, we normally never need to provide problems for them to work with. Instead the students have their own ideas on what they want to dwell deeper into. Furthermore, we do not enforce all members of the group to be equally involved in all aspects of the project, e.g. if some students would prefer to program they can do so within the project. However, the project as a whole must be coherent and integrate at least two sub-areas of cognitive science, such as Psychology and Computer Science. This means that the group of students, although individually working within maybe only one sub-area, must view the problem as a Cognitive Science project.

We also want the students to realize the difficulties of being a cognitive scientist once they have graduated. This is achieved by having two supervisors from different research areas with instructions to pursue their own view on how to best handle the research question raised in the project. This has been quite successful in that the students will have an opportunity to actually hear how researchers from different disciplines argue when in a middle of a research process. It also has the effect that the supervisors, whom come from different research traditions, will get knowledge on research results and methods from other disciplines. As one example of this: a computer scientist and a cognitive psychologist together supervised a group of students studying the phonological loop, with the aim of simulating parts of it using a neural network. From this project the psychologist realized that connectionist models could be useful for such studies, whereas the computer scientist found a new application domain for his work. But most importantly they gained an understanding for cognitive science research that they did not have before, which in turn will have effects on the way they view their role as teachers on the program.

Examples of some recent projects are "Design and evaluation of a web-interface for a help system for nurses preparing patients for advanced X-ray investigations", "The influence of navigational aid and cognitive abilities on navigation in hypermedia" (an experimental study), "The use of linguistic transformations as a mean to trace illegal copying". Many of the projects are of an exceptionally high standard, compared to what other students on similar educational levels in Sweden perform. As teachers we are impressed, but, to be honest, we cannot really for sure say why these students achieve these levels. But we hope that the combination of freedom to find their own ways or views of cognitive science within a structured curriculum where we don’t tell them our view of how the different areas of cognitive science fit together into a (reasonably :) coherent whole, but give them a chance to discover this for themselves, that we have tried to develop, is one of the causal factors of our students’ achievements.

5.2 Cognitive Science Models of Dialogue and Discourse

This is an elective course that can be taken during the third or fourth year, as well as by computer science students provided they have the necessary pre-requisite courses (at least introductory courses in AI, psychology, and linguistics). There are two aims with this course. First, to give a deeper knowledge on dialogue and discourse than what was provided in the courses previously taken. Second, and more important for the present discussion, to provide a closer understanding of similarities and differences between different scientific approaches to ‘the same’ study object. To save space I will only illustrate with the sub-part of the course concerned with dialogue and speech acts.

Here the students read the original works by philosopher/linguists on speech act theory (Austin (Austin, 1962) and Searle (Searle, 1975)). They also study the plan-based approach to speech acts from AI and computational linguistics originating in the work by Perrault, Cohen, and Allen (Allen & Perrault, 1980), (Cohen, 1984). In psychology we study the work by Gibbs (Gibbs, 1979; Gibbs, 1981) on the cognitive processing of indirect speech acts. And finally Levinson’s (Levinson, seminal paper on the (im-)possibility of formal models of speech acts based. Our hope is that the students through the reading and discussing of these different works will gain a deeper understanding of similarities and differences between different cognitive science approaches to one study object, and through this also gaining a deeper understanding of the pros and cons of these different approaches in general.

Acknowledgements

The ideas in this paper have been shaped and influenced through many years of collaboration on research and teaching with friends and colleagues at the Natural Language Processing Laboratory and Linköping University’s Computer Science Department. Special thanks to Arne Jönsson, current director of studies for the Cognitive Science program in Linköping, for lots of serious fun over the years.

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2 This course was developed by Arne Jönsson, and the description here is based on an unpublished manuscript by him.
References


Interdisciplinary Prejudice and Symbiosis in Cognitive Science.

Donald Peterson

Cognitive Science Research Centre,
University of Birmingham.

In teaching multi-disciplinary cognitive science, it is important to encourage a reasoned attitude to the interaction between the component disciplines. There follow some points which I emphasise in the Overview of Cognitive Science which is part of the MSc in Cognitive Science at Birmingham.

The wonder is that the component disciplines of cognitive science can cooperate at all. Most obviously, they differ in primary methodology, variously employing empirical experiment, conceptual analysis and creative engineering. Also, they differ regarding the status and accessibility of their subject matters, the pre-existence of a folk-theory, and on whether their mission is creation or discovery, as indicated in the table below.

<table>
<thead>
<tr>
<th></th>
<th>subject matter</th>
<th>accessible</th>
<th>folk theory</th>
<th>creation or discovery</th>
</tr>
</thead>
<tbody>
<tr>
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<td>no</td>
<td>yes</td>
<td>discovery</td>
</tr>
<tr>
<td>Computer Science</td>
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<td>n/a</td>
<td>no</td>
<td>creation</td>
</tr>
<tr>
<td>Philosophy</td>
<td>conceptual</td>
<td>no</td>
<td>maybe</td>
<td>discovery/therapy</td>
</tr>
<tr>
<td>Linguistics</td>
<td>factual</td>
<td>yes</td>
<td>no</td>
<td>discovery</td>
</tr>
<tr>
<td>Neuro-science</td>
<td>factual</td>
<td>yes</td>
<td>no</td>
<td>discovery</td>
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</tbody>
</table>

We may reasonably ask, therefore, whether cognitive science is a Tropical Balti (a colourful and exciting, but heterogeneous and unnatural mixture of things which do not belong together) or a Lamb Masala (a coherent and natural combination which was waiting to be discovered). What is clear is that a fused and homogeneous cognitive science is not possible, given the differences outlined above. In particular, the different methodologies involved can never amount to the same thing, and so heterogeneity will persist however we redefine the disciplinary or institutional boundaries.
If cognitive science cannot be a Lamb Masala (a fusion), then what can support it in being a cooperation? One powerful factor, more convincing than any programmatic declaration of unity, is the existence of problems which invite the contribution of more than one discipline or methodology. In the study of autism and of 'theory of mind' in 4-year-old children, for example, the involvement of both psychology and philosophy is unavoidable. Again, in cognitive modelling using neural nets, the combination of psychological theory (model specification), engineering (model building), and psychological hypothesis-formation (suggested by the model's behaviour) are all involved.

What then are the obstacles to such problem-based inter-disciplinary cooperation? One is what I shall call the 'Chalk is Bad Cheese Fallacy'. This is the assumption, from the viewpoint of discipline A, that another discipline B has similar objectives and requirements but misguided methods. Thus we have the 'Philosopher's Dream' that what psychologists need is to get into the armchair and clarify their concepts before doing any empirical work at all. We have the 'Psychologist's Dream' that philosophy is a sort of search for psychological facts which misguidedly uses a non-empirical method. And so on. These 'Dreams' can be turned into systematic arguments, and perhaps should be from time to time given the possibility of pointless analysis, pointless experiment, and pointless construction in the component disciplines. However they also appear in unreasoned form, outside (if not inside!) cognitive science, and one thing which the enterprise of cognitive science can offer the world is its contribution to the erosion of such divisive prejudice.
Almost a Decade of Cognitive Science at Sheffield

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Abstract

Sheffield was one of the first UK universities to introduce an undergraduate degree in Cognitive Science with an initial intake of students in 1990. The authors have been involved with teaching, administering, and developing the degree throughout the 1990s and most recently in overseeing its transformation into a degree entitled "Psychology and Cognitive Science". This paper provides a case-study of our experience in developing and coordinating Cognitive Science teaching at Sheffield. We review some of the particular problems we have faced, assess our varied attempts at solving them, and identify some unresolved issues which are likely to be faced by anyone seeking to provide training in Cognitive Science at an undergraduate level.

1 Introduction

The problems that arise in teaching Cognitive Science to undergraduates have previously received attention at a 1993 workshop for the National Science Foundation, and at two workshops for the Annual Conference of the Cognitive Science Society (in 1994 and again in 1998). Summaries of two of these meetings are available on the Internet (Stillings 1993; Kolodner, 1994). Although primarily concerned with teaching Cognitive Science in the US, these reports make reassuring reading for UK-based organisers of Cognitive Science degrees: there seems to be considerable universality in the experience of trying to co-ordinate an undergraduate degree in our field! Rather than reiterating many of the interesting points made in these reports, this paper aims to provide a case-study of our own experience in developing and coordinating Cognitive Science teaching at the University of Sheffield, UK. We will review some of the particular problems we have faced, try to assess our varied attempts at solving them, and identify some of the unresolved issues we are still struggling with today.

Sheffield was one of the first UK universities to introduce an undergraduate degree in Cognitive Science with an initial intake of students in 1990. The authors have been involved with teaching, administering, and developing this degree throughout the 1990s and most recently in overseeing its transformation into a degree entitled "Psychology and Cognitive Science".
Some background on the development of the degree will explain how we got to where we are today.

2 The Original Cognitive Science Degree at Sheffield

Several objectives motivated the introduction of our original single honours degree in Cognitive Science:

- To give students a multi-disciplinary training in the different strands that contribute to Cognitive Science.
- To educate students in the required methodological skills to tackle interesting undergraduate projects in Cognitive Science, and to graduate with the skills to undertake post-graduate research in Cognitive Science.
- To allow students to discover where their own strengths and interests lie and then encourage them to develop expertise in those particular areas.
- To teach subjects closer to the research activities of staff many of whom have strong Cognitive Science interests.

To address the first objective, inter-disciplinarity, our degree began life as a three-way partnership between the departments of Psychology, Computer Science, and Control Engineering. In the first two years of the degree, students were expected to gain a solid grounding in the cognitive and biological areas of psychology; computing and AI; and control theory and robotics. Students also had the option to take courses in the department of Philosophy. Methods courses (objective ii) included experimental and statistical psychology, computer programming and software design, and applied mathematics. To allow students to direct their studies toward target areas (objective iii), the final year included a research project under the supervision of a member of staff, and optional advanced courses in topics of their own choosing. The degree was initially conceived as having very limited specific teaching in Cognitive Science (there was just one full-time post attached to the introduction of the course). However, in line with objective (iv) it was intended that final year students would have the skills to carry out undergraduate projects in particular areas of staff interest, and it was hoped that the best undergraduates could be encouraged to stay on for postgraduate training in Sheffield.

This original degree has seen a number of important changes. First, as a three-way collaboration the degree lasted for only one year! During this time it was decided that the involvement of three departments made the administration of the course too cumbersome. Perhaps more importantly, however, it was felt that the courses on control and robotics taught in Engineering, although in principle concerned with relevant material, in practice were failing to engage or interest our students. This is, of course, symptomatic of the wider problem (discussed by Stillings, 1993), of how to finesse relevant
interdisciplinary training for Cognitive Science undergraduates from courses designed to satisfy the teaching objectives of other fields. We have struggled with this problem in various guises throughout the time we have been teaching cognitive science.

As a more manageable partnership between Psychology and Computer Science the Cognitive Science degree has lasted for nearly a decade (the final students from this degree will graduate in 2001). Further changes during this time have been aimed at (i) narrowing down the core of the degree to provide more student choice, (ii) introducing specific Cognitive Science courses intended to provide a focus for the degree, and (iii) reducing the amounts of compulsory methods training. We briefly consider each of these issues below.

Core material

The problem of defining the core subject matter of Cognitive Science, has concerned previous workshops on teaching this subject to undergraduates (see Stillings 1993, Kolodner 1994), However, as yet, no specific proposals as to what should count as core have been made. There is consensus, however, in past workshop reports, that what distinguishes Cognitive Science from other approaches in the 'sciences of mind' is a computational or information processing perspective. This paradigm has confronted, and adapted to, various challenges over past decades. So, for instance, in response to the resurgence of connectionism in the 1980s, most degrees now recognise neural networks as a core topic, and regard various forms of distributed computation as fitting under the information processing umbrella. In the 1990s, however, there has been a new(ish), and more radical, challenge to the computational view coming from dynamical systems and autonomous robotics research. This work has asserted a dynamical rather computational understanding of cognition (see, for instance, Port and Van Gelder, 1995), and has questioned the significance for understanding human cognition of such core concepts as representation (distributed or otherwise), symbols (or sub-symbols), and computation itself. With the current level of turmoil in the field of Cognitive Science, the problem of designing a core curriculum has become even more difficult. The danger of introducing these alternative paradigms too early in a degree program is that it could encourage students to dismiss the standard computational approach to readily. On the other hand, if we do not provide appropriate coverage of these important debates within Cognitive Science, we could do our students and our subject a disservice, by failing to portray the current 'state of the art'.

The lack of consensus about what constitutes core Cognitive Science provides considerable freedom in designing an Undergraduate degree. At Sheffield we have chosen to play to our strengths and teach to those areas where we have most expertise. This has meant a Cognitive Science degree that emphasises topics such as connectionism, and computational approaches to vision and
neuroscience, with less stress on traditional topics such as classical AI or linguistics. The emphasis in the first two years is on a fairly standard computational/connectionist understanding of mind, while the dynamical/computational debate is given some detailed consideration in a final year course.

As an interdisciplinary field, graduates in Cognitive Science should be expected to have some basic training in a number of contributing areas. The core of our degree has emphasised training in Psychology and Computer Science with some introduction to Philosophy. Professional accreditation is, of course, an issue for Cognitive Science graduates who may wish to enter careers in the more traditional fields (this is not helped by the lack of specific jobs for qualified Cognitive Scientists!). Our graduates are able to gain graduate membership of the British Psychological Society, although to get full graduate registration (allowing training as a clinical, educational, or occupational psychologist) students are required to take further optional courses in Psychology. Accreditation to the British Computing Society has not been an option for our students although this may be a less rigid bar to obtaining work in the computing industry.

Specific courses for Cognitive Science

Early on in the development of the degree we recognised the requirement for specific courses in Cognitive Science. There are several reasons for this. First, faced with an array of disparate modules in Psychology, Computing, and other disciplines, students need some teaching that integrates across these areas and demonstrates how they are related. Without this integration, students may want to migrate into the component discipline they find most appealing (indeed, despite our best efforts we still have several students in each intake moving into one or other of the parent disciplines). Second, specific courses can teach material in a way that makes it more relevant and accessible to our students, for instance, focusing on the use of neural networks for cognitive or brain modelling rather than on their use as function approximators in neural engineering. In practice, specific courses for Cognitive Science have been provided for our degree in the department of Psychology rather than in the department of Computer Science (this situation arose for various reasons including the generally lower teaching loads in Psychology). One unintended consequence of this imbalance, however, is that many students tended to see themselves as 'home' students of Psychology rather than being evenly based between the two departments: organising a degree with two home departments can be a difficult balancing act.

Methods training
When the degree was first established, our aim was to train students in a wide range of methodological skills in psychology, computing, and mathematics. In practice, we have found methods training to be one of the most problematic areas of the degree. The acquisition of programming skills has always proved difficult for a minority of our students and has lead to a significant number leaving the course (generally in the first year). To counteract this problem we have, over several years, reduced the amount of core training in computing methods. The question of whether Cognitive Science students should be trained in software design skills in addition to basic programming has also been a subject of some contention. This issue highlights a problem of teaching a degree which, to some extent, is like a dual honours, but in other ways is trying to target a specific mix of interdisciplinary skills (i.e. those required for computational modelling). Software design is clearly an important subject for students who go on to further training or employment in computing, however, it seems only tangentially related to the core subject matter of Cognitive Science (whatever that may be!). After much deliberation this subject was finally dropped from the core curriculum in 1997 to make way for (what was felt to be) more directly relevant material. Mathematics training has been another bugbear. Having, at various times, placed our students on applied mathematics courses taught in the context of other disciplines, we have found that the only truly satisfactory way to obtain the maths training we want is to provide a maths primer tailored to our students.

3 A Change of Tack: The New Degree in Psychology & Cognitive Science

By 1997 changes in personnel in the Department of Computer Science had resulted in an increase in staff with an interest in Artificial Intelligence. This led to the proposal of a new degree in 'Artificial Intelligence and Computing Science'. With respect to the existing degree in Cognitive Science, it was then agreed that there should be a 'parting of the ways', with Psychology introducing our own degree in 'Psychology and Cognitive Science'. The rationale for this change was the perception that within past cohorts of Cognitive Science students, we had often seen two different 'species', those for whom AI/Computing was a natural habitat and those whose bias was towards Psychology/Computational modelling. Under the modular system at Sheffield both new degrees could take advantage of relevant modules taught in the other department without requiring joint administration. A third reason for the change (from the specific perspective of Psychology) was the problem of recruiting good students to the Cognitive Science degree. Although the Cognitive Science course had always filled its quota, this had never been entirely straightforward. In contrast, the Psychology single honours degree has always been heavily over-subscribed. It was hoped that by increasing the psychology content of the degree (and by including 'psychology' in the title) more good students would be attracted to apply. It is
probably fair to say that there was also some relief, in both departments, at the
prospect of being able to run their own degrees without needing to adopt
compromises required to satisfy the other participant.

A summary of the new degree in Psychology and Cognitive Science, which
has been phased in gradually from 1997-98 onwards, is given in the appendix.
Several features of the degree deserve mention, although it is too early to
judge whether the changes we have made have all been for the better. First,
we have recognised that many of our students want the possibility of a
professional qualification in Psychology, so we have made the path to full
membership of the British Psychological Society easier to follow. Second, we
have reduced to a minimum the amount of required methods training in the
first year (though, of course, students are encouraged to take additional
methods courses as options). Programming and mathematics methods (other
than statistics) will now be taught only in the second year in a module that
will be more directly linked to final year projects in computational modelling.
Finally, we have lessened our emphasis on subjects such as neural networks
and computer vision which required substantial technical training. Instead,
we are providing broader courses in cognitive modelling that use pre-built
computer simulations as the primary vehicle for lab teaching (a downside of
this approach is that modules of this sort require a great deal of preparation).
Technical courses, in various topics, are still available as options for students
who want advanced training in methods.

One of our goals in reducing the technical content of Cognitive Science
modules, is to encourage more students from other degrees (particularly
straight Psychology) to take these courses. This should help to raise general
awareness of the subject within the University (possibly attracting good
students to the degree by internal transfer), and will also create a more
economically-viable base for the specific teaching we provide for this small-
cohort degree (about 17 students p.a.).

Where are we trying to get to?

Why have we taken this route in redesigning our degree? An analogy might
help to illustrate our current position:

A traveller passing through Limerick asks one of the locals how to get to
Dublin. His reply 'Ah, my friend, so its Dublin you're wanting: well I
wouldn't start from here if I were you'.

Essentially, having started out for Dublin (our notion of the technically
sophisticated Cognitive Science degree), and having walked into several bogs,
we are now adopting the more modest goal of exploring the gentler
countryside around Limerick (where we are in Psychology) though tending
toward the Dublin side. In other words, our new degree tries to give students
some education in Cognitive Science while providing a solid foundation in a more traditional discipline and exploiting our particular strengths in teaching both Psychology and Cognitive Modelling. Admittedly, we have stopped short of our original goal (objective ii), to produce fully-fledged Cognitive Science researchers, but we hope to produce graduates with some basic skills, and enough knowledge and sophistication, to succeed on the right type of post-graduate training program.

4 Unresolved issues

Our current position reflects a number of hard choices that we have had to make. Our continuing efforts to improve and modify the course are motivated by a number of key issues which are summarised in the following questions, and which also serve as our conclusion.

What is Cognitive Science?

There is a lack of consensus both about scope of the term 'Cognitive Science' and also about its core subject matter. Currently course designers are left to decide this question themselves, but our collective answers, nationally and internationally, could influence the future shape of our subject.

How Technical?

Research in Cognitive Science often demands a high-level of understanding of computing and applied mathematics. Although the subject matter of Cognitive Science is interesting to many undergraduates, the reality of learning about Cognitive Science can seem very technical and 'hard'. Some of the questions we need to answer are: To what level do we wish to train graduates in the technical skills required to do Cognitive Science research? How can we strike a balance in teaching the subject between the 'gee-whizzery' of demonstrations (e.g. neural nets that learn to talk) and the hard grind of understanding the underlying machinery?

How can we sell Cognitive Science?

We have always found it more difficult to recruit school leavers to our Cognitive Science degree than to our undergraduate degrees in Psychology. This problem has been stubbornly resistant to several attempts to improve our promotional material and advertising. A central difficulty, we believe, is that the term "Cognitive Science" is too unfamiliar to our target audience of sixth formers. A second problem may be the lack of any perceived link between Cognitive Science training and specific vocations or forms of employment outside the research arena. Questions that need to be answered include: How do we raise awareness of Cognitive Science in schools and amongst potential employers? Is there any co-ordinated action that could be
carried out across the UK Cognitive Science community which could help to raise the profile of our field?

**Acknowledgements**

We are grateful to John Frisby, one of the original motivators of Cognitive Science teaching at Sheffield, and to all our colleagues in Psychology and Computer Science at Sheffield who have contributed to Cognitive Science teaching or discussions on course design. Particular thanks go to Rod Nicolson, Peter Scott, John Porrill, Mark Hepple, Peter Green, Yorik Wilks, Mike Holcombe, and Noel Sharkey.

**References**


**Appendix: the Degree in Psychology and Cognitive Science at Sheffield**

In each year students take a total of twelve half-modules (or six full-modules) spread over two semesters. Except where indicated all the modules listed below are half-modules. Asterisks indicates modules provided primarily as support for this degree.

First Year
- Discovering psychology (full-module)
- Discovering cognitive science*
- Psychology and everyday life (full-module)
- Methods and reasoning for psychologists
- Introduction to philosophy (half or full-module)

Four or five further level one half-modules
- Second Year
- Language, memory, and thought
- Perception and learning
- Neuroscience and behaviour
- Psychological methods I
- Thinking and study skills for psychologists

20
Models of mind*
Psychological methods III: computational models*

Three further approved half-modules in psychology, artificial intelligence, or philosophy

Two unrestricted half-modules
Third Year Research project (three half-modules)
Co-operative models of mind*
Computational neuroscience*
Visual perception

Six further approved half modules in psychology, artificial intelligence, or philosophy

Module descriptions for courses with a substantial Cognitive Science component are given overleaf, these descriptions are adapted from the University calendar.

Discovering Cognitive Science

This module introduces Cognitive Science by considering contrasting approaches to modelling and understanding cognitive processes. The lectures describe important computational models from the Cognitive Science literature and relate them to research on human cognition, while in practical classes, students investigate and experiment with these same models using purpose-built demonstration programs. The behaviour of the models investigated here shows many striking similarities to human cognition, and is contributing to a new understanding of how the mind/brain works.

Models of Mind

This module continues the exploration of approaches in cognitive science begun in the first year. The common theme is the use of computer models to understand the function of the human mind and brain. The symbolic approach in cognitive science views intelligence as the manipulation of structured representations using rules. This approach will be investigated by examining symbolic models of the human cognitive architecture. A more brain-oriented approach is taken in the connectionist modelling (neural networks) and in computational neuroscience. These approaches will be explored through models of vision, motor control, and behaviour selection. Cognitive science is rapidly growing field so an important aim will be to track some of the contemporary trends in research in cognitive science.

Psychological Methods III: Computational Models
This module provides students with the basic mathematical and programming skills required for understanding and building computational models of cognition. These topics will be introduced in the context of interesting problems in Cognitive Science such as modelling human vision.

Cooperative Models of Mind

This module examines models of the mind inspired by the architecture of the brain and by the 'style' of biological cognition. A central thread is the idea that complex, intelligent systems are made-up of large numbers of relatively simple, co-operating sub-systems. The main focus of the module is on dynamic systems and connectionist (neural network) approaches to understanding human development and cognition.

Computational Neuroscience

This module deals with computational models of specific brain systems. Typically these models will be neural networks that are tightly constrained by the available neuroscientific data and whose circuits are based on the known connectivity of the corresponding neural tissue. Such models are making an important contribution to our understanding of how neural circuits function in normal brains and dysfunction in damaged brains.

Visual Perception

This module explores selected topics in visual perception, in each case linking psychological, neuropsychological and computational approaches.
Moving the Psychological Soar Tutorial to HTML:  
An example of using the Web to assist learning

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Abstract

This report on updating and translating the Psychological Soar Tutorial into an online version based on the HTML mark-up language and viewable through the World Wide Web. There are several lessons for those who would like to move teaching documents onto the web. We note the ways in which it is not easy. The payoff should be carefully computed first. There are several tools that are likely to be useful. An extended version of this abstract may be available from the first author.

1 Background

Cognitive modelling, like the use of simulation in other sciences, consists of creating mathematical models implemented on a computer. Cognitive models simulate human cognition by duplicating the information processing.

Specialised computer languages, called cognitive architectures, are used to implement this information processing. The idea is that the mechanisms, power, and limitations of the computer language duplicates the mechanisms, power, and limitations of human cognition. The programs represent the knowledge humans use to perform the same task. Programs in these languages should perform a task in the same way and the same pace as a human with the same program (or knowledge). These cognitive architectures are an important trend in psychology, one that advanced students should be exposed to if not converted by.

Soar is an example cognitive architecture. There are over fifty people around the world working with it to characterise human behaviour. It intentionally suffers under several known constraints of human behaviour, such that while memory access is rapid, learning facts is slow and must be deliberate.

Work with these cognitive architectures have been often limited by training materials. The best way to learn in the past was to visit an existing site and serve a two to 18 month apprenticeship. In 1993 we prepared a six to eight hour tutorial to teach workshop participants about Soar. Over the next two years we offered it five times at conferences and workshops (Ritter, Jones, & Young, 1996; Ritter & Young, 1994). In 1995 we received a grant to move the tutorial to the web to be used as a foundation for an advanced undergraduate / postgraduate class at Nottingham.

2 The teaching and learning environment

The initial tutorial consisted of about 30 overheads, two sample programs (models), printouts of sample runs, and thirteen exercises and answers. With a summer student's help, we translated the overheads from Word to HTML using a program called RTF2HTML. The 30 overheads were revised by us and the student, who had taken the tutorial, and additional textual and graphic material was included. Hypertext links were added to the overheads, including references to glossary items, to the exercises, and to other web-based help resources on Soar and cognitive modelling. The tutorial is at <http://www.psychology.nottingham.ac.uk/staff/ritter/pst-ftp.html>.

3 Student Assessment

Ritter initially believed that students would quite willingly sit down in the first class meeting and read the tutorial while he sat quietly waiting in the background for questions. The first time he tried this at Nottingham, in 1996 the students rebelled and demanded lectures to be presented. (Although when the web version was introduced at a workshop, the audience clapped.) Since then, the online tutorial has only been used as an adjunct textbook for students' revision and use during programming exercises, a purpose it serves very well. Because the material appears more polished students appear to take the material more seriously, and they often print it. They appear to have less questions about programming in Soar, and also appear to have less misconceptions because they can review the explanations and rationale for this approach. The online tutorial appears to be mostly used for help and reminders while doing the exercises.

A key aspect of such a course is hands-on experience manipulating and extending cognitive models. The exercises are now well understood and have been adjusted to provide a reasonable but increasingly difficult series of tasks to teach the practical implementation of theoretical constructs. In earlier versions of this and other materials for teaching about programming cognitive architectures, there have been dishearteningly difficult problem sequences. Answers are available for most of the exercises, but some answers are not provided so that as the exercises can serve as continuously accessed work. Having the material on the web supports revi-
sion by the students and continual updating by the instructor.

Students at Nottingham have a week between hourly lectures to complete the exercises. Those students who spend 30 to 60 minutes working will generally get full marks. People taking the tutorial at a workshop can see in ten minutes what working with Soar would be like, but do not have time to complete the exercises. While this seems somewhat odd, it works well. They can see what the question is, what types of knowledge would be necessary, and what the answer should be like. They just do not develop the full ability to answer the question. This approach allows a more complete story to be presented in limited time.

Completion of the tutorial leaves students ready to pursue independent work creating cognitive models. This level of sophistication is rarely achieved at an undergraduate level. While none of these projects have lead to fully published work, one of the models has ended up as examples in the published Soar code, and several more have been archived as useful starting places for models.

The materials have been used at other universities for formal classes (Scotland, Japan, Australia, and Bulgaria) and for informal study (e.g. Brazil, Australia). Oddly enough, we have mostly found out about their use accidentally. Only one person has asked us or told us that they are using it.

4 Evaluation

This tutorial has been offered three times at Nottingham as part of an advanced class, and ten times at conferences and once as staff development at a university. This and associated work is mentioned as an important part of the Soar enterprise by the (US) National Research Council (Pew & Mavor, 1998).

The development of the Psychological Soar Tutorial, including the move to the web, would not be worth doing if there was just a single audience. However, it has been useful for us, teaching undergraduates, training post-graduates, and for the Soar community.

There were several resources that made this work possible. It was useful to have help with the translation to HTML. This amount of effort, about eight weeks of a summer student, can be done on your own, but it would have been hard to find this time.

It was useful to have technical support, people nearby who were familiar with HTML and the web. They were able to help us over some technical hurdles at crucial times. Without them, we would have had to spend an extra week of reading to find the answers, which were available but not simple.

If you are considering developing such online materials, you should keep your audiences in mind, and the costs and benefits should be carefully weighed. These particular materials did not recoup their cost from any single audience. The development was worthwhile because there were multiple audiences. For example, for only 10 students a year, it would not probably not be worth the effort to move material onto the web. It would be better value to photocopy the handouts each year. On the other hand, we now often prepare OHPs and teaching materials in HTML, which removes the need for translation.

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References


A Zoo of Browsable, Runnable Cognitive Models

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An important component of the Cognitive Science curriculum is the study of cognitive modelling, which requires the design, construction, and analysis of symbolic (i.e. non-numerical) models, run on a computer, to simulate the cognitive processes involved in the performance of a task and produce a performance that matches the empirical data on performance (usually human) on the task.

There are difficulties with traditional methods of teaching cognitive modelling to undergraduates (though many of the difficulties apply to graduate-level teaching too). A cognitive model is typically a complex computer program, and requires considerable time and a range of programming and software design skills for its construction. Having students build their own models takes much time and effort, restricts the students' experience to small, "toy", models, and is beyond the ability of some students. Having the instructor build and provide the models places additional burdens on the teaching load and provides access to just one or a very small range of models.

Thanks in part to two recent developments, these problems are becoming potentially solvable. One development is the increasing use of "cognitive architectures" as frameworks for constructing cognitive models, so that the models do not have to be written from scratch. The second is the spread of the World Wide Web (WWW), which provides relatively easy means for researchers to make their models available to others.

The aims of the "Cognitive Zoo" are (1) to assemble a "zoo" of runnable cognitive models, and (2) to provide access to the models and to related information (data, published reports, user documentation, etc.) through a simple hypertext browser. As with an ordinary zoo, the collection provides the opportunity for visiting a range of exhibits with only modest effort by the student, as well as the possibility of studying some of them in more depth.

Various points about the Zoo may help to clarify its nature:

- The Zoo is NOT a piece of "instructional technology". Like a real zoo, it's potentially a resource for learning.

- The Zoo in no sense aims for "completeness". Instead, it presents a representative selection of models.

- Even though the Zoo is aimed primarily at students, once it exists and is populated, it is likely to be useful also for researchers — because it makes it so much quicker and easier to try others' cognitive architectures and models.

The main part of the Zoo is organised under Tools and Architectures, with one or two representative models in each. The intended coverage is something like:

Tools
CLIPS
COGENT
LISP etc.

Cognitive Architectures
ACT
Soar
CAPS
Construction-Integration

Although this list so far includes no purely connectionist models — primarily in order to correct the imbalance in the availability of introductory texts and software — there is no reason why connectionist models should not be added later.

To date, we have finished most of the design, and have implemented a complete "vertical strand", i.e. the material dealing with one modelling tool and one model, including source code, exercises, and references. So the existing Zoo is thin on content, but has basically one example of everything that will be in the finished Zoo. The work so far, although seemingly modest in its ambitions, has pushed us hard against the capabilities of the technology we are using.