COGNITIVE APPROACHES TO SLA

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INTRODUCTION

Getting to know a second language is an act of cognition *par excellence*. Yet 'Cognitive Approaches to SLA' implies something more than the general research enterprise of SLA. It highlights the goals of cognitive psychologists who search for explanations of second language cognition in terms of mental representations and information processing. It places SLA within the broader remit of cognitive scientists, who, influenced by Marr (1982) to seek understanding at all three levels of function, algorithm and hardware, work in collaborations involving cognitive psychology, linguistics, epistemology, computer science, artificial intelligence, connectionism, and the neurosciences. It implies the empiricism of cognitive psychology, searching for truths about the world through observation and experimentation and, at times, the rationalism of cognitive scientists who theorize through the construction of formal systems such as those in mathematics, logic or computational simulation. Much of the research is purely theoretical, but, as in applied cognitive psychology, pure theory can often spin off into important applications, and applied research using longitudinal or training designs in field situations can often advance theory.

This review will follow this tripartite structure: it will define 'Cognitive Approaches to SLA' firstly in terms of this discipline's goals and theoretical orientations, secondly in terms of its methods, and finally, just briefly, in terms of its applications.

GOALS

Twenty years ago, the study of cognition, etymology notwithstanding, was more concerned with knowledge than the getting of knowledge. Today, if anything, the reverse

is true. We realize that we can only properly understand the final state of fluent expertise if we understand the processes by which this came about. Therefore, cognitive science is also concerned with functional and neurobiological descriptions of the learning processes which, through exposure to representative experience, result in change, development, and the emergence of knowledge. A complete theory of SLA must include both a property theory (of what the domain of knowledge is and how it is represented) and a transition theory (of how learners get from one knowledge state to another) (Gregg 1993, Ellis 1998). Thus SLA is a subject of cognitive science *par excellence*. Notable heralds of this liaison include Bialystok (1978), McLaughlin (1987), McLaughlin and Harrington (1989), and Schmidt (1990; 1992).

In what follows, I will identify some of the key questions along with illustrative recent research progress. I am lead to make two moves which will likely appear perverse. Firstly, space limitations dictate that I must ignore much of the good work on second language mental representation and processing that has come from psycholinguistics (de Groot and Kroll 1997): I am excused this area because of the companion chapter by Segalowitz and Lightbown in this volume. Secondly, I will devote some of my time to discussion of first language research. My purposes here are to illustrate the profound ways in which cognitive theorizing about native language development has changed in the last two decades. Since these ideas have yet to make their full impact in SLA, I intend to exhort as much as to celebrate, and where appropriate, to show where the relevant research tools are to be found.

1) Cognitive Approaches to the Property Theory

What are the mental representations of language? For detailed descriptions of the patterns and relations in language, in languages, in all languages, there is no other place to look but linguistics. When language is dissected in isolation, there appear many complex and fascinating structural systematicities, and generative linguistics is rigorous in its attempt

to determine the set of rules that defines the unlimited number of sentences of a language. These careful descriptions are necessary for a complete theory of language acquisition. But they are far from sufficient. Indeed, many cognitive scientists believe that linguistic descriptions are something very different from mental representations. Instead, cognitive science offers a contrasting and much broader set of answers to the question of mental representation than generative approaches which, following Chomsky (1965; 1981; 1986), have been guided by the following assumptions: (1) *Modularity*: language is a separate faculty of mind; (2) *Grammar as a system of symbol-manipulating rules*: knowledge about language is a grammar, a complex set of rules and constraints that allows people to distinguish grammatical from ungrammatical sentences; (3) *Competence*: research should investigate grammatical competence as an idealized hygienic abstraction rather than language use which is sullied by performance factors; (4) *Poverty of the Stimulus*: since learners converge on the same grammar in broadly similar patterns of acquisition even though language input is degenerate, variable and lacking in reliable negative evidence, learnability arguments suggest that there must be strong constraints on the possible forms of grammars, the determination of which constitutes the enterprise of Universal Grammar (UG); (5) *Language Instinct*: the essential constraints of UG are innately represented in the brain, language is an instinct, linguistic universals are inherited, the language faculty is modular by design; (6) *Acquisition as Parameter Setting*: language acquisition is therefore the acquisition of the lexical items of a particular language and the appropriate setting of parameters for that language. These assumptions focus the generative approach to SLA around questions concerning whether the second language learner has access to the innate endowment of UG and how parameters might be reset (Eubank 1995).

Many cognitive scientists doubt these assumptions, particularly *modularity* and *language instinct* and the consequent study of the uniquely human faculty of language alone, divorced from semantics, the functions of language, and the other social, biological,

experiential and cognitive aspects of humankind. They worry that this approach has effectively raised the systematicities of syntax from explanandum to explanans.

Neurobiologists are concerned that the innateness assumption of the language instinct hypothesis lacks any plausible process explanation (Elman, Bates, Johnson, Karmiloff-Smith, Parisi and Plunkett 1996, Quartz and Sejnowski 1998) and that current theories of brain function, process and development do not readily allow for the inheritance of structures which might serve as principles or parameters of UG. The human cortex is plastic, the form of representational map is not an intrinsic property of the cortex but rather it reflects experience to a remarkable degree: for example, auditory cortex, presumably a prime potential site for UG, if solely provided with visual input during early experience, learns to see. Given this plasticity and enslavement to the periphery, it is hard to see how genetic information might prescribe rigid innate language representations in the developing cortex. This is not to deny Fodorian modular faculties in adulthood, or areas of cortex specialized in function. However, (1) the attainment of modularity and cortical specialization may be more the result of learning and the development of automaticity than the cause (Elman et al. 1996); (2) brain imaging studies are resulting in a proliferation of language areas, including Broca's area and Wernicke's area on the right side as well as the left, parts of the cerebellum, a number of subcortical structures, and high frontal and parietal areas (Damasio and Damasio 1992, Posner and Raichle 1994); (3) there are remarkable individual differences, even between MZ twins, (4) none of these regions are uniquely active for language and are involved in other forms of processing as well; all of these regions collaborate in language processing -- ask someone to do a language task as simple as choosing the action verb that goes with a noun (hammer - hit) and you don't see just one of these areas 'light up' (Posner and Raichle 1994). Language cognition cannot be cleanly separated from the rest of cognition.

Innate specification of synaptic connectivity in the cortex is unlikely. On these grounds, linguistic representational nativism seems untenable. A rigidly separate language

module is similarly implausible. So our theories of language function, acquisition and neurobiology must reunite speakers, syntax and semantics, the signifiers and the signifieds. Cognitive approaches, including *Functional linguistics* (Bates and MacWhinney 1981, MacWhinney and Bates 1989), *Emergentism* (Elman et al. 1996, MacWhinney 1998), *Cognitive linguistics* (Langacker 1987; 1991, Ungerer and Schmid 1996), and *Constructivist* child language researchers (Slobin 1997, Tomasello 1992; 1995; in press) are more Saussurean, viewing the linguistic sign as a set of mappings between phonological forms and conceptual meanings or communicative intentions. They hold that simple associative learning mechanisms operating in and across the human systems for perception, motor-action and cognition as they are exposed to language data as part of a communicatively-rich human social environment by an organism eager to exploit the functionality of language are what drives the emergence of complex language representations.

Cognitive linguistics provides detailed qualitative analyses of the ways in which language is grounded in our *experience* and our *embodiment* which represents the world in a very particular way. The meaning of the words of a given language, and how they can be used in combination, depends on the perception and categorization of the real world around us. Ultimately, everything we know is organized and related to other of our knowledge in some meaningful way or other, and everything we perceive is affected by our perceptual apparatus and our perceptual history. Language reflects this embodiment and this experience. The different degrees of *salience* or *prominence* of elements involved in situations which we wish to describe affect the selection of subject, object, adverbials and other clause arrangement. Figure/ground segregation and *perspective taking*, processes of vision and attention, are mirrored in language and have systematic relations with syntactic structure. In production, what we express reflects which parts of an event attract our *attention*; depending on how we direct our attention, we can select and highlight different

aspects of the frame, thus arriving at different linguistic expressions. In comprehension, abstract linguistic constructions (like simple transitives, locatives, datives, resultatives and passives) serve as a "zoom lens" for the listener, guiding their attention to a particular perspective on a scene while backgrounding other aspects (Goldberg 1995). Thus cognitive linguistics aims to understand how the regularities of syntax emerge from the cross-modal evidence that is collated during the learner's lifetime of using and comprehending language.

The *Competition Model* (MacWhinney 1987; 1997a) emphasizes lexical functionalism where syntactic patterns are controlled by lexical items. It is developed as a formal quantitative model and has been broadly applied both in SLA and cross-linguistically. Recent competition model studies have simulated language performance data using simple connectionist models relating lexical cues (like word order, verb agreement morphology, case marking, etc.) and functional interpretations (like agency, topicality, perspective, givenness, etc.) for sentence comprehension or production (Kempe and MacWhinney in press). There are many attractive features of the competition model. It developmentally models the cues, their frequency, reliability, and validity, as they are acquired from representative language input. The competition part of the model shows how Bayesian cue use can resolve in activation of a single interpretative hypothesis from a rich network of interacting associations and connections (some competing, others, as a result of the many redundancies of language and representation, mutually reinforcing). It has been tested to assess the cues, cue validity and numerical cue strength order in different languages. Finally, it goes a long way in predicting language transfer effects, serving as a revival of contrast analysis in a probabilistic guise (MacWhinney 1992).

The competition model has been a good start for investigating the emergence of strategies for the linguistic realization of reference. But the ultimate goal of cognitive approaches is to develop models which properly represent all of the systems of working memory, perceptual representation, and attention that are involved in collating the regularities of cross-modal associations underpinning language use (Ellis in press). We

want the richness of cognitive linguistic analyses and the formal detail and testability of the competition model.

We want a detailed transition theory too. If language is not informationally encapsulated in its own module, if it is not privileged with its own special learning processes, then we must eventually show how generic learning mechanisms can result in complex and highly specific language representations. What of the transition theory?

2) Cognitive Approached to the Transition Theory

Psycholinguistic investigations have long demonstrated that many aspects of language skill intimately reflect prior language use in that they are tuned to the learner's relative frequencies of lifetime experience of language and the world. For example, lexical recognition processes (both for speech perception and reading) and lexical production processes (articulation and writing) are independently governed by the *power law of practice,* a learning function which describes all skills. The power law pervades language acquisition: it is certainly not restricted to lexis. Larsen-Freeman (1976) was the first to propose that the common acquisition order of English morphemes to which ESL learners, despite their different ages and language backgrounds, adhere is a function of the frequency of occurrence of these morphemes in adult native-speaker speech. More recently, Ellis and Schmidt (1997) and DeKeyser (1997) show that the power law applies to the acquisition of morphosyntax and that it is this acquisition function which underlies interactions of regularity and frequency in this domain. To the extent that the power law applies a wide range of skills, psycholinguistic analyses thus suggest that language is cut of the same cloth as other cognitive processes, and that language acquisition, like other skills, can be understood in terms of models of optimal (Bayesian) inference in the presence of uncertainty.

Language learning is special in its complex content, in its many thousands of pieces, in the ways in which these pieces interrelate, and the numerous patterns, some categorical, most fuzzy, by which these pieces serve as cues to meaning. This massive

content entails that language learning, like the learning of other complex domains, takes tens of thousands of hours. During these hours, the extraction of the information concerning the statistical reliabilities and validities of these cues which serve language understanding (as the simultaneous satisfaction of the multiple probabilistic constraints afforded by the cues present in each particular sentence -- Seidenberg 1997) is predominantly unconscious. We do not consciously count frequencies while we are using language, yet nonetheless, this language use tunes our language processing systems. We learn language from using language.

Emergentists (MacWhinney 1998, Ellis 1998) believe that the complexity of language emerges from relatively simple developmental processes being exposed to a massive and complex environment. Thus they substitute a process description for a state description, study development rather than the final state, and focus on the language acquisition process (LAP) rather than language acquisition device (LAD): "Many universal or at least high-probability outcomes are so inevitable given a certain 'problem-space' that extensive genetic underwriting is unnecessary... Just as the conceptual components of language may derive from cognitive *content*, so might the computational facts about language stem from nonlinguistic *processing*, that is, from the multitude of competing and converging constraints imposed by perception, production, and memory for linear forms in real time." (Bates 1984: 188-190). But belief in syntax or other language regularities as emergent phenomena, like belief in innate linguistic representations, is just a matter of trust unless there are clear process, algorithm and hardware explanations. For these reasons, emergentists look to connectionism since it provides a set of computational tools for exploring the conditions under which emergent properties arise.

Connectionism has various advantages for this purpose: neural inspiration; distributed representation and control; data-driven processing with prototypical representations emerging rather than being innately pre-specified; graceful degradation; emphasis on acquisition rather than static description; slow, incremental, non-linear,

content- and structure-sensitive learning; blurring of the representation/ learning distinction; graded, distributed and non-static representations; generalization and transfer as natural products of learning; and, since the models must actually run, less scope for hand-waving (for introductions see Churchland and Sejnowski 1992, Elman et al. 1996, McClelland and Rumelhart 1986, Plunkett and Elman 1997).

Connectionist approaches to language acquisition investigate the representations that can result when simple learning mechanisms are exposed to complex language evidence. Lloyd Morgan's canon (In no case may we interpret an action as the outcome of a higher psychical faculty if it can be interpreted as the outcome of one which stands lower in the psychological scale) is influential in connectionists' attributions of learning mechanisms: "implicit knowledge of language may be stored in connections among simple processing units organized in networks. While the behavior of such networks may be describable (at least approximately) as conforming to some system of rules, we suggest that an account of the fine structure of the phenomena of language use can best be formulated in models that make reference to the characteristics of the underlying networks." (Rumelhart and McClelland 1987: 196).

Connectionists test their hypotheses about the emergence of representation by evaluating the effectiveness of their implementations as computer models consisting of many artificial neurons which are connected in parallel. Each neuron has an activation value associated with it, often being between 0 and 1. This is roughly analogous to the firing rate of a real neuron. Psychologically meaningful objects can then be represented as patterns of this activity across the set of artificial neurons. For example, in a model of vocabulary acquisition, one subpopulation of the units in the network might be used to represent picture detectors and another set the corresponding word forms. The units in the artificial network are typically multiply interconnected by connections with variable strengths or weights. These connections permit the level of activity in any one unit to influence the level of activity in all of the units that it is connected to. The connection strengths are then

adjusted by a suitable learning algorithm, in such a way that when a particular pattern of activation appears across one population it can lead to a desired pattern of activity arising on another set of units. If the connection strengths have been set appropriately by the learning algorithm, then it may be possible for units representing the detection of particular pictures to cause the units that represent the appropriate lexical labels for that stimulus to become activated. Thus, the network could be said to have learned the appropriate verbal output for that picture stimulus.

There are now many separate connectionist simulations of a wide range of linguistic phenomena including acquisition of morphology, phonological rules, novel word repetition, prosody, semantic structure, syntactic structure, etc. (see, e.g., Levy, Bairaktaris, Bullinaria and Cairns 1995, MacWhinney and Leinbach 1991, Plunkett 1998). These simple "test-tube" demonstrations repeatedly show that connectionist models can extract the regularities in each of these domains of language and then operate in a rule-like (but not rule-governed) way. To the considerable degree that the processes of learning L1 and L2 are the same, these L1 simulations are relevant to SLA. The problem, of course, is determining this degree and its limits. Because ground is still being broken for first language, there has been rather less connectionist work directly concerning SLA, although the following provide useful illustrations: Gasser (1990), Sokolov and Smith (1992), Broeder and Plunkett (1994), Kempe and MacWhinney (in press), Ellis and Schmidt (1998), Ellis (in press), Taraban and Kempe (in press).

Where does this leave us regarding the assumptions listed at the beginning of this paper? Emergentists are more inclined to integrate language with the rest of cognition. The systematicities of language derive from the interaction of a wide range of mental representations and processes, including those involved with attention, vision and motor control. Where there appears evidence of modularity, it is more likely a result of learning and the development of automaticity, in the same way that skilled word reading or car driving meet criteria of modularity. Since there are as yet no clear mechanisms for innate

linguistic representations, it seems more likely that the regularities of language emerge as abstractions of the regularities in the input exemplars (both linguistic and perceptual). Thus generative theories which describe such regularities as syntactic rules or constraints are exactly that -- theoretical descriptions, not mental representations: putting metalinguistic knowledge aside for the moment, there are no symbol-manipulating *rules* which do mental work in fluent, automatic language processing. Nor is all of language processing *symbol-manipulation.* Many of the representations which conspire in the semantics from which language is inextricable, in vision, in motor action, in emotion, are analogue representations. There are interesting interactions between all levels of representation (in reading, for example, from letter features through letters, syllables, morphemes, lexemes...). These different levels interact, and processing can be primed or facilitated by prior processing at subsymbolic or precategorical levels, thus demonstrating subsymbolic influences on language processing. These processes are readily modeled by distributed representations in connectionist models. Non-exclusivity of symbolic representation is by no means a denial of symbolic processes in language. Frequency of chunk in the input, and regularity and consistency of associative mappings with other representational domains, results in the emergence of effectively localist, categorical units, especially, but by no means exclusively, at lexical grain.

Where does this leave us with regard the cognitive processes of language learning? If language is indeed a learning problem that is special in content but not process, then psychological studies of learning are directly applicable. Just as the issues of the role of consciousness and attention, the value of explicit learning or explicit instruction, and non-interface *vs.* interface positions have been central topics in SLA debate for the last twenty years, so they have been the subject of considerable cognitive psychological research (Reber 1993, N. Ellis 1994, Stadler and Frensch 1998). *Explicit learning* is a more conscious, problem-solving operation where the individual attends to particular aspects of the stimulus array and generates and tests hypotheses in search of structure. *Implicit*

learning is acquisition of knowledge about the underlying structure of a complex stimulus environment by a process which takes place automatically and without conscious operations simply as a result of experience of examples. Human learning can take place implicitly, explicitly, or, because we can communicate using language, it can be influenced by declarative statements of pedagogical rules (*Explicit instruction*). Psychological research broadly shows: (1) When the material to be learned is simple, or where it is relatively complex but there is only a limited number of variables and the critical features are salient, then learners gain from being told to adopt an explicit mode of learning where hypotheses are to be explicitly generated and tested and the model of the system updated accordingly. As a result they are also able to verbalize this knowledge and transfer to novel situations. (2) When the material to be learned is more randomly structured with a large number of variables and when the important relationships are not obvious, then explicit instructions only interfere and an implicit mode of learning is more effective. This learning is instance-based but, with sufficient exemplars, an implicit understanding of the structure will be achieved. Although this knowledge may not be explicitly available, the learner may nonetheless be able to transfer to conceptually or perceptually similar tasks and to provide default cases on generalization ('wug') tasks. (3) Learning the patterns, regularities or underlying concepts in a complex domain with advance organizers and instruction is always better than learning without cues. Psychological research suggests "students who receive explicit instruction, as well as implicit exposure to forms, would seem to have the best of both worlds. They can use explicit instruction to allocate attention to specific types of input..., narrow their hypothesis space..., tune the weights in their neural networks..., or consolidate their memory traces." (MacWhinney 1997b: 278). Laboratory and field studies of SLA point to the same conclusions (Hulstijn and DeKeyser 1997, Ellis and Laporte 1997, Spada 1997). Yes, we learn language from using language, we update cue reliability statistics unconsciously, but, in the initial search for what cues are relevant, there is almost always value in explicit instruction, provided it is based on a proper analysis on

the problem space, the learner, and the stage of learning. Here, of course, lie the cruces of applied linguistics. We will return to them in the final section.

METHODS

Whatever the progress to date, certainly, there remain more questions than answers. In this section, which focuses on "Cognitive *approaches*", I am going to give detailed pointers to methods, tools and resources so that the interested reader can more readily follow these ways.

1) Observation

If we want to understand language acquisition, first we need to be able to observe language acquisition. Language research, like language learning, thrives on data collected from spontaneous interactions in naturally occurring situations. The greater the belief that input is important, the greater the need for a good record of input. The greater the desire to describe and analyze transition, the greater the need for accurate longitudinal records of individual language development. We must look carefully to language acquisition data, and other researchers must be able to scrutinize these data too. But the processes of collecting, transcribing, analyzing and sharing data are difficult, time-consuming, and often idiosyncratic and unreliable. The CHILDES project (MacWhinney 1995) has provided a number of tools and standards designed to facilitate the sharing of transcript data, increase the reliability of transcriptions, and automate the process of data analysis. These are the CHAT (Codes for the Human Analysis of Transcripts) transcription and coding format, the CLAN (Computerised Language ANalysis) programs for frequency counts, word-searches, co-occurrence analyses, MLU counts, interactional analyses, and so on, and the CHILDES (Child Language Data Exchange System) itself: over 150 megabytes of data gathered and stored in CHAT format by research teams from all over the world with diverse interests including second language learning, adult conversational interactions,

sociological content analyses, language recovery in aphasia, and the native acquisition of an increasingly wide range of first languages. These archives are accessible for secondary analysis on-line (MacWhinney and Higginson 1993) or on CD-ROM.

For scientific progress we need to be able to share in the analysis of language data. Introspection is no better a scientific method for linguistics than it is for psychology. It is preferable to observe performance than to speculate about some idealized competence. Corpora of natural language are the only reliable sources of frequency-based data and they provide the basis of a much more systematic approach to the analysis of language. For these reasons, we need large collections of representative language and the tools for analyzing these data. *Corpus linguistics* (McEnery and Wilson 1996) bases its study of language on such examples of real life performance data. Systematic study of corpora over the last two decades has led to four simple but profound conclusions: (1) it is impossible to describe syntax and lexis independently, (2) meaning and usage have a extensive and systematic effects on each other, or, in other words, syntax is inextricable from semantics and function, (3) language use is often closed and memory-based rather than open and constructive (the *principle of idiom*, Sinclair 1991), and (4) the structure of spoken language is very different from that of written language (Brazil 1995, Leech, Myers and Thomas 1995, McCarthy and Carter 1997, UCREL 1998). If language learners are extracting regularities of language input and language-reference mappings, if, as "cognitive approaches" believe, that is exactly what language learning is about, then language researchers should be studying representative samples of language. Useful leads to corpora can be found at University of Edinburgh Language Technology Group (1998). Sources for corpus and collocational research tools can be found at Barlow (1998).

2)   Experimentation

George Miller, one of the founding fathers of cognitive psychology, once joked, "Some of my friends... would not believe that people have two arms and two legs unless

you do an experiment proving it" (Baars 1986: 217). Maybe not always, but ideally you need experimental control to test causal hypotheses.

If we wish to investigate the effects of input and practice on the acquisition of language structure then we need a proper record of learner input. Yet it is impossible to gather a complete corpus of learners' exposure and production of natural language. There is a therefore a tradition of investigating detailed processes of language acquisition during relatively small amounts of exposure, usually several hours, to second-, foreign- or miniature artificial languages (MALs) under experimental conditions. Reber (1967) first championed this approach within psychology, McLaughlin (1980) within SLA. The number of published studies is now at least in the hundreds, if not more (see Winter and Reber 1994, Ellis and Laporte 1996 for review). This is because such experiments have many advantages. They allow: (a) a complete log of exposure to be recorded, (b) accuracy to be monitored at each point, (c) factorial manipulation of the potential independent variables of interest and the teasing apart of naturally confounded effects, and (d) relatively rapid collection of data. But these advantages are bought at the cost of reduced ecological validity: (a) MALs are toy languages when compared to the true complexity of natural language, (b) the period of study falls far short of lifespan practice, (c) laboratory learning exposure conditions are far from naturalistic, and (d) volunteer learners are often atypical in their motivations and demographics. All of these very real problems of laboratory research stem from the sacrifices made necessary by the goals of experimental control and microanalysis of learning in real time. This is the classic "experimenter's dilemma": Naturalistic situations limit experimental control and thus the internal logical validity of research; laboratory research limits ecological validity (Jung 1971).

In choosing to adopt laboratory experimental research, one is not denying naturalistic field studies. The first provides valid descriptions of artificial language learning while the latter proves tentative descriptions of natural language learning. Both are necessary for triangulation. Field experimentation is very difficult to operationalise, yet

nonetheless, as evidenced in Chaudron (1988), Lightbown, Spada and White (1993) and Doughty and Williams (1998), classroom research that is tight enough to properly inform second language instruction is possible. Nevertheless, some issues, for example those concerning the roles of attention or consciousness in learning, can only be properly conducted in the laboratory. Hulstijn and DeKeyser (1997) provides a review of these issues illustrated by several examples of recent laboratory investigations. Psycholinguistic research of this type which controls language exposure and which accurately records various responses in real time demands computer control using powerful experiment generation packages such as PsyScope, MEL and E-Prime. A review of such software, and pointers to them, can be found at CTI Psychology (1998).

3) <u>Simulation</u>

Any theory of SLA worth its salt will involve the interaction over time of many different variables from many different levels (sociolinguistic down to biological). If we just consider the surface form of written language, humans acquire, and are sensitive to, distributional frequency and associative information for hundreds of thousands of units ranging in size from individual letters through bigrams, trigrams, ngrams, lexemes, biwords,... up to collocations small and large, slot and frame patterns, and, ultimately, more abstract syntactic patterns which summarise the regularities of exemplars. The interactions between these associations both in learning and in the processing of language are highly complex. Emergentists believe that the regularities of language emerge from this massive associative database. But such notions require rigorous testing as computational models.

Since the 1960s psychology has used artificial intelligence (AI) techniques to build network models of, for example, semantic memory and spreading activation, and schema theories of knowledge representation. Production system simulations include (i) ACT* (Anderson 1983) which implemented declarative memory structures varying in level of

activation, condition-action rules, a constrainable working memory system, and various learning algorithms, (ii) ACT-R (Anderson 1993; 1997) which additionally builds in rational analysis using Bayesian reasoning to guide activation levels and (iii) SOAR (Newell 1990, SOAR Group 1997) which uses chunking as the fundamental learning mechanism in all domains (see Ellis 1996; in press for the relevance of this to SLA). All of these systems are available from the relevant URLs for use by the scientific community. The L_0 project is modeling embodied language development using Petri nets (Bailey, Feldman, Narayanan and Lakoff 1997). These different types of simulation all attempt to test the adequacy of theories as implementations in the same way that computational linguists might express and test their generative grammars in Prolog. But additionally, these production system approaches try to model extra-linguistic domains of representation, make a nod at constraining working memory resources to human levels, and try to model learning and development as well as fluent functioning. Such simulations are attractive in that the theory-builder has to specify every aspect of the theory that is required to make it run -- with so many interactive components, we simply cannot test the adequacy of such theories in our heads. Nevertheless, these AI approaches have been criticized for (i) failing to specify which parts of the program are principled and which not (kludges), (ii) a lack of sufficiently plausible human information-processing and neuro-architectural constraints, (iii) exclusively symbolic representations, and (iv) the fact that too little is learned and far too much is given by the programmer in terms of representational structure.

Thus, as explained above, emergentists have tended to use connectionist simulation systems for exploring the conditions underlying emergence. It used to be that fairly sophisticated programming skills were a prerequisite for any connectionist research. This is no longer necessarily the case. Plunkett and Elman (1997) have written a very readable workbook introduction which accompanies the Tlearn programming environment (Elman 1997). Anyone who can use a stats package or a complicated word-processor could manage to use this, and just about all of the above-listed SLA-relevant simulations (Gasser

through Taraban and Kemp) could have been implemented in Tlearn. Of course, other more sophisticated programming environments have their advantages, but connectionism is much like statistics in that in order to discover what structures are latent in the language evidence we have to run analyses of the language evidence, and Tlearn is a good starting package.

APPLICATIONS

Research on instructed SLA clearly warrants its own entry in this volume and, thanks to (*ADD REF TO ARAL 19 II. F. - Instructed SLA*) it has one that does it full justice. All I am able to do in my remaining allocation is to outline some of the relations between 'Cognitive approaches' and instruction. Effective instruction is promoted by a proper understanding of the problem domain and by instructors who evaluate their practices. As M. A. K. Halliday said "Applied linguistics is fine -- I'm an applied linguist -- but you've got to have something to apply"[1].

Cognitive approaches to SLA believe that a functionalist, usage-based model of language is the most appropriate analysis. This approach clearly dictates that in learning, as in theoretical analysis, language must not be separated from its function. Language and semantics are inextricable and thus we need functional, naturalistic, communicative situations for learning. Language learning is like other complex skills that demand at least ten thousand hours on task: it is exemplar-based, involving the cognizance of many thousands of structural cues to meaning and the subsequent implicit gathering of statistical frequency information, the tuning of weights, updating of probabilities, and assessment of reliabilities and validities of these cues; thus it requires years on-task. The learner's sample of experience must be properly representative of the frequencies in the language population, hence the advantages of real texts, corpus and collocational-analysis resources for language learners, and dictionaries and materials based on the patterns of language as they are regularly used. In the initial search for what cues are relevant, learners can benefit from explicit instruction, provided it is based on a proper analysis on the problem space, the

learner, and the stage of learning -- the relevant cues can be made salient by input enhancement, the ways in which they relate to meaning can be explained and made explicit, and that which is attended and understood is that which is memorized.

These are all very general implications. But the content and developmental sequences of language are special and they need detailed analysis so that explicit instruction can be appropriately tuned to learner development. Cognitive approaches to *SLA* thus involves a host of *SLA*-special issues, such as: longitudinal descriptions of the development of L1 and L2 interlanguage; incremental hierarchical representations in language development; effects on learning of structural complexity of cue/function pairings; language transfer; the best ways of providing explicit instruction -- whether to focus on forms or form, whether to build a curriculum around tasks, around structures, or whether it is better to give learners free rein in naturalistic discourse but provide negative evidence as appropriate; how to make patterns salient while maintaining a communicative focus; the role and content of metalinguistic knowledge; language learner aptitude; the development of automaticity and fluency; the interplay of formulas and creative patterns; learnability, teachability constraints and timing of focus on form; learner strategies; and the rest too numerous to list, never mind discuss, here. These issues are being investigated from a cognitive point of view and good introductions can be found in McLaughlin (1987), Larsen-Freeman and Long (1991), Lightbown, Spada and White (1993), N. Ellis (1994), R. Ellis (1994), Doughty and Williams (1998), Skehan (1998), Pienemann (in press), and Robinson (in press).

In language instruction as in other educational domains, too much practice has been based on a naïve operationalization of theory. The classroom is a long way from the laboratory. It is even further from the academic journal. Instructional practices, however well informed by theory, need to be evaluated, assessed, and refined in everyday practice. To the impressive extent that these volumes describe studies of real-world classroom and NS-NNS interactions and assess the effects of these interactions on learner progress, they

give testament to the realization of a genuine Applied Cognition of SLA. Nonetheless, there's a long road ahead in the development of the cognitive science/practice of SLA.

FOOTNOTES

[1]   I am grateful to Bill Sullivan and Marie Nelson of University of Florida for reporting this remark made by Halliday at the First LACUS Forum, 1974.

ANNOTATED BIBLIOGRAPHY

de Groot, A. M. B. and J. F. Kroll (eds.) 1997. Tutorials in bilingualism: Psycholinguistic perspectives. Hillsdale, N.J.: Lawrence Erlbaum.

A collection of contemporary psychological, psycholinguistic, applied linguistic, neuropsychological and educational research on bilingualism. The issues raised within this perspective not only increase our understanding of the nature of language and thought in bilinguals but also of the basic nature of the mental architecture that supports the ability to use more than one language.

Doughty, C. and J. Williams (eds.) 1998. Focus on form in classroom second language acquisition. Cambridge: Cambridge University Press. [Cambridge Applied Linguistics Series.]

This edited book presents and analyses empirical evidence from recent studies of classroom second language acquisition which evaluate focus on form methods of connecting grammatical form to meaning during primarily communicative tasks. The different studies address details including: which linguistic forms to target, the optimal degree of explicitness of attention in focusing on form, the appropriate timing of focus on form, and the integration of focus on form into the second language curriculum. If, like me, you suspected 'rigorous classroom research' to be an oxymoron, think again.

Ellis, N. C. (ed.) 1994. Implicit and explicit learning of languages. London: Academic Press.

This volume concerns human learning, particularly the cognitive processes underlying the acquisition of second, foreign, and native languages. It gathers carefully chosen contributions from key researchers in psychology, linguistics, philosophy, computing and neuroscience to present a cognitive scientific account of the separable types of human learning, their resultant representations and their interactions in language learning and in second language instruction.

Elman, J. L., et al. 1996. Rethinking innateness: A connectionist perspective on development. Cambridge, MA: A Bradford Book.

In this provocative book, six co-authors, representing cognitive psychology, connectionism, neurobiology, and dynamical-systems theory, synthesize a new theoretical framework for cognitive development with special focus on language acquisition. In the Emergentist perspective, interactions occurring at all levels, from genes to environment, give rise to emergent forms and behavior. These outcomes may be highly constrained and universal, but they are not themselves directly contained in the genes in any domain-specific way. *Rethinking Innateness* presents a taxonomy of ways in which behavior can be innate. These include constraints at levels of representation, architecture, and timing, with behavior emerging through the interactions at all of these levels.

MacWhinney, B. (ed.) 1998. The emergence of language. Hillsdale, NJ: Lawrence Erlbaum.

Proceedings of the NSF-sponsored 28th Annual Carnegie Mellon Symposium on Cognition, the founding conference for Emergentist Approaches to Language. Child

language researchers, linguists, psycholinguists and modellers using a range of formalisms present emergentist accounts of a wide range of linguistic phenomena.

Plunkett, K. (ed.) 1998. Language and Cognitive Processes, 13, special issue on connectionist models of language.

A collection of recent demonstrations of how the cognitive representation of linguistic structure can emerge from the interaction of a structured environment with a linguistically naïve connectionist network. Simulated phenomena include early speech perception, syllabic and lexical segmentation, word class identification, learning nouns and adjectives, inflectional morphology, reading, and the origins of propositional knowledge.

Plunkett, K. and J. L. Elman. 1997. Exercises in rethinking innateness. Cambridge MA: MIT Press.

This companion volume to *Rethinking Innateness* serves as a teach-yourself guide to connectionism. The chapters present different types of model architecture illustrated by simulations that are particularly relevant to linguistic and cognitive development. The book comes with a complete software package for the Tlearn system, the result of what must be thousands of hours of development effort, which is a friendly but reasonably powerful programming environment for hands-on learning on Macintosh or Windows 95 operating systems.

Robinson, P. (ed.) In press. Cognition and second language instruction. Cambridge: Cambridge University Press.

This collection presents summary papers concerning the links between cognition and second language instruction. The first section discusses the conceptual foundations: research into second language memory, automaticity, attention, processing, and learnability. The second section addresses the implications of cognitive theory for L2

instruction. Each of five applications chapters focuses primarily on a different pedagogical issue and shows how cognitive theory can lead to greater understanding of it. The final section concerns research methods, with chapters on connectionism, computerized instruction and on-line assessment of processing, and protocol analysis.
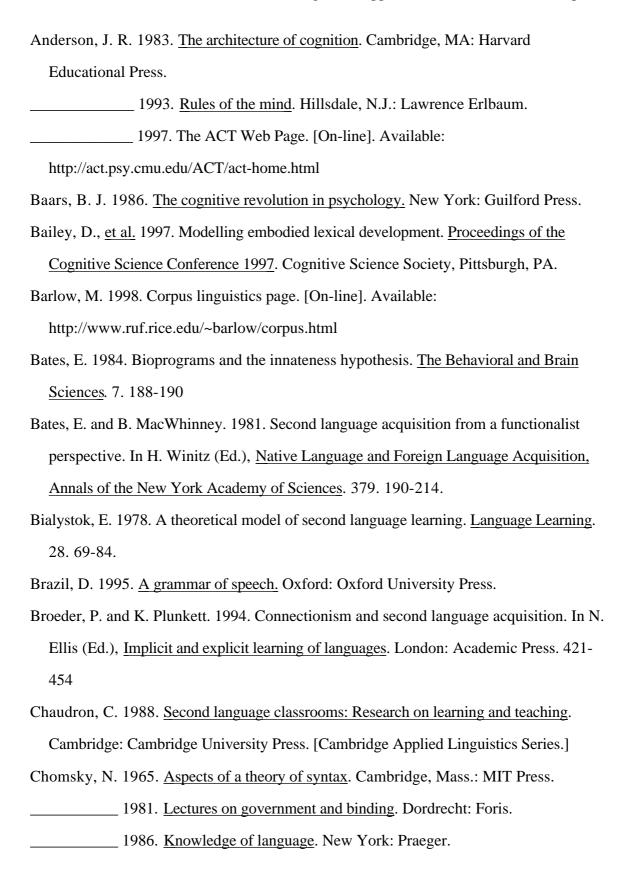
Slobin, D. I. 1997. The origins of grammaticizable notions: Beyond the individual mind. In D. I. Slobin (ed.) The crosslinguistic study of language acquisition, Vol. 5. Mahway, NJ: Erlbaum. 265-323.

The father of the study of child language acquisition from a cross-linguistic perspective describes how language theorists, including himself, have erred in attributing the origins of language structure to the mind of the child, rather than to the "interpersonal communicative and cognitive processes that everywhere and always shape language".

Ungerer, F. and H. J. Schmid. 1996. An introduction to cognitive linguistics. Harlow Essex: Addison Wesley Longman.

A clear and up-to-date introduction to Cognitive Linguistics where the use of syntactic structures is largely seen as a reflection of how speakers perceive the things and situations in their lives, their conceptualizations being governed by the attention principle. Language is based on experience of the world, human embodiment, and general principles of cognition. To the extent that we share similar bodies and experience, although languages may supply different linguistic strategies for the realization of the attention principle, the underlying cognitive structures and principles are probably universal.

UNANNOTATED BIBLIOGRAPHY

Anderson, J. R. 1983. The architecture of cognition. Cambridge, MA: Harvard Educational Press.

_____ 1993. Rules of the mind. Hillsdale, N.J.: Lawrence Erlbaum.

_____ 1997. The ACT Web Page. [On-line]. Available: http://act.psy.cmu.edu/ACT/act-home.html

Baars, B. J. 1986. The cognitive revolution in psychology. New York: Guilford Press.

Bailey, D., et al. 1997. Modelling embodied lexical development. Proceedings of the Cognitive Science Conference 1997. Cognitive Science Society, Pittsburgh, PA.

Barlow, M. 1998. Corpus linguistics page. [On-line]. Available: http://www.ruf.rice.edu/~barlow/corpus.html

Bates, E. 1984. Bioprograms and the innateness hypothesis. The Behavioral and Brain Sciences. 7. 188-190

Bates, E. and B. MacWhinney. 1981. Second language acquisition from a functionalist perspective. In H. Winitz (Ed.), Native Language and Foreign Language Acquisition, Annals of the New York Academy of Sciences. 379. 190-214.

Bialystok, E. 1978. A theoretical model of second language learning. Language Learning. 28. 69-84.

Brazil, D. 1995. A grammar of speech. Oxford: Oxford University Press.

Broeder, P. and K. Plunkett. 1994. Connectionism and second language acquisition. In N. Ellis (Ed.), Implicit and explicit learning of languages. London: Academic Press. 421-454

Chaudron, C. 1988. Second language classrooms: Research on learning and teaching. Cambridge: Cambridge University Press. [Cambridge Applied Linguistics Series.]

Chomsky, N. 1965. Aspects of a theory of syntax. Cambridge, Mass.: MIT Press.

_____ 1981. Lectures on government and binding. Dordrecht: Foris.

_____ 1986. Knowledge of language. New York: Praeger.

Churchland, P. S. and T. J. Sejnowski. 1992. The computational brain. Cambridge, MA: MIT press.

CTI Psychology 1998. CTI Centre for Computers in Psychology Home Page. [On-line]. Available: http://www.york.ac.uk/inst/ctipsych

Damasio, A.R. and H. Damasio. 1992. Brain and language. Scientific American, 267 (3). 63-71.

DeKeyser, R. M. 1997. Beyond explicit rule learning: Automatizing second language morphosyntax. Studies in Second Language Acquisition. 19. 195-222.

Ellis, N. C. 1996. Sequencing in SLA: Phonological memory, chunking, and points of order. Studies in Second Language Acquisition. 18. 91-126.

_____ 1998. Emergentism, connectionism and language learning. Language Learning. 48. xxx-xxx.

_____ In press. Memory for language. In P. Robinson (Ed.), Cognition and second language instruction. Cambridge: Cambridge University Press.

Ellis, N. C. and N. Laporte. 1997. Contexts of acquisition: Effects of formal instruction and naturalistic exposure on second language acquisition. In A. M. B. de Groot and J. F. Kroll (eds.), Tutorials in bilingualism: Psycholinguistic perspectives. Hillsdale, N.J.: Lawrence Erlbaum. 53-83

Ellis, N. C. and R. Schmidt. 1998. Rules or associations in the acquisition of morphology? The Frequency by regularity interaction in human and PDP learning of morphosyntax. Language and Cognitive Processes. 13.307-336.

Ellis, R. 1994. The study of second language acquisition. Oxford: Oxford University Press.

Elman, J. 1997. Tlearn software page. [On-line]. Available: http://crl.ucsd.edu/innate/tlearn.html

Eubank, L. 1995. Generative research on second language acquisition. Annual Review of Applied Linguistics. 15. 93-107.

Gasser, M. 1990. Connectionism and universals of second language acquisition. Studies in Second Language Acquisition. 12.179-199.

Goldberg, A. E. 1995. Constructions: A construction grammar approach to argument structure. Chicago: University of Chicago Press.

Gregg, K. 1993. Taking explanations seriously; or, let a couple of flowers bloom. Applied Linguistics. 14. 276-294.

Hulstijn, J. and R. DeKeyser (eds). 1997. Studies in Second Language Acquisition. 19. [Special issue devoted to Testing SLA theory in the research laboratory.]

Jung, J. 1971. The experimenter's dilemma. New York: Harper and Row.

Kempe, V. and B. MacWhinney. In press. Acquisition of case marking by adult learners of German and Russian. Studies in Second Language Acquisition.

Langacker, R. W. 1987. Foundations of cognitive grammar, Vol. 1: Theoretical prerequisites. Stanford, CA: Stanford University Press.

_____ 1991. Foundations of cognitive grammar, Vol. 2: Descriptive application. Stanford, CA: Stanford University Press.

Larsen-Freeman, D. 1976. An explanation for the morpheme acquisition order of second language learners. Language Learning. 26. 125-134.

Larsen-Freeman, D. and M. H. Long. 1991. An Introduction to Second Language Acquisition Research. Harlow: Longman.

Leech, G., G. Myers and J. Thomas (eds.) 1995. Spoken English on computer: Transcription, mark-up and application. London: Longman.

Levy, J. P., et al. (eds.) 1995. Connectionist models of memory and language. London: UCL Press.

Lightbown, P. M., N. Spada and L. White (eds.) 1993. Studies in Second Language Acquisition. 15. [Special issue devoted to The role of instruction in second language acquisition.]

MacWhinney, B. (ed.) 1987. Mechanisms of language acquisition. Hillsdale, NJ: Erlbaum.

_____ 1992. Transfer and competition in second language learning. In R. J. Harris (ed.), Cognitive processing in bilinguals. Amsterdam: North Holland. 371-390

_____ 1995. The CHILDES project: Tools for analyzing talk. Second Edition. Hillsdale, NJ: Lawrence Erlbaum Associates.

_____ 1997a. Second language acquisition and the competition model. In A. M. B. de Groot and J. F. Kroll (eds.), Tutorials in bilingualism: Psycholinguistic perspectives. Hillsdale, N.J.: Lawrence Erlbaum. 113-144

_____ 1997b. Implicit and explicit processes: Commentary. Studies in Second Language Acquisition. 19. 277:282.

MacWhinney, B., and E. Bates. 1989. (eds.) The crosslinguistic study of sentence processing. New York: Cambridge University Press.

MacWhinney, B. and R. Higginson. 1993. CHILDES Home Page. [On-line]. Available: http://poppy.psy.cmu.edu/childes/index.html

MacWhinney, B. and J. Leinbach. 1991. Implementations are not conceptualizations: Revising the verb learning model. Cognition. 40.121-157.

McCarthy, M. and R. Carter. 1997. Exploring spoken English. Cambridge: Cambridge University Press.

McClelland, J. L., D. E. Rumelhart and the PDP Research Group (Eds.) 1986. Parallel distributed processing: Explorations in the microstructure of cognition, Volume 2: Psychological and biological models. Cambridge, MA: MIT Press.

McEnery, T. and A. Wilson. 1996. Corpus linguistics. Edinburgh: Edinburgh University Press.

McLaughlin, B. 1980. On the use of miniature artificial languages in second-language research. Applied Psycholinguistics. 1.357-369.

_____ 1987. <u>Theories of Second Language Acquisition</u>. London: Edward Arnold.

McLaughlin, B. and M. Harrington. 1989. <u>Annual Review of Applied Linguistics</u>. 10. 122-134.

Marr, D. 1982. <u>Vision</u>. San Francisco: W. H. Freeman.

Newell, A. 1990. <u>Unified theories of cognition</u>. Cambridge, MA.: Harvard University Press.

Pienemann, M. In press. <u>Language processing and second language development</u>. Amsterdam: John Benjamins.

Posner, M.I. and M. E. Raichle. 1994. <u>Images of Mind</u>. Scientific American Library.

Quartz, S. R. and T. J. Sejnowski. In press. The neural basis of cognitive development: A constructivist manifesto. <u>Behavioral and Brain Sciences.</u>

Reber, A.S. 1967. Implicit learning of artificial grammars. <u>Journal of Verbal Learning and Verbal Behavior</u>. 77.317-327.

_____ 1993. <u>Implicit Learning and Tacit Knowledge: An Essay on the Cognitive Unconscious</u>. New York: Oxford University Press.

Rumelhart, D. E. and J. L. McClelland. 1987. Learning the past tense of English verbs: Implicit rules or parallel distributed processes? In B. MacWhinney (ed.), <u>Mechanisms of language acquisition</u>. Hillsdale, NJ: Erlbaum.

Schmidt, R. 1992. Psychological mechanisms underlying second language fluency. <u>Studies in Second Language Acquisition</u>. 14. 357-385.

_____ 1993. Awareness and second language acquisition. <u>Annual Review of Applied Linguistics</u>. 13. 206-226.

Seidenberg, M. S. (1997). Language acquisition and use: Learning and applying probabilistic constraints. *Science, 275*, 1599-1603.

Sinclair, J. 1991. <u>Corpus, concordance, collocation</u>. Oxford: Oxford University Press.

SOAR Group 1997. SOAR Home Page. [On-line]. Available:

http://www.isi.edu/soar/soar.html

Skehan, P. 1998. A cognitive approach to language learning. Oxford: Oxford University

Press. [Oxford Applied Linguistics Series.]

Sokolik, M. and M.Smith. 1992. Assignment of gender to French nouns in primary and

secondary language: A connectionist model. Second Language Research. 8.39-58.

Spada, N. 1997. Form-focussed instruction and second language acquisition: A review of

classroom and laboratory research. Language Teaching. 30(2).

Stadler, M.A. and P. A. Frensch. Eds. 1998. Implicit Learning Handbook. Sage.

Taraban, R. and V. Kempe. In press. Gender processing in native (L1) and non-native

(L2) Russian speakers. Applied Psycholinguistics.

Tomasello, M. 1992. First verbs: A case study of early grammatical development.

Cambridge: Cambridge University Press.

_____ 1995. Language is not an instinct. Cognitive Development. 10. 131-156.

Tomasello, M. and P. J. Brooks. In press. Early syntactic development: A construction

grammar approach. In M. Barrett (ed.), The development of language. Hove, East

Sussex: Psychology Press.

UCREL 1998. Lancaster university centre for computer corpus research on language

Home Page. [On-line]. Available:

http://www.comp.lancs.ac.uk/computing/research/ucrel/

University of Edinburgh Language Technology Group 1998. Texts/Corpora Page. [On-

line]. Available: http://www.ltg.ed.ac.uk/helpdesk/faq/Texts-html/general.html

Winter, B. and A.S. Reber. 1994. Implicit learning and the acquisition of natural

languages. In N. Ellis (Ed.), Implicit and explicit learning of languages. London:

Academic Press. 115-146

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