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Centre for Cognitive Science

and

Human Communication Research Centre

Handbook 1989 – 1990

University of Edinburgh

Contents

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Intended Audience

This handbook is primarily for the use of students who are considering a postgraduate course in cognitive science. It is therefore a concentrated source of information about the Centre for Cognitive Science and the Human Communication Research Centre. Given this, it should also be of use to those with a general interest in the research activities and facilities of these two institutions.

Abbreviations

In this handbook, the Centre for Cognitive Science is generally abbreviated to CCS, and the Human Communication Research Centre is abbreviated to HCRC. Other abbreviations are explained where they occur.

1 Personnel

Members of the Centre for Cognitive Science

Ewan Klein
Head of Department
Ellen Bard [Linguistics]
Ingemarie Bethke [Computer Science]
Robin Cooper [Artificial Intelligence]
Elisabet Engdahl [Artificial Intelligence]
Brendan McGonigle [Psychology]
Terry Myers [Psychology]
Paul Schweizer
Keith Stenning [Psychology]
Henry Thompson [Artificial Intelligence]
David Willshaw[1]

Associate Members

Robert Ladd [Linguistics]
Gordon Plotkin [Computer Science]
Graeme Ritchie [Artificial Intelligence]
Peter Whitelock [Artificial Intelligence]

Where members are also associated with departments other than the Centre for Cognitive Science, this is shown in parentheses.

[1] MRC External Scientific Staff

Principal Investigators of the Human Communication Research Centre

Anne Anderson [Psychology, Glasgow]
Ellen Bard [Linguistics, Edinburgh]
Robin Cooper [Artificial Intelligence/Cognitive Science, Edinburgh]
Elisabet Engdahl [Artificial Intelligence/Cognitive Science, Edinburgh]
Simon Garrod [Psychology, Glasgow]
Stephen Isard [Linguistics, Edinburgh]
Ewan Klein [Cognitive Science, Edinburgh]
James Miller [Linguistics, Edinburgh]
Anthony Sanford [Psychology, Glasgow]
Keith Stenning [Psychology/Cognitive Science, Edinburgh]
Rosemary Stevenson [Psychology, Durham]
Henry Thompson [Artificial Intelligence/Cognitive Science, Edinburgh]

Research Staff

Centre for Cognitive Science

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Neil Leslie
Michael Malloch
Marc Moens
Glyn Morrill[2]
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Luis Pineda
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Human Communication Research Centre

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Robert Dale [Edinburgh]
Gwyneth Doherty [Glasgow]
~~Martin Gemmell [Edinburgh]~~
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Catherine Sotillo [Edinburgh]
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Alex
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[2]SERC Postdoctoral Fellow
[3]British Academy Postdoctoral Fellow

2 The Centre for Cognitive Science

The Centre for Cognitive Science was established in 1969 as 'The School of Epistemics', and from the beginning the aim has been to contribute to the development of cognitive science through both research and postgraduate teaching.

In the early years, the activities consisted mainly of short courses coupled with particular research projects. The success of these ventures, together with the maturing of cognitive science, led in 1978 to the founding of the Postgraduate Programme in Cognitive Science, which has now grown to over 50 students, a third of whom come from overseas. To ensure stable growth, in 1985 the University established the Centre as a department in the Faculty of Science, with special links to five collaborating departments: Artificial Intelligence, Computer Science, Linguistics, Philosophy and Psychology. The Centre currently has a core staff of eleven members, most of whom are either jointly appointed with, or partly seconded from, the collaborating departments. There are also four associate members whose appointments are in collaborating departments.

The research programme of the Centre, though covering a wide range of topics, is directed towards the study of language and related cognitive processes, mainly from a computational perspective.

At present there are several research projects in progress, with funding from ESRC, from the Joint SERC/ESRC/MRC[4] Initiative in Cognitive Science and Human-Computer Interaction, and from the European Community ESPRIT Programme. In particular, many of the research activities detailed in this handbook are encompassed by an ESPRIT Basic Research Action, *Dynamic Interpretation of Natural Language*, DYANA. The range of projects in CCS and HCRC, and the associated postdoctoral fellows, are broadly representative of current interests in cognitive science. Supported by a well-developed system of collaboration, the Centre provides a rich and integrated environment for research in cognitive science.

3 The Human Communication Research Centre

The Economic and Social Research Council together with the University Grants Committee has awarded Edinburgh and Glasgow Universities a grant of about £350K per year over the next five years to establish an Interdisciplinary Research Centre in Human Communication. The organisation—HCRC for short—

[4] ESRC: Economic and Social Research Council
SERC: Science and Engineering Research Council
MRC: Medical Research Council

is attached to CCS as an independent ESRC designated research centre. It has been established through substantial contributions, chiefly in the form of senior staff, from the departments of Artificial Intelligence, Cognitive Science and Linguistics in Edinburgh, and Psychology in Glasgow University. It is located in Buccleuch Place, with additional accommodation in the Psychology Department in Glasgow.

HCRC's research focuses on knowledge and inference in human communication and on real language processing. It has a training function at the post-graduate and post-doctoral levels, and has accommodation for both national and international scientific visitors. HCRC actively pursues training and research links with outside users in both the public and private sectors. In the medium term, it is expected to generate matching external funds, and a long term goal is to achieve independence from Research Council funds.

4 The Postgraduate Programme in Cognitive Science

The Centre for Cognitive Science offers a programme of postgraduate studies in cognitive science, centred on the study of language and the cognitive processes involved. The programme, in cooperation with the Departments of Artificial Intelligence, Computer Science, Linguistics, Philosophy and Psychology, leads to the degrees of PhD, MPhil and MSc.

It is designed to help students acquire a secure knowledge of the principles and formal techniques in four of the relevant disciplines: computational linguistics, cognitive psychology, formal semantics and theoretical linguistics. Through its intensive training programme, the Centre aims to produce well-trained scholars to undertake research on outstanding problems in this rapidly developing field.

4.1 Type of Programme

In the first term of the first year students attend four courses covering the following subjects:

- Computational Linguistics
- Cognitive Psychology
- Formal Semantics and Logic
- Theoretical Linguistics

In the second term, students specialise in two of these four courses, and also attend additional interdisciplinary courses which draw together the subjects, by focussing on specific issues on which they offer differing perspectives. In May, degree candidates sit four written examinations based on material drawn from the courses, and show a basic facility to program in PROLOG, for which there is an appropriate introductory course.

Each student is assigned two supervisors, normally with different but related expertise. During the first year (in addition to course work) the student works with his or her supervisors to formulate a detailed research project.

Given satisfactory performance in the first year of study, a student may be recommended for registration for the degree of either PhD or MPhil. Although course work is an essential part of the Programme, the award of a degree is determined solely on the basis of a thesis submitted in accordance with University regulations. The MSc is a one-year degree awarded for satisfactory course work and a dissertation.

4.2 Curriculum

Computational Linguistics

The first term provides an introduction to the programming language PROLOG and some basic computational notions and techniques associated with natural language processing. Practical exercises allowing critical assessment of these techniques are set on a weekly basis. The topics covered include: data structures in PROLOG, definite clause grammars, miscellaneous programming techniques, and parsing algorithms, including in particular those for chart parsing.

The second term examines in depth some current research issues in computational linguistics. Detailed practical examples are examined using PROLOG. The topics covered include: complexity, graph unification, and the relationships between unification and grammatical formalisms including PATR and categorial grammars. We go on to discuss the computation of semantic representations, including the problems raised by quantifier scope, and the issues which arise from processing connected discourse. We end by discussing some issues relating to the social responsibility of computational linguists. By the end of two terms, students should be capable of designing and implementing non-trivial programs.

Cognitive Psychology

The first term begins with an introduction to computational theories of mind. This general, partly philosophical, introduction is followed by illustrations from

the literature on human memory and reasoning. An introduction to speech perception and human sentence processing is followed by lectures on the representation and processing of lexical concepts.

The second term is intended to cover the research approaches and methods used in psychological research in the Centre. It contains sections on PDP modelling, developmental approaches to representation and inference, and the organisation of the lexicon and lexical access.

Throughout the course every effort is made to integrate what is known about human language processing with the formal characterisations of language that are developed in the other three quarters of the course.

Formal Semantics

In the first term a systematic course is given, proceeding from propositional and predicate logic to tense and modal logic. The main objective is to introduce sufficiently rich foundations on which to explore concepts and questions of interest to the semantics of natural language.

The second term extends this basis with a survey of a number of richer logical systems, such as the theory of types, and demonstrates the application of these in a logical grammar. At the beginning stands a thorough discussion of Montague's pioneering work. Subsequent post-Montagovian developments, e.g. partial logics, are then considered. In addition, semantic descriptions of fragments of natural language will be examined.

Theoretical Linguistics

The first term provides an introduction to the methodology and concepts of linguistics, to the major constructions types of English, and to key theoretical ideas in generative grammar. Among the topics covered are constituency and X-bar theory, unbounded dependency constructions and empty categories, constraints and linguistic universals. One transformational (government-binding) and one non-transformational (generalized phrase structure grammar) approach to these topics are discussed and compared.

In the second term, we turn to grammatical approaches which encapsulate a large amount of information into lexical entries and which exploit the expressive potential of complex feature structures. Particular attention is paid to head-driven phrase structure grammar and to various versions of categorial grammar. A key concern is the interaction between different levels of linguistic representation, particularly syntax and semantics. A second important theme is the use of inheritance hierarchies in the lexicon as a tool for expressing generalizations.

5 Research Interests of Staff

5.1 Members and Associates of CCS

Ellen Bard

My work is centered around the higher level factors operating in the production and recognition of spoken words. This has led to two rather different kinds of interest. First, I am interested in the particular kinds of contextual information which bear upon how words are produced and how they may be decoded from the speech signal. Secondly, I am interested in the general architecture of the mechanisms whereby words may be recognized in meaningful running speech. Specific areas of interest include:

1. The constraints imposed on parsers by the fact that words in spontaneous speech are unlikely to be recognizable one by one in chronological order.
2. The constraints imposed on models of speech recognition by the acoustic under-determinacy of words in spontaneous speech; in particular the extent to which the modularity of lexical processing is affected by local word intelligibility.
3. The role of extra-sentential and extra-linguistic information in the encoding and decoding of word tokens in spontaneous speech.
4. The implications of variations in word intelligibility for automatic speech recognition.

Ingemarie Bethke

My main research interests lie in the areas of mathematical and linguistic semantic theories. I am currently working on topics within the semantics of pure and applied type theory and the theory of applicative structures, especially lambda calculus and combinatory logic, which also offer various ways for describing phenomena in natural language.

In addition to this, I am involved in collaborative research on intensional logic that explains temporal and modal contexts in natural language semantically via spatio-temporal references; these are related to shifting patterns through time and certain sets of relevant worlds or situations.

Moreover, I am interested in the recent move from 'total' to 'partial' views of semantic entities and linguistic interpretation, a move that represents a modification in the interpretation of formal semantics rather than a shift in its basic conception.

My research in the past has also been concerned with phenomena occurring in constructive mathematics and intuitionistic logic.

Robin Cooper

My main research interests are syntax and semantics of natural language and their relationship to natural language processing by computers. I am working on situation theory and situation semantics and their relationship to computational unification formalisms provided by PROLOG and PATR. A particular focus of this research is quantification in natural language. Current projects include a book, *Introduction to Situation Semantics*, and a paper with Elisabet Engdahl, 'Long Distance Dependencies in Situation Semantics'.

Previously I have carried out work in the Montague tradition, including integrating Montague's semantics with transformational grammar and the development of a technique of quantifier storage to account for scope interpretation and long distance dependencies without complicating the syntax.

I am also interested in Germanic languages and recently have been pursuing work on Swedish syntax and semantics.

Elisabet Engdahl

Natural languages vary considerably but not randomly. Much of my research has involved looking at patterns of variation across languages, especially with respect to so-called unbounded dependencies, i.e. relative clauses, topicalizations, and constituent questions. One conjecture that has come up is that natural languages typically display binary dependencies whereas no natural language uses constructions that would require triple dependencies of the form $a^2b^2c^2$. This raises some interesting questions for the formal characterisation of natural language as well as for models of human processing. Within several recent linguistic theories it is customary to talk about systematic variation among languages in terms of parameter settings. I am currently interested in studying how notions like parameter setting can be employed in writing implementable grammars for related languages.

The semantics of questions is another topic which interests me a great deal. I have recently started to analyse questions using notions from situation semantics and want to look further at possible implications for the use of relational databases in question-answering systems.

I am also involved in a project called STAGR (Situation Theory and GRammar) which investigates how analyses of natural language phenomena bear on the formulation of situation theory and vice versa.

Ewan Klein

Most of my research has been concerned with developing formal grammars for fragments of English. Emphasis has varied between the syntax, the semantics, and the interconnections between the two. To date, the phenomena I have studied include referential opacity, comparative constructions, control verbs, pronominal anaphora, and verb phrase ellipsis.

Recently, I have been involved in collaborative research on a grammar framework, dubbed *unification categorial grammar*, that combines categorial grammar with devices from unification-based grammar formalisms. Grammatical representations in such a framework contain partial information about (at least) three dimensions of linguistic description, namely semantics, syntax and phonology, and the grammar provides a parallel inductive definition of well-formedness on each of these dimensions. Since both semantics and syntax have been treated with reasonable success in this manner (though many problems remain), I am currently interested in the problem of how to integrate detailed phonological information into the same framework. Once this has been achieved, the hope is that it will be possible to capture some of the complex and subtle constraints which arise in the interfaces between phonology, on the one hand, and syntax and semantics on the other hand.

Bob Ladd

My research interests over the past fifteen years have focused on intonation and prosody. My doctoral research dealt extensively with phenomena like the placement of sentence accent and the relation of linguistic to paralinguistic (emotional, expressive) aspects of intonation, but since then my primary concentration has been on intonational phonetics and phonology.

Since 1982 my major long-term project has been to analyse the system according to which intonational targets are scaled relative to each other, and the relation of that system to syntactic structure and prominence. I have developed a model of pitch realisation (which incorporates various aspects of work by Clements and by Pierrehumbert and her colleagues) which has been implemented in the text-to-speech system developed at the Centre for Speech Technology Research in Edinburgh.

Other background interests outside the major area just outlined include:

1. Tone systems, especially intonational aspects of tone systems.
2. The theory of Lexical Phonology, in particular the problem of distinguishing lexical, post-lexical, and phonetic realisation rules, and the question of what sort of representation is output from the lexical rules.

Brendan McGonigle

The aim of my research is to examine a functional or task motivated decomposition of the cognitive processes underwriting inference in human and non-human primates. A prime candidate for such decomposition is the ability to seriate, where, conventionally, children are required to copy a model series by assembling blocks of (say) ascending size. Essentially modular, the approach stresses the need to analyse intelligent systems into functionally separable and relatively independent sub-systems, in order to help determine the cognitive properties which may emerge from task domains which demand their coalition.

The general aim is to help establish a strong theory of how cognitive skills are acquired and to account for transitions in such competence over evolution and development.

Terry Myers

My research takes as its main objective a psychologically adequate characterization of the semantic representations that mediate between forms and meanings in language understanding. At the word level, which is the current focus of my work, these are widely assumed to be lexical concepts. The research programme begins, accordingly, by examining the problem of characterizing lexical concepts and of determining how they combine.

Concepts have played a traditional role in theories that treat categories of thought as the stable basis of linguistic communication. In classical accounts, a concept is the set of properties that define membership of the category it represents. Understood in these terms, concepts lead readily to deductive treatments of representation and inference. However, the theory that arises from such an approach does not capture the observed variability of meaning in dynamic contexts of reasoning and discourse, where semantic inferences tend to be non-monotonic. Moreover, recent attempts to meet these shortcomings, within the framework of Prototype Theory, have also been largely unsuccessful. The work examines the theoretical consequences of adopting the alternative view, that categories of thought are inherently unstable and that a theory of concepts must treat their combinatorial flexibility as central.

The aim is to develop a computational theory of concepts and concept combination that will accommodate the semantic flexibility of natural language processing. This is found to be a subtly pervasive property. For example, in a noun phrase, the meaning of the adjective may vary according to the meaning of the noun with which it combines (e.g. *red hair*, *red wine*), and the meaning of a noun may vary with the choice of adjective (e.g. *hungry lion*, *stone lion*).

Gordon Plotkin

My interests are mainly in the semantics of programming languages in the Scott-Strachey tradition, although I remain interested in a variety of formal languages and their semantics.

One part of my research concerns the refinement of the semantic models to reflect one's computational intuition. This has entailed moving from complete lattices to complete partial orders to partial functions. The move avoids a certain mathematical coding and permits very clean tie-ups with operational semantics, which offers a contrasting 'symbol-pushing' approach to programming languages. I have developed this together with other colleagues in the Computer Science Department, notably Robin Milner and Rod Burstall. In attempting to refine these models, I have been interested in the study of concurrency, which entails the need to consider nondeterminism.

I am also interested in developing situated approaches to the semantics of natural language, and in particular, Jon Barwise's situation theory.

Finally, it is clearly important to use the semantics to find logics of programs (to state and prove correct their specifications). Recently intuitionistic formalisms have come to be seen as particularly promising. Since constructive mathematics is surely intimately related to programming, this is perhaps not surprising. It is significant that such potentially useful ideas have roots in the endeavours of philosophical logicians.

Graeme Ritchie

My past research has included the parsing and semantic interpretation of English sentences, the representation of temporal information, generation of English text, and computationally feasible mechanisms for morphological processing.

More recently, my work has been largely concerned with formal properties of linguistic mechanisms, and the practical implementation of natural language query systems (to back-ends, such as databases).

Paul Schweizer

My primary area of specialization is philosophical logic and the philosophy of language, and I am also interested in epistemology and the philosophy of mind. In the field of philosophical logic, my research is presently concerned with the detailed formalization of a metalinguistic approach to modality, wherein necessity is construed as a predicate attaching to codes of syntactical objects, rather than as an operator attaching directly to statements. In this manner, the formal

modal device is interpreted simply in terms of first-order models, which shows that possible worlds semantics is not a prerequisite for doing standard modal logic. Since the necessity operator shares many of the structural characteristics of the knowledge operator, this work is also directly related to current issues in the field of knowledge representation, and indicates that knowledge can be consistently formalised as a first-order predicate attaching to names of formulas.

In this connection, I am also very interested in the phenomenon of linguistic self-reference, which plays a central role in the antinomies that have threatened the predicate approach to truth, necessity and knowledge, and which was originally used in Gödel's incompleteness results to construct self-referential assertions about provability. Diverse strategies have been developed for coping with the formal ramifications of circularity and self-reference, and I am presently studying the effects of limiting the scope of the axiom schemas through the use of arithmetical predicates which sort the codes of object language expressions.

Another area of current research is singular reference in natural language, particularly via complex singular terms and definite descriptions, and the modifications of classical logic which are motivated by cases in which grammatically proper singular terms fail to refer.

Keith Stenning

My central research interest is in memory for knowledge acquired through language. Processes of inference and belief revision are integral to a satisfactory account of memory. Pecific areas of interest are the following:

1. Experimental studies of memory for individuals which are successively specified in text. The theoretical goal is to explain how human memory for novel particulars is dependent on general knowledge, and how the 'binding' of properties to individuals is achieved by knowledge-rich means. This in turn leads to questions about:
2. The interface between Working Memory and Long Term Memory, and in particular the role of rehearsal processes in this interface. The fundamental problem is to explain how the contents of Working Memory after a 'retrieval' are interpreted as having the significance assigned.
3. Studies of inductive and deductive processes in human inference and their content-dependence. I am particularly interested in using techniques developed for studying memory to analyse the representations which occur during processes of reasoning.
4. The role of Parallel Distributed Processing systems in theories of all of the above. These systems interest me because they have an architecture in which resource limitations are not readily separated from processing

elements. For a psychologist, effects of resource limitations on processing are the main object of theoretical interest, rather than an aspect of the data which can be idealised away.

Henry Thompson

My research interests divide into a number of areas—broadly speaking, computational linguistics, cognitive science and, bringing those two together, speech recognition.

In computational linguistics, I have worked extensively on fundamental issues in parsing and its relation to linguistic theory. In particular I have been interested in the methodology of active chart parsing, producing and working within a widely distributed modular chart parsing framework. The possibility of exploiting parallelism in it is now being explored. I have also formulated a methodological stance intended to clarify the relationship between computational and theoretical linguistics by suggesting that both might profit from a distinction between macro-notation and micro-formalism, the connection between the two being akin to compilation.

In cognitive science, my main interest is the human sentence processing mechanism HSPM, particularly in the area of lexical access—the process whereby the HSPM individuates and identifies the words which make up the stream of incoming speech. In collaboration with colleagues in CCS, theories about possible architectures and processing modules for this task have been developed and in some cases subjected to experimental test.

The study of speech recognition brings these interests together in efforts to construct large-scale speech input systems. Over the last five years I have been involved in a large research and development effort under the auspices of the Alvey Programme, directed towards a complete data path from spoken input to textual output. Here, I have explored an explicit rule-based approach to segmentation and labelling at the phonemic level, and the integration of this with stochastic mechanisms for improved flexibility and robustness.

Robustness is also the key in ongoing work in the area of lexical access for speech input systems, where we are trying to combine top-down filtering from syntactic processing with a flexible mapping between phonemic and lexical hypotheses, mediated by finite-state transducers for the representation of both system-induced and hearer-induced irregularities.

Finally, under the recently inaugurated Esprit Basic Research Action (DYANA) and in HCRC, I am exploring the possibility of replacing the admittedly *ad hoc* approach we are now using (semantic grammars) with a more principled approach based on incremental interpretation.

Peter Whitelock

My research is concerned with the development of grammars for English and Japanese. I assume a unification or constraint-based framework. Lexical entries consist of sets of constraints on form and meaning which are monotonically incorporated into derivations, with partiality replacing the traditional procedural characterisation of linguistic phenomena.

I am particularly interested in two application areas of constraint-based grammars. The first of these is machine translation. Traditional approaches have assumed a paradigm in which abstract levels of linguistic representation are successively computed. The constraint-based approach offers a more opportunistic and flexible way of integrating information from diverse 'levels'—syntax, semantics, pragmatics, discourse etc. and a more direct way of putting the grammatical systems of the languages concerned into correspondence.

Secondly, within the field of speech generation, the constraint-based approach provides a framework for formalising and implementing current non-linear theories of phonology such as metrical and autosegmental. This offers the possibility of moving away from the procedural computation of allophone sequences from phoneme sequences and the heuristic nature of treatments of sub- and suprasegmental phenomena typical of current speech synthesis systems.

David Willshaw

My principal line of research is in collaboration with Dr Richard Morris (Pharmacology) on an MRC-funded Programme Grant to investigate the function and structure of the hippocampal formation. The hippocampus is a large intricate structure situated between the midbrain and the overlying mantle of the neocortex. Its local circuitry, and its anatomical connections with these other parts of the brain, are now quite well worked out. It is widely believed that it plays an important role in certain kinds of learning and memory, changes in synaptic efficacy being held to underlie memory.

We are following the late David Marr's idea of analysis at three different levels of explanation: the computational level (what task or tasks does the hippocampus perform?); the algorithmic level (what methods are used?) and the implementational level (how does the circuitry of the hippocampus do it?). We hope to link these different levels by conducting both psychological and physiological studies of specific tasks in which it is believed that the hippocampus is involved. In addition, we will consider the application of a variety of different parallel algorithms for solving these tasks, and investigate aspects of hippocampal circuitry from the perspective of how it might implement any of these algorithms.

With Jay Buckingham, I have been analysing the performance of current theories

of the hippocampus. With Peter Dayan I have been establishing the optimal associative learning rule for neural networks with structure similar to that of the hippocampus.

In addition, I continue my interest in neurally inspired algorithms through work with Marcus Frean on new parallel methods for solving the Travelling Salesman Problem and related problems of combinatorial optimization.

5.2 Principal Investigators of HCRC

Principal investigators who are also members or associates of the Centre for Cognitive Science are included in the previous section.

Anne Anderson — Glasgow Psychology

My research interests lie in the psychological aspects of language and communication. I am interested in, and have conducted research on, topics such as the process of text comprehension and speech perception, but most recently I have been investigating the development of communication skills from early childhood to adulthood. This research has explored such issues as the way in which pairs of speakers in a dialogue deploy their interactive skills to ensure mutual comprehension, and how these processes vary among subjects of different ages and communicative abilities. Research funded by the ESRC and the Scottish Education Department has tackled these issues from both theoretical and practical standpoints. On the one hand, the main aim is to develop a psychological model of how interactive skills are used in dialogue to ensure successful communication; and on the other, to explore the educational implications of our growing knowledge in this field.

Simon Garrod — Glasgow Psychology

My research background is in the areas of cognitive psychology and psycholinguistics, and the main thrust of my research has been to investigate how both production and comprehension of language is dominated by the context of utterance. I am currently pursuing three main research topics:

1. On-line processes in reading. This project is mainly concerned with the nature and time course of inference processes in reading. The processes I am interested in are typically directed at resolving inter-sentential anaphors such as pronouns or definite descriptions which require access to the reader's model of the prior discourse. The main techniques used in the research

are based on either measuring self-paced reading rates or tracking eye-movements during reading.

2. Interactional processes in dialogue. This project addresses the problem of interactional inference during normal conversation. It studies how both adult and child conversants are able to utilise the interactional context to co-ordinate their interpretations. The research mainly involves careful analysis of experimentally elicited dialogues.
3. Psychological theories of semantics in relation to spatial prepositions. This project explores cognitive aspects of our use and interpretation of spatial prepositions such as *in*, *on* or *at*. It is based on the view that these expressions can only be fully understood in relation to mental models of space which capture the functional geometry of the situations being portrayed.

Stephen Isard — Edinburgh Linguistics

I have developed a diphone speech synthesis system and continue to try to improve its quality through:

1. Variations on the standard LPC synthesis algorithms to improve voice quality.
2. Variations on the choice of basic units to yield a better phonology to phonetics mapping in a number of contexts.
3. New algorithms for controlling phoneme durations.
4. More naturalistic pitch contours.

This work began at the University of Sussex, and continues at the Centre for Speech Technology Research in Edinburgh. It will be used as a tool in the dialogue work discussed below.

In the area of speech recognition, I am working on a pre-phonetic acoustic classification of sound features to act as input to a sort of 'sound parser' for the construction of higher level phonetic units such as phones and syllables. This is being done within the larger speech recognition enterprise in CSTR. In connection with (4) above, I am also working on the recognition of the repertoire of intonation contours. This work was begun with Chris Brew in Sussex, who has joined the DYANA project where we are continuing the collaboration.

For the past several years, primarily within an Alvey project in collaboration with George Houghton and Mark Pearson in Sussex, I have been modelling the use of intonation in dialogue. The work has been built around the notion that the speaker's choice of intonation contour type is largely determined by the sort

of move he or she is making within a dialogue 'game'. The theory of moves and games on which this work has been based so far derives from the work of Richard Power and has been refined in Houghton's doctoral thesis. To date we have concentrated on a very restricted set of games and contexts, and the intention is to extend the coverage of the theory, partly by analysis of natural dialogue.

Jim Miller — Edinburgh Linguistics

My general research interests lie in the areas of syntax, morphology and semantics. Current research focuses on the relation between the syntax and semantics of natural language. I am particularly interested in the idea that syntactic structure and semantic structure require separate representations and overlapping but not identical categories.

The specific topics I am working on are:

1. Generative grammar, especially models that are lexicalist, transformation-free, systematic and represent dependency relations.
2. The relationship between syntax and semantics, especially localism, and the implications for semantic structure of parts of speech and grammatical categories.
3. Correlations between linguistic theory and psycholinguistic theory.
4. Tense and aspect in Slavic and Indo-European languages.

Tony Sanford — Glasgow Psychology

My interests broadly concern the nature of human understanding; my research is mainly aimed at understanding natural language, especially written language. Having a psychological background, I see language as a medium for manipulating the thoughts, beliefs and actions of people. This is the motivation for studying how utterances control what someone will attend to, what inferences they will make (and not make), and what questions they will ask.

These questions must be answered within a process-model framework, so most of my efforts are towards a psychologically viable process-model of language comprehension. Specific problems being actively studied include:

1. The comprehension of vague, hedged, and quantified expressions.
2. The control of attentional focus by linguistic description.
3. The control of inference patterns, including the notion of cohesion.

4. How background knowledge is used in driving 'noticing' behaviour.
5. The relation of style and rhetoric to focus control.

Many of these problems can be thought of in terms of multiple constraint satisfaction, seem to be impossible to express by simple rules, and require a high degree of parallelism and content-addressing. I am therefore actively engaged in connectionist modelling of some of the above list.

Rosemary Stevenson — Durham Psychology

My research concerns the roles of syntax, semantics and non-linguistic general knowledge in natural language processing. The aim is to develop a detailed model of language comprehension that shows how the local processing of individual sentences maps onto the more global processing of discourse. I am particularly interested in the understanding of reference and in the way a knowledge of reference might underlie a general theory of language comprehension.

Topics currently under investigation are:

1. The comprehension of anaphora: local and global processes; the incremental representation of individuals successively mentioned in texts; the role of thematic processes.
2. The comprehension of temporal reference.
3. The comprehension of quantified expressions.

5.3 CCS Research Staff

Patrick Blackburn

The following are some of my main interests:

1. Modal logics that I term *sorted*: these have different types of atom, each encoding a particular type of information.
2. Partial logics, proof theory, definability in partial modal languages, and the development of efficient proof methods for extended modal languages.
3. The construction of an event ontology adequate for coping with Vendler-style verb classifications, and a language for talking about these entities that mimics at least the more obvious aspects of natural language usage.
4. The treatment of grammatical formalisms as logical languages: for example, investigating their proof theory and model theory.
5. Providing an account of presupposition that can be linked with existing semantic frameworks such as Discourse Representation Theory.

My research is supported by an SERC Postdoctoral Fellowship.

Chris Brew

My main current concerns are:

1. Building a computer model which tracks the fundamental frequency of speech signals.
2. Looking for ways of taking the hypotheses which explain why an intonation contour has been produced, and integrating them into a framework (probably based on a chart parser) that includes hypotheses from other sources about the identity of words and the syntactic structures in which they participate.
3. Experimental work on the influence of dialogue context on the way in which speakers say words and phrases.
4. Knowledge representation formalisms (particularly systemic networks and unification grammars) and techniques for exploiting them in parsing.

Most of my work, supported by the DYANA Basic Research Action, is in collaboration with Ellen Bard, Stephen Isard and various others involved with work on dialogue at Glasgow and Edinburgh.

Jay Buckingham

How do brains work? That is the central question which is addressed by my research. So far, most brain research has concentrated on either high level behaviour or low level neuroscience. For example, there are a number of accounts which specify the functions that particular brain structures are involved in; and there are detailed descriptions of the anatomy of various brain regions. My work is concerned with building explanations which span the neuronal and behavioural levels of description; that is, I attempt to describe how particular neural circuits generate the functions observed.

Since even simple nervous systems exhibit quite complex dynamic behaviour it is difficult to decide on a line of inquiry that might give us new insights. Some researchers have attempted to gain more understanding of brain function by using abstract models of nervous systems that consist of networks of highly interconnected simple computing elements. It was shown that such networks can in principle compute solutions for any computable function, but the difficult question of how to characterize the behaviour of any given network remains. Much of this work ignores a central point—that nervous systems have evolved in order to enhance an animal's ability to survive in the world; such systems will probably not be very good at doing general purpose computing. So in my work I am focusing on how neural circuits implement functions which are relevant for survival.

I am currently a member of the MRC team which is investigating the relationship between the structure and function of the hippocampus.

Mimo Caenepeel

My research centres on the way readers process narrative texts. One issue which I have looked at in considerable detail is the extent to which perspectival refractions in narrative (i.e. the fact that the reader will infer that some situations are described from a particular point of view) are syntactically identifiable. This has, among other things, involved an exploration of the effect of aspectual categories on the reader's interpretation of point of view in narrative.

So far, I have primarily concentrated on the relevance of perspectival phenomena for literary analysis (the corpus I have used for my research consists solely of novels and short stories). I now want to widen the scope of my investigation to natural language processing in general, which I feel would benefit from a better understanding of the relationship between linguistic form and point of view, and of the (textual and extra-textual) conventions that distinguish narrative from other discourse genres.

Another strand of my current research concerns the way temporal information is

extracted from narrative texts. This involves studying the referential properties of tense and related categories, and examining the relevance of focusing mechanisms for a formal account of temporal anaphora resolution; I am addressing these issues in a Discourse Representation Theory framework.

My research is supported by an ESRC grant.

Jonathan Calder

My main interests lie in the area of lexical description, in particular in extending the current trend towards grammatical frameworks with logical, declarative interpretations, so as to encompass treatments of morphology and phonology. Previous work in these two areas has been adversely affected by formally ill-motivated and descriptively limiting assumptions about the nature of phonological and morphological representations and operations.

As a result of the strongly lexicalist trend in linguistics of the last two decades, the lexicon has become the locus for the statement of universal, parametric and parochial information. The key notion is that of the *hierarchical* lexicon which is able to capture the ubiquitous semiproductivity of natural language in a perspicuous and general way. One of the ultimate aims of this work is to develop computationally tractable logics for lexical description that directly reflect these properties.

My work is supported by the ACORD project, for which I have designed and implemented grammar and lexicon development environments, and by DYANA, in which my work focusses on formal properties of unification-based systems.

Judy Delin

My interests lie in the pragmatics of discourse, most recently in my thesis work on the discourse conditions and effects surrounding the use of cleft sentences, but now extending to the analysis of other pragmatically-marked syntactic constructions. In each case, we can ask: what features of context, and properties of syntactic form, condition the use of each construction? And how do these factors interact in the decision to use a particular construction? Marked syntactic structures are viewed as different ways of providing messages with the desired pragmatic markings. Syntactic choice depends crucially on what these markings are, and what effects they achieve in discourse. So far, I have concentrated on the issues of presupposition, focus, contrast, and the principles of sentence design based on making processing easier for hearers and readers. My approach relies on naturally-occurring data, particularly spoken data, since I am convinced that focus at least cannot be analysed separately from sentence

accent.

In a broader attack on the question of how texts cohere, I am also involved in the design of interactive language tools for deaf children, who have problems in constructing sentences with correct sequencing and with constructing coherent written texts. Particularly intriguing problems in this area are the incorrect use of anaphora and ellipsis, and interference from sign language, causing, for example, temporal marking in written English to appear in the wrong places (anywhere but the verb, usually).

My work in the Centre is supported for the next two years by a post-doctoral fellowship from the SERC. I am involved in three projects: an ESPRIT project on Discourse and Dialogue, an HCRC project on pragmatics in unification categorial grammar, and an informal collaboration with the CALL (Communication Aids for Language and Learning) Centre to implement language tools for the deaf.

George Dunbar

I am studying phenomena of lexical flexibility in terms of time, semantic integration and syntactic dependency. Phenomena of interest include polysemy, generalisation, figurative language and diachronic change. The following topics are currently on my agenda:

1. Diachronic change and semantic lenition.
2. Emergence of meaning through contextual interaction during combination.
3. Transient denotation and lexicalisation.
4. Concepts, lexical concepts and background knowledge.
5. Language development as an aesthetic struggle.
6. Abstraction and the methodology of interdisciplinary research.

I am exploring these issues in the framework of cognitive grammar using the techniques of descriptive linguistics and experimental psychology. I am currently supported by an ESRC research grant.

Bradley Franks

My research interests centre around the psychology and philosophy of word-meaning. I am interested in developing an approach to semantic anti-realism which demands that any semantic knowledge ascribed to agents must be manifestable knowledge; this means in particular that it must respect constraints from psychology.

In this connection, I have been looking at questions concerning:

1. The defeasibility of properties in their ascription to concepts.
2. The relativity of categorisation judgements to the description or perspective under which they are made.
3. Holism and network-dependence of word-meanings and concepts, and how it might be constrained.
4. How one can have manifestable knowledge of inaccessible domains (other minds, the future, the past, etc.): that is, exactly how we might reconcile semantic anti-realism with ontological and scientific realism.
5. Situation theory, since it seems to be committed to some form of semantic anti-realism (though retaining an ontological realism), and since the central notion of a constraint has appealing parallels with the criterial relations of anti-realism.

In a more psychological vein, I have been developing a 'sense generation' approach to concepts and their combination. This has resulted in a position that takes concepts as partial objects, whose informational extensions are defeasible during the generation of a sense for a word or phrase. This approach has been applied to some particularly troublesome types of combination: privative (e.g., *fake gun*, *stone lion*, *apparent friend*), and attributive (e.g., *attractive ballet-dancer*, *successful swimmer*).

My work is supported by DYANA.

Alexandra Lascarides

Formal semantics in service to natural language understanding constitutes the framework of my research. The particular issues I am thinking about lie in the general problem area of temporal reference:

1. How can one supply a uniform semantic characterisation of the different temporal behaviours of various verb phrases?
2. How do tense and aspect affect the ordering of events present in discourse?
3. How can formal theories on the semantics of temporal reference in natural language contribute to theories in the area of temporal reasoning and knowledge representation?

My research is supported by an SERC Postdoctoral Fellowship.

Neil Leslie

I am currently working on the ESPRIT-funded ACORD project on the implementation of grammar and lexicon development environments.

I am interested in computer-aided learning, and my previous work has involved the implementation of a simple natural deduction proof-editor which has been used to teach beginning philosophy students about first-order Classical and intuitionistic logic, and to teach more advanced students about the modal logics S4 and S5.

I am also interested in the use of Martin-Löf's intuitionistic Type Theory as a program development logic.

Marc Moens

My research, supported by DYANA, is mainly concerned with the problem of how people understand, describe and reason about events in a changing world. On the linguistic side, the starting point of this work is the observation that the comprehension of discourse involves the construction of a model of the events and situations talked about in the discourse. My research here has concentrated on a study of the ontology that underlies such a representation. Work continues within this framework on a formulation of the semantics of a range of tense and aspect phenomena in English and an account of the anaphoric properties of tense.

Most research areas in Artificial Intelligence involve reasoning about time in one way or another. A second strand of my research is aimed at a study of the efficacy of these formalisms and the development of an event-based ontology that can be used to solve time-related puzzles in Artificial Intelligence as well as being able to store in an efficient way event-related information as it is expressed in natural language.

Glyn Morrill

My interest lies in the development of formal grammars for natural language, and in their computer implementation. I have examined 'computational' monostratal theories based on phrase structure grammar and categorial grammar; this has been done with particular reference to unbounded dependency and coordination constructions, and certain complex instances of these in which discontinuities are compounded.

From a more semantic perspective, I have studied how an assumption of compositionality can ensure the effects of fundamental principles in theories of syntax

with less emphasis on how meanings are built up. In relation to processing, I have studied the problem of parsing generalised categorial grammars which assign large numbers of equivalent derivations: the problem has been approached by defining normal form derivations.

Recent work has drawn links between syntactic locality and islandhood on the one hand, and semantic intensionality on the other; the account claims that the combinatorics of intensional types are given by the logic of necessity. Also, operations useful in grammar, such as intersection, union, iteration and optionality have been found to be governed by laws similar to those governing operators in linear logic. Thus categorial grammar emerges as just the implicational fragment of a more general logical grammar.

My research is uspported by an SERC Postdoctoral Fellowship.

Jon Oberlander

My main interests lie in computational theories in the philosophy of mind, and in the perspective on them offered by drawing links between the philosophy of science and knowledge representation. The points of contact are many and fertile. My recent research addresses the following topics:

1. The relation between explanation and defaults. By drawing parallels between Cartwright's view of scientific theories and default/causal reasoning in AI, I have derived a view of defaults that treats them as *ceteris paribus* laws, framed within a knowledge organisation that eschews the deductive 'generic specific' account of the truth of laws.
2. Rationality and mental states. With Peter Dayan, I have been exploring the consequences for the philosophy of mind of recent work on parallel distributed processing. Rejecting Elster's view that rationality requires global optimisation, we suggest an alternative view, utilising locally maximising mechanical devices. We have also explored the consequences of adopting finite-state, non-von Neumann architectures for machines, and argued that they offer a way of saving folk-psychology from instrumentalism.
3. Reasoning about action and change. With Marc Moens, I have developed an approach to the Frame, Ramification and Qualification problems in AI. Taking advantage of attribute-value grammars, we have established a treatment of events as underspecified objects, operating on other feature-value structures representing partial objects.
4. Event-based semantics for representing temporally coherent texts. The ontology from (3) can be used to generate text in a causally complex domain.

My research is supported by a British Academy Postdoctoral Fellowship.

Luis Pineda

My current research interest is the production of natural language and graphics human-computer interfaces and their applications to computer-assisted design systems. The linguistic component of the kind of systems currently being considered is based on unification categorial grammar. In this research, the development of models for dealing with the phenomena of deixis and ostension is a crucial task. Another topic of study is the structure of graphical representations. Here, compositional methods commonly used in the analysis of the syntax and semantics of natural language are applied to graphics. For the implementation, the framework provided by logic programming, in particular PROLOG, is being used.

My long term research goal is the understanding of the relations between symbolic systems realised in different mediums and their role in a comprehensive theory of inference. I believe that design acts are, for instance, inferences in which linguistic and visual symbols are used in integrated and systematic way. I believe as well that visual symbols facilitate other inference processes, such as induction, and play an important role in learning tasks. Formal models of these issues require an integrated psychological, linguistic and computational framework.

My research is supported by a grant from the Joint Councils' Initiative in Human-Computer Interaction and Cognitive Science.

Mike Reape

My research interests are a combination of computational linguistics, theoretical linguistics and the mathematical and logical foundations of linguistic theory.

On the one hand, I am committed to the point of view that the development of nontrivial computational grammars of natural languages is essential for progress in theoretical linguistics. So, in the past I have worked on parsing, computational grammars of English, grammar formalism and grammar environment development, computational morphology and generation.

On the other hand, I am interested in the semantics of grammatical formalisms, the abstract specification of linguistic theory (in particular, axiomatic specification) and the inadequacies of current linguistic methodology. In concrete terms, this means that I am trying to use mathematical logic to formalise fragments of linguistic theory in a way which is as formalism-independent and descriptively convenient as possible. In particular, I am working on a formal treatment of

implicational universals in Germanic word order which is heavily influenced by lexicalist, unification-based theories of grammar, government and binding theory and dependency grammar. I am also working on an account of the role of formalisation and abstraction in linguistic theory which rejects the identification of linguistic *theories* with linguistic *formalisms*.

My work is supported by funding from the ACORD project, and DYANA.

5.4 HCRC Research Staff

Joy Aked

I work with Tony Sanford, mainly in the Semantic Processing Working Group, but also in the Anaphora Group. My research interests at the moment centre on the use of thematic subject, and the effects of agenthood on attentional focus and inference. I am currently working on acceptability judgements, in other words, what we do to check that a sentence or utterance is acceptable in the way of discourse, grammar, semantics and style. I am interested in how these factors relate to speech in order to be acceptable: we usually have to *say* a sentence to know whether or not it is acceptable.

A further concern lies in the use of different stylistic factors such as length of sentence or rhythm. Speech, it seems, is more likely to bring out the more subtle aspects of style than written discourse; there may be some advantage in presenting a person with their own text in this way, using speech synthesisers to enable imbalances to be drawn out. An area of possible future attention includes an interest in eye-tracking experiments in relation to anaphora and focus.

Liz Boyle

The research I am involved in concerns the development of communication skills. Spontaneous interactive dialogue is elicited using a map task in which a subject has to draw a route on a map following the instructions of his or her partner. Transcripts of the dialogue are coded according to various features, which are then analysed and related to the accuracy of the route drawn on the map. This allows us to identify the skills which characterise successful communicators. At present we are setting up a database of the coded transcripts.

I also intend to carry out more work on the relationship between comprehension and inference, particularly within a developmental context. This interest stems from my doctoral research which concerned the development of reasoning abilities and the role of logic in explanations of reasoning. Children and adolescents between 5 and 18 years were presented with a variety of tasks designed to assess

their comprehension of, and ability to reason with, class and conditional statements. Neither Piaget's theory nor propositionally based theories of reasoning could account for the observed differences in performance associated with task and linguistic form.

It was proposed that the poor inferential performance of the younger children indicated that they construct inadequate models of the premises. Older children have developed increasingly accurate models of the premises which will then support correct inference. I intend to utilise situation theoretic notions to extend my existing proposals.

Matt Crocker

Central to current linguistic theory is the notion of Universal Grammar (UG). For instance, recent Chomskyan linguistics has proposed a 'principles and parameters' paradigm for syntactic theory, in which languages are characterised by a set of fundamental, or *universal*, principles of grammar. Associated with the principles are parameters of variation which account for differences across languages. One of my interests is the application of such principle-based theories of grammar within computational linguistics. My past research has included the development of parsers which reflect the compact, and cross-linguistic, nature of the principle-based grammatical theory.

I am currently interested in the development of principle-based models of human sentence processing. The aim of my research is to explore how the human sentence processor uses the principles of grammar to parse sentences, with the intent of providing processing accounts of various phenomena such as garden path sentences, attachment preferences, gap-filling strategies, and semantic interaction. I am further interested in evaluating the cross-linguistic status of such a processing model, by examining how parametric variation in the grammar affects processing in various languages. If such universal processing algorithms exist, this would support their innateness in parallel with UG, and possibly provide further insight into the relationship between parser and grammar.

Robert Dale

My research interests are in two distinct areas: natural language generation, and intelligent text processing. Within work on natural language generation, my focus of interest is in the generation of referring expressions, both in characterising the conditions under which particular forms of anaphoric reference can be used, and in characterising the representational requirements underlying reference to non-singular entities. Typical questions that arise are then: when can a pronoun be used to refer to an entity? When can definite reference be

used? How is the semantic content of a referring expression determined? How are complex mass and plural entities to be represented, so that strategies for subsequent reference can be easily applied?

In the area of intelligent text processing, I am primarily interested in the semi-automation of editorial assistance. This involves tasks like that of massaging a text into a house style, and the detection of grammatical errors. This work is inspired by the AI paradigm of expert systems, so that, for example, house style rules can be maintained in knowledge bases which are applied to a text by an 'inference engine' which knows about the relevant aspects of text.

Gwyneth Doherty

Currently I am working with Simon Garrod in the Speech and Dialogue Working Group on the dialogue database. My research interests are in the field of spontaneous, natural conversation. More specifically, I am interested in the structure of turn-taking mechanisms in such dialogues, and also how these mechanisms may differ from other speech-exchange systems. I hope to be able to formulate a general model of the constraints acting in dialogues to produce various distributions of turns. Using the corpus of dialogues I am presently working on, I hope to be able to investigate what developmental changes, if any, occur in the structure of conversation.

Martin Gemmell

My work is supported by DYANA, and I work in Keith Stenning's group. My principal interest is in demonstrating how general knowledge can be recruited to facilitate memory for different individuals. At present I am looking at how the degree of stereotypy of textual individuals affects both reading times and their recall in a memory task. It is hoped that statistical and PDP (connectionist) models can be produced to account for the use of general knowledge in the formation of contentful associations in such tasks.

Claire Grover

My main interest lies in formal syntactic and semantic theory, and especially in unification-based grammatical formalisms such as Generalized Phrase Structure Grammar, Head-Driven Phrase Structure Grammar and Unification Categorial Grammar. Most of my research has centered around the development of wide-coverage grammars of English; some of this work has resulted in the English grammar that is now part of the ALVEY Tools Release. Specific areas that I have

worked on have been the syntax of coordination, long-distance dependencies, subcategorisation of verbs and adjectives and the syntax of noun phrases. This work was carried out at Lancaster University in collaboration with the Computer Laboratory in Cambridge.

I am currently employed by the University of Cambridge on an IED-funded[5] project which will develop a richer semantics for the ALVEY Tools grammar formalism. In particular, I am interested in the variety of ways a particular semantic argument structure can be realised syntactically. Of immediate interest here is the role of lexical semantics in an account of phenomena like control.

Joe Levy

I have worked with Keith Stenning and other members of the Human Text Comprehension and Memory workshop on the development of models of the representation of simple descriptions in memory. This involved the construction of statistical models of the reading times and recall errors of texts describing pairs of individuals such as a tall fat Swiss dentist and a short fat Polish priest.

I extended the statistical model of recall errors as a PDP model capable of correct recall but able to make the same categories of errors that the subjects made when subjected to noisy input.

Current work includes efforts to model the articulatory loop system responsible for rehearsal and ways in which PDP systems can be used to model the representation of incremental descriptions of individuals.

Marie McGinley

I work with Tony Sanford in the Semantic Processing Working Group, which aims to develop a psychological account of meaning in the context of communication.

My main interests lie with statements of quantity, confidence and doubt, as well as complex hedges. These are all vague and unscaleable expressions, yet all are widely employed for communicative purposes. This phenomenon suggests a certain 'robustness' in the human interpreter with respect to these terms, well worthy of investigation. To date, research by Tony Sanford and Linda Moxey into the conditions of use of English quantifiers has lead to a re-evaluation of the accepted use of quantifiers and how they function. I hope to extend these results—which indicate the powerful rhetorical properties of such terms—to other uncertainty expressions. Perhaps these characteristics partly contribute

[5] IED: Information Engineering Directorate

to our apparent adeptness when confronted with so much that is vague.

My interests extend to questions concerning factors that positively and negatively affect this robustness; this encompasses the effects of context, expectations and the like, on what is communicated. A related interest concerns certain logical and linguistic properties of inexact terms, which I hope to relate to their apparent rhetorical properties. This research should contribute to a general psychological model of communication under uncertainty, and in turn to a greater understanding of the whole comprehension process.

Sandy Nelson

I work with Keith Stenning, Joe Levy and Martin Gemmell within the Human Text Comprehension and Memory workshop. Recent work, using simple texts describing two individuals, has identified interesting reading time effects. We interpret these reading time effects as articulatory loop phenomena. My immediate interest is in investigating the role that rehearsal plays during the encoding processes used by people in our experimental task.

We hope to model the encoding processes within a PDP framework. My previous work has been to produce a simple PDP model of stereotypy for individuals described in our experimental texts.

Jerry Seligman

Our understanding of the mind as an information processor suffers from the lack of a theory of the information we process. Existing logical systems tend to ignore the almost ubiquitous phenomena of context dependency in inference, representation and language understanding. My main research interest is the mathematical modelling of context dependency in semantics and psychology, mainly within the framework of Barwise and Perry's situation theory. Current research in situation theory has raised interesting foundational questions about the nature of information and its mathematical structure. In particular I am interested in the application of non-wellfounded sets and Aczel's replacement systems in this area.

More broadly, I am interested in various topics in mathematical and philosophical logic including constructivism, logics of weak entailment, theories of truth, and intensional logic. In the philosophy of mind I am especially interested in recent approaches to providing 'naturalised' accounts of meaning and the relationship between meaning and mechanism in general.

Cathy Sotillo

My research interests lie specifically within the area of speech variability. As a linguist I am interested in the broad areas of morphology, phonology, and (primarily acoustic) phonetics. I have considerable experience in the transcription and labelling of spoken English and have been trained in the reading of unlabelled speech spectrograms by Victor Zue. My background in psychology is responsible for my interest in speech perception and the related issues of language processing and language acquisition.

My present research is concerned with differences among the acoustic realisations of multiple tokens of the same words and with the consequences of these differences for theories of speech perception and language processing. In the last year I have been looking closely at intra-speaker variability in production in different discourse and extra-linguistic contexts and the consequences this has for speech recognition systems. In particular I have been looking at the occurence of the phonological processes of reduction and assimilation, and their effects on the intelligibility of the speech signal. Since work on the under-determinacy of spoken language has shown that contextual information is essential for the recognition of words as pronounced in running speech, we are now attempting to cast some light on the relationship between contextual knowledge and the production of words. The work should have implications both for models of speech production (and consequently applications in the field of speech synthesis) and also first language acquisition.

Regina Weinart

I am interested in the relationship between the spatial, temporal and metaphorical uses of prepositions/locatives. In particular, I am interested in investigating the possibility of the various uses of prepositions being explainable in terms of basic spatial relations. Investigation will involve contrastive analysis of locatives in German and English and possibly analysis of the use of locatives in first and second language acquisition.

I am interested in comparing different types of spoken language from the point of view of syntactic analysis. In particular, I am interested in establishing what kinds of units of analysis are appropriate. Investigation will look at spoken language as part of dialogue of varying degrees of interactional intensity. The expectation is that traditional syntactic analysis based on the sentence, clause and phrase will be least appropriate in situations where intense interaction is required and most appropriate in situations where dialogue participants assume extended control over what they are saying, i.e. where they are engaged in a mini-monologue.

Garry Wilson

I am interested in the factors that appear to bias readers towards choosing a particular entity in text as the antecedent in pronoun assignment. Of particular interest are thematic roles themselves, (such as Goal-Source, Experiencer-Stimulus, Agent-Patient), but I am also interested in their interaction with other factors such as the method of introduction, animacy, and the restrictive role of verbs. Central to the understanding of this interplay is a quantification of the magnitude of effect these factors have on pronoun resolution.

I am also interested in the organisation and retrieval of semantic information, because of its possible role in specifying main, subsidiary, and scenario-dependent entities, and because of the processes which 'focus' attention on these entities, and signal the switches in attention in a text.

Henk Zeevat

Over the past years I have worked on the semantics of propositional attitudes and on meaning theories, both realist ones and the one implicit in discourse representation theory (DRT). The most intriguing aspect of DRT for me is the claim that there is a certain amount of non-trivial structure to natural language semantics. This aspect is crucial for the DRT account of discourse anaphora and for attempts to represent attitudes in that theory.

I am also interested in grammar formalisms, especially those in the unification grammar, categorial grammar and dependency grammar traditions. More recently, driven by my involvement in the ACORD project, I have become interested in such things as pronoun resolution, text structure and interpreter expectations as a crucial notion in natural language interpretation.

6 Research Groups

6.1 CCS Workshops

The research programme of the Centre is organized around a number of workshops in which staff and students collaborate on specific projects. During the current session there is a large variety of active workshops, summaries of which are given below.

1. Applied Logic Group (APLOG)

Over the last few years logic has proved applicable in many new fields: Cognitive Science, Computer Science, and Artificial Intelligence. Previously its applicability had largely been confined to Mathematics and Philosophy. This process is of interest for at least two reasons: the new problems encountered have led to the development of new techniques; and, perhaps more importantly, consideration of these fields is changing—often radically—our conception of what logic is.

APLOG is a group for those interested in these recent developments. Current interests of members include: foundations of situation semantics, linear logic, belief logic, type theory, modal logic and non-well-founded set theory.

2. Formal Semantics

The workshop exists to foster discussion of natural language semantics. While the emphasis is on technical accounts of the semantic behaviour of particular constructions, some more philosophical and methodological issues arising in semantics research are also occasionally discussed. Our meetings take one of two forms. On the one hand, participants use the workshop as a forum in which to present their own research. On the other, the workshop as a whole undertakes extended studies of particular topics.

The group has recently looked at the following subjects: polyadic quantification, non-boolean conjunction, compositional accounts of anaphora, and presupposition. We also conduct regular literature reviews in order to keep abreast of new developments.

3. Foundations for Intelligent Graphics (FIG)

Drawings convey information. Sometimes we can re-formulate this information using words, or a logical formalism. So, up to a point, a drawing and a text can

have the same semantic interpretation. What should this semantics be?

Another question is: how do drawings and texts provide a supporting context for each other? With a few exceptions, the interpretative conventions for drawings are highly local—we need textual labels to tell us that a rectangle represents a window rather than a floor-plan of a room. On the other hand, drawings can often provide us with concrete models which aid in the interpretation of abstract ideas expressed in text. Thus drawings and text convey their messages in different ways. Why is this so?

It is not clear what a full answer to these questions would look like, but research in this workshop is attempting to develop at least partial solutions. We are currently exploring an approach in which graphical representations are assigned an algebraic structure, and interpreted against a knowledge base which encodes domain-specific information. Our medium-term goal is to develop computational systems which allow the user to:

1. Construct complex graphical configurations out of primitive graphical elements drawn from a fixed vocabulary.
2. Provide a compositional semantic interpretation, relative to an intended domain, for such configurations.
3. Interactively change and extend the imputed interpretation of graphical complexes.

This research is supported by a grant from the Cognitive Science/HCI Joint Initiative.

4. Human Speech and Sentence Processing

The workshop is focused on the modelling of the mental activities involved in hearing and understanding ordinary conversational speech. We are particularly concerned with the following issues:

1. How are words recognized? How are they segmented out of the continuous acoustic stimulus which is the speech stream? What is the detailed time course of the events involved in determining what words have been heard? How is human knowledge of language organized at the word level, and what mechanisms employ that knowledge?
2. What is the functional architecture of the Human Sentence Processing Mechanism (HSPM)? How is it divided up into functional sub-systems? At what level of the processing of speech does the effect of context make itself felt? Are there aspects of speech processing which are completely automatic and impenetrable by contextual effects?

3. How can work on the HSPM and work on the processing of printed text be reconciled?
4. How do speakers adjust the pronunciation of words to reflect the other linguistic and discourse information which can aid the listener in decoding speech sounds into intended words?

Experimental and computational investigations of these questions are being carried out by workshop members supported by grants from the ESRC, DYANA and HCRC. Researchers on these projects usually participate in workshop meetings.

5. Human Text Comprehension and Memory

Our common concern is with the acquisition of knowledge from language sources. One strand of our work concerns the processing of the referential structures of texts—what representations underlie memory, how are they constructed during text processing, how are they accessed at retrieval? Other work concerns the comprehension and representation of conditional and quantified sentences, and the inferential processes which they invoke.

While we are committed to detailed experimental observation and analysis of peoples' comprehension, memory and reasoning, our methods include cognitive modelling techniques such as PDP system simulations.

Members' work includes studies of: the 'binding' of properties to individual identities in immediate memory, the interface between immediate and long term memory, the role of articulatory rehearsal in 'binding' in working memory, the build up of interference effects in memory for interpreted structures, PDP simulation of retrieval processes, memory processes involved in reasoning with syllogisms, interactions between general knowledge and memory for the specific, PDP modelling of people's stereotypes of person descriptions, interactions between form and content in human conditional reasoning, and treatments of the semantics of conditional constructions.

Past and present support for this research has been from SERC(Alvey) and ESRC.

6. The Mental Lexicon

The workshop is concerned with the implications of the view that a 'mental lexicon' is the locus of information regarding the morphology and semantic representation of words. We are therefore concerned with the appropriate format for the representation of information regarding individual words, and the semantic relations between words.

In the past, the workshop has considered the psychological representation of derivational and inflectional morphology, and some of the implications for a theory of lexical representation of the cognitive grammars of Jackendoff and Langacker. More recent work has focussed on the cluster of problems concerned with providing a psychologically motivated and formally precise description of the semantic components of lexical entries. In this vein, several topics are of import:

1. What is the relationship between 'concepts' and word-meanings?
2. Is there a one-to-one mapping between semantic entries in a mental lexicon and the representation of a word's meaning on any occasion of use ('sense selection')? Or is it a one-to-many mapping, in which the representations of a word's meaning are context-sensitive extensions of a single semantic entry ('sense generation')? What evidence and issues would bear on the choice?
3. What are the principal constraints on an account of the combination of concepts?
4. If combination has non-monotonic results, what is the relation between such phenomena and formal accounts of non-monotonic inference?

In a collaborative venture with the Situation Theory and Grammar (STAGR) workshop, a principal concern is to examine formally precise ways of interpreting concepts and word-meanings in general, and to consider the possible interaction of situation theory and sense generation in particular.

7. Metaphor

The purpose of this workshop is to examine the phenomenon of metaphor from a number of different perspectives, including the philosophical and the psychological. An understanding of how metaphor is understood is important in order to throw some light on how literal meaning is understood. One of the central goals of the workshop is to characterise precisely the relationship between literal and non-literal language, and to assess whether the distinction, in the light of the evidence, remains valid. Furthermore, the determination of the desired form of a computational theory of metaphor is crucial to the endeavour.

8. Parallel Distributed Processing Systems

Computational concepts play a central theoretical role throughout cognitive science. The idea that networks of simple neuron-like elements with rich interconnections could be the basis for human computation is an old one, traceable back

to the associationists. Recent advances in the algorithms used to train massively parallel networks of simple computing units have lead to a resurgence of interest in these architectures. Their radical contrast with conventional serial computers promises to enrich our concepts of computation and interpretation generally, and particularly to enhance theories of how computations are implemented in human beings.

The workshop draws together members from a wide range of departments of the University, including Physics, Artificial Intelligence, and the Centre for Speech Technology Research. It provides a forum for discussion of general developments in the literature on PDP systems, a focus for local research developments in this area, and teaching on the fundamentals of PDP computation. These include the cognitive modelling of memory errors, semantic priming, speech perception, and the neural modelling of the hippocampus.

9. Parametric Variation in Germanic and Romance

We investigate parametric variation in the Germanic and Romance languages. Our specific goals include the identification of candidate dimensions of parametric variation in these two language families, the development and contrastive analysis of grammar fragments for these phenomena in a variety of formal frameworks and the development of an integrated analysis of the parameters identified in a sufficiently expressive specification language with a rigorous semantics. Our wider goal is the further development of the theory of cross-linguistic variation and its relationship to diachronic change.

We consider these issues from a variety of theoretical perspectives including GB, LFG, HPSG, various forms of categorial grammar and some nonstandard frameworks. We consider competing extant analyses as well as developing new analyses of our own. Furthermore, we are interested in both the 'parameter setting' account of GB and axiomatic accounts of variation. In the past, topics have included:

1. Grammatical relations in ergative and non-ergative languages.
2. Subject pro-drop outside the Romance languages; is it a unified parameter?
3. Word order and constituency in the West Continental Germanic languages, in particular, the interaction of fronting, extraposition and semi-free word order, and apparent cross-linguistic asymmetries involving these phenomena.
4. Word order and clitic behaviour in the Romance languages.
5. Auxiliary selection and related phenomena in both Germanic and Romance.

10. Parsing

The workshop explores theoretical and practical issues related to computational linguistics, and is concerned with the interaction of processing considerations with syntactic and semantic theory. The following are some of the general areas of interest:

1. The linguistic, mathematical and computational properties of grammar formalisms, including:
   - Unification-based and constraint-based grammar formalisms.
   - Categorial grammars and extended categorial grammars.
2. The relationship between syntactic and semantic processing.
3. Practical algorithms for parsing and generation.
4. Large-scale natural language systems.

Speakers include the workshop participants and invited speakers. Presentations are given on both recently published material and current research within CCS and the Department of Artificial Intelligence.

11. Phonology

Despite its obvious connection to purely physical parameters of a largely non-cognitive nature, phonology is increasingly coming to stand at the centre of a number of key issues in cognitive science generally; in particular how a categorical symbolic system relates to continuous, parametric behaviour. Phonology is a heterogeneous field within linguistics, and amongst practitioners there can be found a corresponding diversity of methodologies and approaches. This diversity extends to the membership of the phonology workshop, which is drawn from the Linguistics department and the Centre for Speech Technology Research as well as from Cognitive Science. Our primary goal is to establish a constructive dialogue between proponents of competing approaches and to clarify, and sometimes reach consensus on, the key issues.

Workshop members' current interests include: interfaces between phonology/phonetics and morphology/syntax, prosody and intonation, speech processing, autosegmental phonology, harmony systems, external sandhi, the place of phonology in constraint-based grammar formalisms, and the computational representation of phonological information. Languages being studied include the following, amongst many others: Arabic, Chamorro, English, Gaelic, Italian, Japanese, Kikuyu, Mongolian, Navajo, Swiss-German and Yoruba.

12. Practical Epistemics

The workshop studies the issues which cluster around the problem of providing formal models for the interaction between an agent and the environment in which it is located. Last year, we focused on the following topics for agents acting and perceiving, both physically and linguistically:

1. Causal and temporal reasoning. Predicting and explaining actions and events. We critically examined ontological and inferential modelling strategies, including the work of Hanks and McDermott, Poole and Pearl.
2. Belief systems. Located believers can change their minds. We discussed and criticised homuncular theories of mind, as exemplified in the work of Fodor and Lycan.
3. Functionalism and explanation. Explaining behaviour in terms of mental states is beset by problems. We examined work by Marr, Elster, Fodor, Stich and Dennett, and began development of a new approach.

13. Topics in Grammar Formalisms

Modern linguistic theories are often intimately associated with a specific grammar formalism. This is especially true of the so-called *unification-based* approaches to grammar such as GPSG, HPSG, UCG and LFG. In fact, it is often the case that restrictions on the expressive power of the formalism are considered to be substantive claims about the nature of human language. This workshop investigates the connections between such linguistic theories and their associated linguistic formalisms. In particular, we examine three aspects of the relationship between theory and formalism.

1. The semantics of grammar formalisms, independent from particular linguistic theories.
2. The substantive claims made by modern grammatical theories and the ways that these claims depend on and are encoded in their associated grammatical formalisms.
3. The options that grammar formalisms provide for describing specific dimensions of linguistic structure.

6.2 HCRC Working Groups

Anaphora

The long term aim of this group is to develop a processing model of the comprehension of anaphora which shows how syntax, semantics and pragmatics interact during processing. In order to fulfill this aim, we plan to develop existing work on focus and topicalisation to produce a detailed model of the way in which inferences are derived from non-linguistic world knowledge. It is hoped that this model will provide the detail of the pragmatics component of the processing model. Similarly, we plan to develop existing work on discourse representation theory to provide an integrated theory of anaphora and presupposition. It is hoped that this theory will provide the detail for the semantics component of the processing model. The work overlaps with projects being carried out in the Grammar and Processing Working Group, which may provide the detail for the syntactic component of the processing model. Work on situation semantics in the Situation and Grammar Working Group and on quantifiers in the Semantic Processing Working Group will also contribute to the semantic and pragmatic components of the model.

We also plan to extend and develop existing work on representation and anaphora to show how a representation is updated when an anaphor is encountered and interpreted. It is hoped that the model developed here will provide a representational format for the processing model. At the moment the Anaphora Group is concentrating on pronouns, but all strands of the work will also include other forms of anaphora such as definite noun phrases and verb phrase ellipsis.

Current projects include:

1. Incremental representation and pronoun resolution.
2. Anaphora and presupposition in discourse representation theory.
3. Thematic processes in the comprehension of anaphora.

Dialogue: Speech and Discourse

This group has adopted a vertical approach to the study of dialogue. Its work is based on a corpus of taped dialogues of a form previously used by Anne Anderson, Simon Garrod and their colleagues to study the establishment and maintenance of reference during the performance of shared tasks. A related working group will study the dialogues as texts, but spoken dialogue offers more to the listener than can be indicated in a standard orthographic transcription. We plan to investigate at least two ways in which the additional information is conveyed, and one way in which the listener might profit.

One kind of information is the pairing of syntactic form and intonational pattern which helps to define the utterance's intended perlocutionary effect. We will work towards an 'intonational parser' which will limit the ambiguity of the utterance which a text parse would allow and also classify the utterance within a model of conversational games.

A second kind of additional information resides in the pronunciation of individual words. They may be made more or less prominent and intelligible depending on the speaker's view of the word's relationship to knowledge shared with the listener. We will study the discourse conditions determining and the perceptual results following from the variable pronunciations of words, with particular reference to certain well-attested phonological reductions; and we will integrate this work on the choice and perception of word tokens with the work on the selection of referring expressions.

We also plan to use this corpus in at least the initial stages of an exploration of the integration of incremental syntactic and semantic processing into a speech recognition system. The goal is to provide a principled source of top-down constraint on the lexical access process which lies at the heart of speech recognition and which is psychologically plausible, given what we know about the kinds of information present in speech. Although fundamental progress in knowledge representation is also required before the principled approach can be broadly effective, textual and phonological studies of dialogues created in pursuance of a constrained task will help in framing a pilot study of the mechanisms involved.

While the group's work is motivated primarily by a desire to develop a unified account of human conversation and speech recognition, our approach has practical applications within automatic text-to-speech and speech-to-text systems.

Grammar and Processing

One purpose of the workshop is to provide an environment for HCRC to test empirical linguistic theories within an implemented grammar environment. The other purpose is to improve on current methods in grammar and processing. Thus, the prediction project is directed at obtaining strong semantic and syntactic predictions from the context on an item considered by a speech processor, or by any other processor that has to choose between a large class of possible analyses. Other projects are concerned with integrating pragmatics into computational linguistics, and with developing models of the human sentence processor. A further aspect of the working group is to provide a framework for externally funded projects in computational linguistics.

Inference in Communication

Graphics Sub-group

The activities of the group are centred around the realisation that, despite its prevalence, the use of graphics in communication has been neglected by studies in cognitive science. In collaboration particularly with EdCAAD (Edinburgh Computer-Aided Architectural Design, in the Department of Architecture), several lines of research are being developed.

Cognitive aspects of the use of pictorial material, relating to issues concerning image-based processing and 'analogical' mental models, will be investigated with a new emphasis on communication as well as inference. These topics have a broad relevance, for instance to the activities of design in many fields, from engineering to generalised graphical design (e.g. in business presentations or advertising). With the Department of Geography, University of Glasgow, who have provided a number of interesting problems involving the use of roadmaps, it is hoped also to extend and deepen existing work on the use of map-like data structures in spatial cognition.

There is a history of research in Edinburgh into the ways in which graphical communication is commonly integrated into natural language dialogue, and the possibilities for exploiting this in human-computer interaction (HCI). Funded hitherto by ESPRIT, a shared grant to continue this work with EdCAAD has already been obtained under the Joint Research Councils' Initiative in Cognitive Science and HCI. The emphasis now is on integrating these ideas with the rest of the work of HCRC.

Situation Theory and Grammar Sub-group (STAGR)

Research within the STAGR workshop is centered around one important aspect of information processing: relativity to context. Situation theory is a foundational enterprise which aims to supply a unified mathematical formalism for understanding the range of information processing activity in both living organisms and artificial devices. The key theoretical concept is the 'situation', or locus of informational content. By making the context in which an informative transaction occurs an object of study in its own right, it is hoped that the theory will be able to account for many context relative phenomena.

Language processing has provided the main focus for work in situation theory. Current linguistic theories are full of subtle problems which demand attention by any prospective theory of information. Research in situation semantics is directed at applying the ideas of situation theory to these problems; but also using them to motivate distinctions in the theory. Particular attention is given to the idea that the informational content of an utterance is built up incrementally, drawing on circumstantial information in the context as well as that implicit in

the linguistic form.

Our research interests are more or less evenly divided between situation theory and situation semantics. The former owes a lot to the seminal work of Barwise and Perry and the STASS group at Stanford University, with whom we have close connections. The first international workshop in situation theory was held in Edinburgh during the summer of 1988; another is to be held in the summer of 1990.

Semantic Processing

This group is concerned with developing a psychologically realistic account of meaning in the context of communication. While formal (semantic) theories have assisted efforts at computational interpretation, they have tended to overlook many of the crucial nuances of meaning in communication. Specific topics include:

1. Communicating under uncertainty, including quantity statements, confidence and doubt, and complex hedging. This includes a re-evaluation of accepted views of quantifiers and how they function.
2. Communicating spatial and temporal information, with special emphasis on the notion of functional space and functional periods.
3. How linguistic expressions manipulate attentional focus (hence inference) and connotation.
4. The role in communication of (everyday) stylistic variables, including paralinguistic phenomena.

The group aims to couple new avenues of experimentation with the development of richer theories with an eye to formalisation.

7 Theses Under Supervision

The Centre for Cognitive Science currently has around forty PhD students. Their thesis topics cover the broad range of research problems in the field of cognitive science. The list below includes all and only the thesis titles of students being supervised by teaching staff located in the Centre for Cognitive Science in October 1989.

Cath Ardin: The Mental Representation of Texts with Logical Structure.

Guy Barry: Extensions of the Lambek Calculus and their Applications.

Steven Bird: Declarative Phonology.

Patrick Blackburn: Reasoning in and about Time: Nominal Tense Logic and other Sorted Intensional Frameworks.

Nick Braisby: A Situated Account of Word Meaning.

Stephana Broadbent: Children's Construction of Implicit Theories: The Case of Horizontality.

Jo Calder: The Design and Construction of Large-Scale Computational Lexicons.

Francesco Cara: Modelling the Child's Development of Cardinality: From Counting to Conservation of Number.

Kathrin Cooper: Topics in Zurich German Syntax.

Richard Cooper: Constituent Hierarchies, HPSG and Parsing.

Sophia Cormack: Incorporating Sidner's Algorithm for Focus into Discourse Representation Theory.

Kenny Coventry: The Meaning of Spatial Prepositions and their Analogical Extensions.

Peter Dayan: Theoretical and Practical Aspects of Symbolic Connectionism.

Judy Delin: Cleft Constructions in Discourse.

Martin Emms: Logical Ambiguity.

Greg Filz: An Aspect of Child Language Acquisition.

Steven Finch: Concept Combination and Evidential Reasoning.

Carol Foster: Philosophical Foundations of Artificial Intelligence.

Brad Franks: Criteria and Concepts: An Antirealist Approach toward Meaning.

Marcus Frean: Feedforward Neural Net Algorithms.

Claire Gardent: Semantic and Computational Properties of Verb Phrase Ellipsis.

Mark Hepple: The Word Order and Constituent Structure of Germanic Languages.

Alexander Holt: A Flexible Syntax for Graphics.

Joe Levy: Methods of Modelling the Mental Representation of Individuals Derived from Descriptions in Text.

Colin Matheson: English Noun Phrases.

Scott McGlashen: A Lexical Approach to the Contribution of Thematic Relations in Word Combination with Special Reference to Control.

Michael McPartlin: Logics of Belief.

Denise Neopolitan: The Experimental Decomposition of a Cognitive Skill.

Michael Newton: Grammars and Specification Languages.

Martin Pickering: A Psycholinguistic Account of Unbounded Dependencies.

Luis Pineda: A Semantics for Graphics with Some Applications to HCI-CAD.

Ehud Rahat: Metaphor and the Role of Regularities in theories of Meaning.

Mike Reape: A Formal Theory of Word Order: A Case Study in Germanic.

Catrin Rhys: Zero Anaphora and Related Topics in Chinese.

Antonio Sanfillipo: Grammatical Relations and Thematic Roles in Linguistic Theory and Natural Language Processing.

Jim Scobble: On the Spreading and Sharing of Phonological Information.

Jerry Seligman: Quantified Information in Situation Theory.

Ben St Johnston: Transitive Infererence: A Connectionist Model of Integrative Processes in Memory.

Max Volino: The Linguistic and Computational Properties of Word Grammar.

8 Computing and Research Facilities

The facilities for research in cognitive science within the University are extensive.

The Centre for Cognitive Science and the Edinburgh site of the Human Communication Research Centre share a network of computing resources, supported by a computing staff of four persons. The following are connected by Ethernet:

- Three RISC-based SUN SPARCserver 330s, running UNIX: these provide the central source of computing power within the two institutions.
- Half a dozen SUN 4 and SUN 3 workstations, which provide graphics front-ends to UNIX; HCRC takes delivery of at least three more such machines towards the end of 1989.
- A considerable number of terminals, which provide distributed access to the UNIX resources.
- A network of six Xerox D-machines (donated by Rank Xerox), along with a dedicated file server and a dedicated printer: these provide hardware

specifically tailored to the execution of programs written in list processing languages for AI applications.

- A separate network of Apple Macintoshes, which is bridged to the Ethernet to provide UNIX-based file storage and printing facilities: currently this network consists of around 20 Macintosh Pluses, SE/30s, IIxs, IIcxs, and this number is expected to increase in the near future.

Our network also provides access to the mainframe resources of the University Computing Service, and to the machines in the Departments of Artificial Intelligence and Computer Science. Links to JANET and the outside world provide easy access for electronic mail.

To support experimental work, there is also has a network of BBC microcomputers. For more specialised work, there is access to the resources of the Departments of Linguistics and Psychology, and the Centre for Speech Technology Research.

A major use of computing power in the two institutions is text processing: the major packages used are LaTeX (on both UNIX machines and on Macintoshes) and Microsoft Word. GnuEmacs and MicroEmacs are both used extensively. Research-related programming centres around the use of PROLOG, although we support a number of other programming languages.

The University Library is one of the largest in Britain, and includes a comprehensive serial list in the relevant areas. Also available for use are the more specialised libraries at the Departments of Computer Science and Artificial Intelligence.

9 CCS Publications

The Centre for Cognitive Science maintains two internal publications series for circulating material prior to submission to journals and conferences. The Research Papers series comprises individual papers reporting recent work, and the Working Papers series comprises volumes collecting together research undertaken by teams and workshops. A complete list of papers and pre-publications is available from the Librarian at CCS. HCRC will be launching a separate report series in the forthcoming academic year.

We include in the following subsections lists of research papers, working papers, and PhD theses published over the last year by the Centre for Cognitive Science; these are followed by a list of publications by CCS personnel covering the academic year 1988–1989.

9.1 CCS Reports 1988–89

Lascarides, A.: The Semantics of Aspectual Classes using Reference to Intervals. Ref. No: EUCCS/RP-22.

Calder, J.: Paradigmatic Morphology. Ref. No: EUCCS/RP-23.

Bird, S. and Klein, E.: Phonological Events. Ref. No: EUCCS/RP-24.

Delin, J.: The Focus Structure of *It*-clefts. Ref. No: EUCCS/RP-25.

Klein, E.: Grammar Frameworks. Ref. No: EUCCS/RP-26.

Chater, N. and Oaksford, M.: Autonomy, Implementation and Cognitive Architecture: A Reply to Fodor and Pylyshyn. Ref. No: EUCCS/RP-27.

Stenning, K. and Oaksford, M.: Choosing Computational Architectures for Text Processing. Ref. No: EUCCS/RP-28.

Oaksford, M., Chater, N. and Stenning, K.: Connectionism, Classical Cognitive Science and Experimental Psychology. Ref. No: EUCCS/RP-29.

Klein, E. and Stainton-Ellis, K.: A Note on Multiple VP Ellipsis. Ref. No: EUCCS/RP-30.

Seligman, J. and Chater, N.: Devlin on Information and Cognition. Ref. No: EUCCS/RP-31.

Morrill, G.: Intensionality, Boundedness, and Modal Logic. Ref. No: EUCCS/RP-32.

Myers, T., Franks, B. and Braisby, N.: Partiality and Coherence in Concept Combination. Ref. No: EUCCS/RP-33.

Morrill, G.: Grammar as Logic. Ref. No: EUCCS/RP-34.

Oberlander, J.: How the Laws of Thought Lie. Ref. No: EUCCS/RP-35.

Braisby, N. and Cooper, R.: (eds). Situation Theoretic Studies in Psychology, Language and Logic. Ref. No: EUCCS/WP-3.

9.2 PhD Theses 1988–89

Dunbar, G. [1988] The Cognitive Lexicon. Ref. No: EUCCS/PHD-17.

Lowe, A. [1988] The Relative Contribution of Top-down and Bottom-up Information During Lexical Access. Ref. No: EUCCS/PHD-18.

Oaksford, M. [1988] Cognition and Inquiry: an Investigation into the Psychosemantics of Conditional Reasoning. Ref. No: EUCCS/PHD-19.

Popowich, F. [1988] Reflexives and Tree Unification Grammar. Ref. No: EUCCS/PHD-20.

Lascarides, A. [1988] A Formal Semantic Analysis of the Progressive. Ref. No: EUCCS/PHD-21.

Haddock, N. [1988] Incremental Semantics and Interactive Syntactic Processing. Ref. No: EUCCS/PHD-22.

Morrill, G. [1988] Extraction and Coordination in Phrase Structure Grammar and Categorial Grammar. Ref. No: EUCCS/PHD-23.

Carpenter, R. [1988] Phrase Meaning and Categorial Grammar. Ref. No: EUCCS/PHD-24.

Kamareddine, F. [1988] Semantics in a Frege Structure. Ref. No: EUCCS/PHD-25.

Pareschi, R. [1988] Type-Driven Natural Language Analysis. Ref. No: EUCCS/PHD-26.

Roberts, P. [1988] Action, Intention and Language: A Davidsonian Study. Ref. No: EUCCS/PHD-27.

Dale, R. [1988] Generating Referring Expressions in a Domain of Objects and Processes. Ref. No: EUCCS/PHD-28.

Stirling, L. [1988] Switch-Reference and Logophoricity in Discourse Representation Theory. Ref. No: EUCCS/PHD-29.

Chater, N. [1989] Information and Information Processing. Ref. No: EUCCS/PHD-30.

Patel, M. [1989] Human Text Processing and Models of Knowledge Representation. Ref. No: EUCCS/PHD-31.

9.3 Publications by CCS Staff 1988–89

Bard, E. G., Shillcock, R., and Altmann, G. [1988] The recognition of words after their acoustic offsets in spontaneous speech: effects of subsequent context. *Perception and Psychophysics*, 44, 395–408.

Calder, J., Klein, E. and Zeevat, H. [1988]. Unification Categorial Grammar: A Concise, Extendable Grammar for Natural Language Processing. In *Proceedings of the 12th International Conference on Computational Linguistics and the 24th Annual Meeting of the Association for Computational Linguistics*, Budapest, August, 1988.

Calder, J. [1989] Paradigmatic morphology. In *Proceedings of the 4th Conference of the European Chapter of the Association for Computational Linguistics*, University of Manchester Institute of Science and Technology, Manchester, UK, 10–12 April, 1989, pp58–65.

Calder, J., Reape, M. and Zeevat, H. [1989] An algorithm for generation in Unification Categorial Grammar. In *Proceedings of the 4th Conference of the European Chapter of the Association for Computational Linguistics*, University of Manchester Institute of Science and Technology, Manchester, UK, 10–12 April, 1989, pp233–240.

Dale, R. [1989] Cooking Up Referring Expressions. In *Proceedings of the 27th Annual Meeting of the Association for Computational Linguistics*, University of British Columbia, Vancouver BC, Canada, 26–29 June 1989, pp68–75.

Dunbar, G. L. and Myers, T. F. [1988] Concept combination and the characterisation of lexical concepts. In Hullen, W. and Schulze, R. (eds.) *Understanding the Lexicon: Meaning, Sense and World Knowledge in Lexical Semantics*, pp292–302. Tubingen: Niemeyer.

Engdahl, E. [1988] Relational interpretation. Chapter 3 in Kempson, R. M. (ed.) *Mental representations: The Interface between language and reality*, pp63–82. Cambridge: Cambridge University Press.

Hepple, M. and Morrill, G. [1989] Parsing and Derivational Equivalence. In *Proceedings of the 4th European Meeting of the Association for Computational Linguistics*, Manchester, 10–12 April, 1989, pp10–18.

Klein, E. [1989] Grammar Frameworks. Chapter 3 in Schnelle, H. and Bernsen, N. O. (eds.) *Logic and Linguistics*, Volume 2: *Research Directions in Cognitive Science: European Perspectives*, pp71–107. Hillsdale, N.J.: Lawrence Erlbaum Associates.

Moens, M. [1988] Temporal Databases and Natural Language. In Rolland, C., Bodart, F. and Leonard, M. (eds.) *Temporal Aspects in Information Systems*, pp171–183. Amsterdam: North Holland.

Moens, M. and Steedman, M. J. [1988] Temporal ontology and temporal reference. *Computational Linguistics*, 14, 15–28.

Moens, M., Calder, J., Klein, E., Reape, M. and Zeevat, H. [1989] Expressing generalizations in unification-based grammar formalisms. In *Proceedings of the 4th Conference of the European Chapter of the Association for Computational Linguistics*, University of Manchester Institute of Science and Technology, Manchester, UK, 10–12 April, 1989, pp174–181.

Pineda, L. A., Klein, E. and Lee, J. R. [1988] GRAFLOG: Understanding Drawings through Natural Language. *Computer Graphics Forum*, 7.

Pineda, L. A. [1988] A Compositional Semantics for Graphics. In *Proceedings*

of Eurographics '88, North-Holland, 1988.

Pineda, L. A. and Chater, N. J. [1988] GRAFLOG: Programming with Interactive Graphics and Prolog. In CGIC88, 1988.

Pineda, L. A. [1988] GRAFLOG: A Graphical and Logical Programming Language. In *Proceedings of* IFIP TC5 *Conference on* CAD/CAM *Technology Transfer to Latin America*, Mexico City, 1988.

Reape, M. and Thompson, H. S. [1988] Parallel Intersection and Serial Composition of Finite State Transducers. In *Proceedings of the 12th International Conference on Computational Linguistics and the 24th Annual Meeting of the Association for Computational Linguistics*, Budapest, August, 1988, pp535–539.

Reape, M. [1989] A logical treatment of semi-free word order and bounded discontinuous constituency. In *Proceedings of the 4th Conference of the European Chapter of the Association for Computational Linguistics*, University of Manchester Institute of Science and Technology, Manchester, UK, 10–12 April, 1989, pp103–110.

Richards, B., Bethke, I., van der Does, J. and Oberlander, J. [1989] *Temporal Representation and Inference.* London: Academic Press.

Ritchie, G. [1989] On the Generative Power of Two-level Morphological Rules. In *Proceedings of the 4th Conference of the European Chapter of the Association for Computational Linguistics*, University of Manchester Institute of Science and Technology, Manchester, UK, 10–12 April, 1989.

Shillcock, R., Bard, E.G., and Spensley, F. [1988] Some prosodic effects on human word recognition in continuous speech. Proceedings of SPEECH 88, 7th FASE Symposium, pp819-826.

Stenning, K., Shepherd, M. and Levy, J. [1988] On the construction of representations for individuals from descriptions in text. *Language and Cognitive Processes*, **2**, 129-164.

Stenning, K. and Levy, J. [1988] Knowledge-rich solutions to the 'binding problem': some human computational mechanisms. *Knowledge Based Systems*, **1**.

Stenning, K. and Levy, J. [1989] The computational architecture of human memory: analyses and simulations of attribute binding. In UK IT *88*, Information Engineering Directorate, London, 1989, pp189-191.

Thompson, H. S. [1988] Speech Technology and the Language Industry: Opportunities and Pitfalls. In *Proceedings of Online Information 88*, Learned Information Ltd, Oxford.

Zeevat, H. [1989] Realism and Definiteness. In Partee, B., Chierchia, G. and Turner, R. (eds.) *Property Theory, Type Theory and Natural Language Semantics.* Dordrecht: Reidel.

Zeevat, H. [1989] A Compositional Approach to Discourse Representation Theory. *Linguistics and Philosophy*, **12**, 95–131.

10 Seminars and Visiting Scholars

CCS and HCRC run a joint seminar programme devoted to issues of relevance to cognitive science. There are regular meetings during term, normally addressed by visiting scholars. The centres are fortunate in being able to attract visitors from the international community, particularly from Europe and the USA.

In the 1988–89 academic year, speakers included the following: Marcus Kracht, Peter Seuren, Anna Szabolcsi, Michael Moortgat, Stephen Read, Jan van Eijck, Rosemary Stevenson, Graeme Forbes, Yves Lafont, Roger Evans, Michael Morreau, Lynn Cooper, David Dowty, Ned Block, Susan Carey, Andrew Barto, Gert Smolka, Lynda Hardman and John Perry.

The centres also welcome scholars who wish to visit for longer periods of time. Those who might be interested should to write to the Head of Department of the Centre for Cognitive Science, or the Director of HCRC.

11 Admission to the Postgraduate Programme

Students from the UK and overseas are invited to apply for admission to the postgraduate programme. The minimum academic requirement is normally an upper second class honours degree, or its equivalent, in a subject related to cognitive science, e.g. Computer Science, Linguistics, Mathematics, Philosophy or Psychology.

For UK students, financial support may be provided by the Research Councils (SERC and ESRC). Training awards are also available from the Department of Education and Science and the Scottish Education Department.

Students from overseas should inquire within their own countries about scholarships available for study abroad. Graduates from Commonwealth and European Community countries may apply to the British Council.

Any applicant wishing to register for a PhD is eligible to apply for an Edinburgh University Studentship. However, these are limited in number and awarded on a competitive basis: they are primarily appropriate for overseas students who are unable to gain other funding support.

For further information on admission and funding, please write to the Director of the Postgraduate Programme at the Centre for Cognitive Science.

12 Addresses for correspondence

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