Implicit Learning and the Cognitive Unconscious:
Of Artificial Grammars and SLA

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INTRODUCTION


Although there have been numerous variations on the basic theme, the experimental paradigm developed by Reber involves exposing subjects to strings of letters (e.g., MXRMXT, VMTRRRR) generated by an underlying “grammar” or rule system, usually a finite-state system that
generates strings of symbols in a left-to-right, non-hierarchical fashion, often referred to as a Markov grammar (see Winter & Reber, this volume). In many experiments, groups of subjects are exposed to such input with either (a) instructions to try to figure out the rules for letter order or (b) instructions to memorise the examples for a memory test. The acquisition phase, typically a few hours but sometimes longer, is followed by a testing and transfer phase to assess what subjects have learned. The testing phase requires subjects to identify new letter strings as grammatical (i.e., generated by the rules of the underlying grammar) or ungrammatical (items that violate the grammar). In some experiments, the testing phase has also included probing subjects' awareness in order to find out whether they were able to discover and verbalise the underlying rules of the system.

The basic findings from these experiments are as follows:

1. Through exposure to examples, subjects become sensitive to underlying regularities in input, as shown by the fact that they can accurately characterise new strings which they have never seen before as grammatical or ungrammatical at above chance levels.
2. Subjects are generally unable to verbalise the rules of the underlying grammar used by the experimenters to generate strings.
3. The grammaticality judgements of subjects receiving rule-search or memorisation instructions typically do not differ significantly.

Learning an MAG is unlike learning a natural second or foreign language in many respects, so it is not immediately obvious whether theories based on the results of learning MAGs may be relevant for theories of second language acquisition (SLA). Most artificial grammar experiments involve short training sessions, whereas learning a second or foreign language takes a long time. The short training sessions in artificial grammar experiments are sufficient to obtain above-chance performance, but the level of performance remains very low (Matthews et al., 1989), while the requirements for establishing success in second language learning are much higher than merely above-chance performance. The nature of what is to be learned is also different in important ways. The “sentences” generated by MAGs consist only of ordered strings of letters, but natural language grammatical processes depend heavily on the syntactic structure of sentences rather than on the linear order of elements (Comrie, 1990). For example, the rule for forming questions in English must refer to the subject of a sentence and the first element of the auxiliary, not simply the first and second words of a string. The strings generated by MAGs are also meaningless, having neither morphology nor combinatorial semantics nor pragmatics, and thus are useless for communication. Artificial languages that more closely resemble natural languages (because they have constituent structure and/or semantics) have been used in some psycholinguistic studies (Braine et al., 1990; MacWhinney, 1983; Moeser & Bregman, 1972; Morgan, Meier & Newport, 1987, 1989; Morgan & Newport, 1981; Navyak, Hansen, Kreger & McLaughlin, 1990), but these studies have not usually examined the central issues of implicit learning. The ways in which learners approach the task of learning are also quite different for MAG experiments and for second language acquisition in both naturalistic and classroom settings. Some subjects in artificial grammar experiments are told to search input strings for rules, not a common language teaching/learning strategy, although Ellis (1990, 1993; Fotos & Ellis, 1991) has recommended more use of rule-induction tasks as a consciousness-raising technique, and naturalistic learners may do this more often than is generally appreciated. Other artificial grammar learning subjects are told to memorise examples, a task that resembles the now largely discredited audio-lingual method of language teaching: memorisation has been claimed to make only a minor contribution to SLA (Krashen & Scarcella, 1978). Neither condition in the basic artificial grammar learning paradigm includes instruction by teachers, practising the application of rules or production of any kind, interactions with teachers, peers or speakers of the language or negotiation for meaning, sometimes considered crucial for second language learning (Pica, 1991, 1992; Pica, Young & Doughty, 1987). Finally, it may be noted that only grammatical strings are presented during MAG training sessions, and no feedback is given in the testing and transfer phase. This may be seen as a strength of the paradigm by those who argue that natural language learning also proceeds exclusively on the basis of positive evidence (Pinker, 1984; Wexler & Culicover, 1980), but it precludes examination of the effects of corrective feedback and other types of negative evidence on implicit learning.

In spite of these major differences between MAG experiments and real language learning, the artificial grammars used in implicit learning studies are very roughly analogous to natural languages, in the sense that sentences of the language are viewed in both cases as the product of a complex underlying system. The underlying systematicity of natural languages may be discussed in terms of rules, constraints, and exceptions or (in more recent theory) principles and parameters, but regardless of terminology it is assumed that linguistic competence rests upon symbolic mental representations (propositions) and abstract statements that manipulate such symbols (Bechtel & Abrahamsen, 1991; Chomsky, 1986; MacWhinney, Leinbach, Taraban & McDonald, 1989; Sokolik, 1990). Through exposure to input containing exemplars of the grammar, in second language learning as in artificial grammar experiments, learners do become sensitive to regularities in the input, suggesting that the underlying grammar is internalised in some sense.
In both cases, grammaticality judgements are seen as an appropriate test of this internalised competence, and in both cases, real learning is only considered demonstrated through transfer to new examples.

Unconscious Learning of MAGs

Reber has interpreted the findings of MAG experiments as support for a detailed conception of the process by which one develops intuitive knowledge about the underlying structure of a complex stimulus environment, an account that may be relevant for theories of SLA. As used by Reber, implicit learning is characterised by a number of critical features:

1. It is an unconscious process.

However, given the notorious ambiguities of the terms conscious and consciousness (McLaughlin, 1990; Schmidt, 1990), there are several ways to interpret this assertion. The process of implicit learning in artificial grammar experiments is said to be unconscious in two senses. First, because whether or not subjects have the intention to discover rules (assumed to follow from the instructions and the demands of the experimental task) does not make a difference in learning outcomes, artificial grammar learning is considered to be unintentional. Learning that is unconscious in this sense is commonly referred to as incidental learning. Second, implicit learning is believed to involve induction without awareness, on the grounds that processes such as the formation and testing of conscious hypotheses (encouraged by rule-search instructions and presumed blocked by the demands of the memorisation condition) do not make a difference in the outcome of these experiments. The second of these interpretations of implicit learning as an unconscious process is considered basic. As Reber (1989) puts it, “the pickup of information takes place independently of consciousness or awareness of what is picked up” (p. 231).

2. The product of implicit learning is also largely unconscious.

Once again, unconscious has several senses. The first of these is that the information acquired exceeds what can be verbally expressed. This represents a significant revision to Reber’s earlier position that the knowledge acquired in artificial grammar learning studies is completely inaccessible to consciousness (Reber, 1965). Subsequent studies have shown that this extreme position is inaccurate, since subjects in such experiments show an increase in their ability to communicate their knowledge of underlying rule systems (Mathews et al., 1989; Reber & Lewis, 1977). However, Reber maintains that “the implicitly acquired epistemic contents of mind are always richer and more sophisticated than what can be explicated” (Reber, 1989, p. 229). For future reference, it will be useful to refer to this sense in which implicit knowledge (the product of implicit learning) is unconscious as the expressibility issue. The second sense in which the knowledge resulting from implicit learning is unconscious is that, whether or not such knowledge is potentially accessible to conscious awareness and is expressible, it is presumably not present in conscious awareness and not used deductively as the basis for making grammaticality judgements in the testing phase (Reber, 1989, p. 230). Instead, such judgements are intuitive. This sense of implicit knowledge as unconscious knowledge can be referred to in shorthand fashion as the issue of intuitive judgements. The notion of unconscious knowledge as the basis for spontaneous judgements is somewhat similar to the contrast between explicit and implicit memory (Nelson, Schrieber & McEvoy, 1992; Schachter, 1987). Explicit memory refers to the (usually intentional) recollection of previous experience when engaging in a task; implicit memory refers to the influence of past memories on present performance without the activation of such memories into awareness.

3. The product of implicit learning is abstract.

The evidence for this derives from the fact that the knowledge acquired in such studies generalises to strings that are not presented during the training phase, and even to different symbol sets as long as the same underlying rule structure is used to generate the strings (Reber, 1969, 1976; Mathews et al., 1989).

Reber has argued that the results of experiments with artificial grammar learning are reflective of processes that are general and universal in human learning, the foundation processes for the development of abstract, tacit knowledge of all kinds. Contrasting implicit learning with overt, conscious cognitive processes such as problem solving and decision making, implicit induction systems are considered to be evolutionarily older, more robust in the face of psychiatric or neurological insults, and independent of standard measures of cognitive capability such as IQ tests (Reber, 1992; Reber, Walkenfeld & Hernstadt, 1991).
Unconscious Learning and SLA

Reber's claims concerning the processes that underlie implicit learning of artificial grammar have much in common with widely held views concerning the processes of SLA. Second language acquisition is often considered to be unconscious, in all four senses identified above, and the product of learning is usually viewed as abstract.

Natural language acquisition is most often considered to be unconscious in the sense that it is incidental or non intentional learning. This is argued by Chomsky for first language learning as follows:

The learner has no ‘reason’ for acquiring the language; he does not choose to learn, and cannot fail to learn under normal conditions, any more than he chooses (or can fail) to organise visual space in a certain way—or, for that matter, any more than certain cells in the embryo choose (or can fail) to become an arm or the visual centres of the brain under appropriate environmental conditions. (Chomsky, 1975, p. 71)

For adult second and foreign language learning, this is less obviously true. Learners often do have specific reasons and purposes for learning new languages and in the absence of such reasons may choose not to learn them. However, Krashen (1985) has argued that the basic principle is the same. As long as the “affective filter” is down and appropriate comprehensible input is presented, acquisition is inevitable. This is considered by Krashen to be the “fundamental principle” in second language acquisition (Krashen, 1985, p. 5). In Krashen's model, acquisition is also incidental in the sense that it is independent of the focus of attention. Krashen's view is that linguistic form is not only acquirable but best acquired when the learner's attention is focused on meaning (Krashen, 1981, 1982, 1985, 1989). Others have also pointed out that language learning is incidental in the sense that grammar (typically considered the most significant aspect of language learning) is learned as a by-product of the intentional learning of some other aspect of language. Hatch argues that learners intend to learn to converse and interact and that they learn grammar incidentally in the process (Hatch, 1983; Hatch & Hawkins, 1987). Shaw (1992) finds it plausible that with respect to writing, “conscious attention to the composing process might facilitate unconscious acquisition of the necessary grammatical competence” (p. 20).

Second language learning is also widely believed to involve induction without awareness. It is in this sense that Seliger's comment that “obviously, it is at the unconscious level that language learning takes place” (Seliger, 1983, p. 187) is most reasonably interpreted. Krashen is explicit on the matter. Conscious hypotheses about the underlying structure of language, whether obtained through rule teaching or through discovery by the learner, belong to learning, not acquisition in Krashen's theory (Krashen, 1985). Felix (1981, 1985) is another SLA theorist who stresses the irrelevance of conscious hypothesis formation and other conscious processes typical of problem solving behaviour for successful acquisition. In Felix's view, such conscious processes are characteristic of adult second language learning, but they are ultimately detrimental to the process because general problem solving abilities are inferior to the innate, domain specific language acquisition system with which they compete.

With respect to the accessibility of implicit knowledge and the expressivity issue, it is commonly argued in SLA that implicit knowledge can be brought to conscious awareness, but that such explicit, conscious knowledge is the end product of acquisition, not the cause (Bialystok & Bouchard Ryan, 1985). Chomsky's position with respect to first language acquisition is somewhat different, since he has argued that the principles, conditions and rules of universal grammar that determine the course of first language acquisition are in principle inaccessible to conscious awareness (Chomsky, 1975, 1986).

Finally, with respect to the issue of intuitive judgements and spontaneous performance, SLA theories are in agreement that consciously held rules can only be consciously applied by language learners under limited circumstances and cannot serve directly as the basis for truly fluent language performance. There is less agreement concerning how fluent performance is achieved, however (for review, see Schmidt, 1992). Sharwood Smith (1981) theorises that it develops through practice from an earlier nonfluent stage in which rules are consciously applied. McLaughlin, Rossman and McLeod (1983) propose an SLA model based on Shiffrin and Schneider's (1977) information processing account of the development from controlled to automatic processing, avoiding discussion of conscious and unconscious processes. For others, there is no relationship at all between the application of consciously held rules and fluent production. Once again, Krashen's position is clearest by virtue of its categorical nature: only implicitly acquired knowledge can be the basis of fluent production.

There are two major ways in which the process of implicit learning is viewed differently in artificial grammar learning and in SLA. First, the role of transfer from the LI is a major issue in SLA but not in artificial grammar learning. Second, Reber has been clear that the results of experiments in learning MAGs do not in his view carry any implication that learning languages is special in any way. Implicit learning is viewed as a pervasive phenomenon in all spheres of life. SLA theorists are divided on this issue. Some attribute a crucial role to a language acquisition device (LAD) or (a more current conceptualisation) universal grammar (UG) (Maurer, 1984; White, 1985, 1987, 1989; Felix, 1991). For Krashen, acquisition (implicit learning) takes place when
INCIDENTAL (UNINTENDED) LEARNING

Learning in MAG experiments is considered incidental (unintentional), because subjects become sensitive to the underlying structure of the system independently of any intention to learn the system, that is, the grammaticality judgements of subjects receiving rule-search or memorisation instructions typically do not differ significantly (Abrams & Reber, 1988; Danks & Gans, 1975; Dienes, Broadbent & Berry, 1991; Dulany et al., 1984; Mathews et al., 1989; Perruchet & Pacteau, 1990). However, some experiments have been reported in which rule-search subjects performed worse than memorisation subjects (Brooks, 1978; Reber, 1976), as well as experiments in which rule-search subjects outperformed those given memorisation instructions (Howard & Dallas, 1980). Reber, Kassin, Lewis and Cantor (1980) found that rule-search instructions could either improve or worsen performance, depending partly on when instructions to look for rules were given. Mathews et al. (1989) found that learning a biconditional rule was impaired by incidental rather than intentional learning conditions, but that finite-state grammar rules were not.

It is generally assumed that children acquire the grammar of their first language incidentally, as a by-product of communication and socialisation, without any specific intention to learn the linguistic system itself. Adult second and foreign language learning may be either incidental or intentional. Some learners are very concerned with mastering grammar rules, improving their pronunciation, expanding their vocabularies, and approximating target language norms of appropriateness, and have the definite intention to master these aspects of language, while other learners are concerned only with the communication of meaning. Language teaching techniques can also be characterised as predominantly intentional or incidental in approach, either focusing on discrete aspects of language (for which an impending test may be announced to further support the intention to learn) or focusing only on the successful accomplishment of communicative and pedagogical tasks (Long, forthcoming). One may ask, then, whether the intention to learn particular aspects of language does lead to learning, whether learning takes place without such intentions and whether intentional or incidental approaches are superior.

There are situations in which the intention to learn is largely irrelevant, and in psychology incidental learning is considered commonplace, uncontroversial and relatively easy to manipulate experimentally through appropriate task instructions. Whether or not learning takes place is determined far more by the nature of the processing activities in which learners engage than by the intention to learn per se.
and some tasks (in both laboratory and classroom settings) focus learners' attention on what needs to be learned and engender appropriate processing more effectively than other tasks. Krashen (1989) has reviewed the evidence supporting incidental approaches to teaching spelling and vocabulary, arguing that extensive reading is as effective as focused study. Elley (1991) summarises studies of the effects of “book floods” on students' acquisition of a second language in elementary schools, reporting that children who are exposed to high-interest story books are consistently found to learn the target language more quickly than students learning by means of structured, audio-lingual programs. Hulstijn (1992) conducted experimental studies of the incidental learning of second language vocabulary occurring in reading passages in order to provide support for a mental effort hypothesis predicting that inferred word meanings would be retained better than meanings given to the reader through the use of marginal glosses. The results indicated that incidental learning clearly took place and that inferred meanings were retained better, as predicted, although the multiple-choice inference procedure used in the experiment was found to be inherently error prone.

Theories of SLA recognise that intentions do not cause learning. Gardner, whose model of the role of motivation in second language acquisition in classroom settings is the best known in the field, argues that the desire to learn a second language is useless by itself and that motivated learners achieve more than unmotivated learners only because they are more active learners (Gardner, 1985, 1988). Pintrich (1989) suggests that intentional learning is superior in classroom learning if and only if the motivation to learn leads to the exercise of effective cognitive and metacognitive strategies. Schumann, who earlier proposed that acculturation (a combination of social distance and psychological distance factors, including motivation) causes SLA in naturalistic settings (Schumann, 1978), now argues that acculturation acts only as a remote cause in a chain of factors (Schumann, 1986).

However, it should be noted that intentional subjects do consistently better than incidental subjects in controlled studies of vocabulary and spelling acquisition (Krashen, 1989). Purcell and Suter (1980) found that “concern for pronunciation” was one of only four predictors of pronunciation accuracy in a study of adult ESL learners. Andersen (1988) points out that through attempts to communicate learners come to perceive the forms and form-meaning encoding devices used by native speakers, but Skchan (1992) proposes that attempts by adults to learn second languages incidentally through communicative interaction are only partially successful because, although such interaction has the potential to provide the necessary evidence for acquisition, the use of comprehension strategies and communication strategies motivated by communicative pressure or learner predispositions means that the analysis necessary for acquisition is avoided. Schmidt (1990) has proposed that deliberate attention to communicatively redundant grammatical forms may be necessary for adult SLA and developed a speculative argument for why this does not appear to be so for first language acquisition. Crookes and Schmidt (1991) argue that motivation is important only when learners have choices, but that second and foreign language learners do indeed have many choices. Learners may be able to choose to take a course or not, to pay attention in class or not, to review or drop out, to study for an hour or two or not at all, to talk to native speakers or let the opportunity pass and to persist in the struggle to communicate meaning or abandon the attempt.

The intention to learn is thus assumed to facilitate but not to cause learning. The question of intentional vs. incidental learning is, moreover, separable from the other issues involved in implicit learning, specifically the issue of unconscious induction. Reber (1989) recognises this point in his discussion of the fact that subjects given rule-search instructions did better in some MAG experiments than those given memorisation instructions, arguing that the intention to discover the underlying rules is facilitative if and only if one succeeds in discovering them, which is what subjects apparently did in some experiments. However, in most such experiments the underlying rule system is too complex for successful induction during the course of the experiment. Therefore, it is argued, both intentional and incidental subjects learn through the automatic exercise of unconscious processes. On the other hand, Perruchet and Pacteau (1991) have argued that both intentional and incidental subjects may learn through conscious rule induction during the transfer phase of MAG experiments and that memorisation instructions do not guarantee implicit processing even during the learning phase, because subjects may adopt mnemonic strategies of searching for rules that would be helpful in memorising strings of consonants. Dienes, Broadbent and Berry (1991) found no evidence for either distinct learning modes or different knowledge types in MAG learning based on incidental vs. intentional instructions. These cautions regarding the interpretation of experimental results on the basis of instructions given to learners are even more important for SLA. It should not be assumed that learners who read extensively for pleasure fail to attend to the spelling of unfamiliar words when they encounter them or that children or adult immigrants or learners enrolled in communicative language courses do not form and test conscious hypotheses about the language to which they are exposed. Nor should it be assumed that learners in more traditional language courses share their teachers' enthusiasm for conscious linguistic analysis or that their learning should be attributed to hypothesis testing strategies.
The Role of Attention in Learning

While the intention to learn is not always crucial to learning, attention to the material to be learned is. Attention has several major psychological functions. Most psychological models of memory hold that the allocation of attention is the necessary and sufficient condition for encoding a stimulus into long-term memory, and that efficient retrieval depends on both the quantity and the quality of attention at the time of encoding (Logan, 1988). In SLA as well, the claim has frequently been made that attention to input is necessary for input to become intake that is available for further mental processing (Scovel, 1991; Ellis, 1993; Long, 1991, forthcoming; van Lier, 1991). In support of the argument for the necessity of attention to linguistic form in context, Long (forthcoming) cites premature stabilisation or failure to incorporate basic target language structures by adults with prolonged exposure to comprehensible input, reviews showing a global benefit for instructed learning over purely naturalistic acquisition, studies showing incomplete acquisition by learners in immersion programs (Swain, 1991) and demonstrations of the effectiveness of focusing on specific structures in classroom and quasi-experimental contexts (Doughty, 1991; White, 1991a; White, Spada, Lightbown & Ranta, 1991).

Attention also controls access to conscious experience. When people pay attention to something, they become conscious of it (Baars, 1988). If the attentional threshold for storage in memory and the threshold for conscious awareness could be shown to be the same, then it would follow that all learning must be accompanied by awareness. Schmidt (1990) has proposed that the subjective experience of “noticing” is the necessary and sufficient condition for the conversion of input to intake in SLA. A further extension of the noticing hypothesis is that what must be attended to and noticed is not just the input in a global sense but whatever features of the input are relevant for the target system (Schmidt, 1993a, b), i.e. that in order to acquire phonology one must attend to phonology; in order to acquire pragmatics, one must notice both linguistic forms and the relevant contextual features; etc.

Both of these proposals are controversial, since there is a widespread belief that one can somehow “pick up” aspects of a language without making them the object of focal attention or being really aware of them, and it is inherently difficult to demonstrate that all learning outside tightly controlled experiments requires noticing. Schmidt (1990) discusses the evidence from his own learning of Portuguese (Schmidt and Frota, 1986) in support of the hypothesis that intake is the subset of input that is attended to and noticed, finding an extremely close connection between his recorded noticings (diary entries) and what could be shown through the analysis of tape-recorded interactions with native speakers to have been learned. Altman (1990) reached different conclusions from a study of her acquisition of Hebrew during five years of both formal instruction and naturalistic exposure, drawing upon evidence from a series of taped production tasks which she compared with introspective entries in her language learning diary, class notes, underlings in newspapers and marks she made in her dictionary whenever she looked up a word. She found that approximately half of all new Hebrew verbs appearing in her oral production could be traced to specific input, and that there was a clear effect for formal instruction. However, the source of half the new verbs could not be identified, suggesting to Altman that those items may have appeared in input without any special attention being allocated to them and that some input becomes intake subconsciously. The difficulty in interpreting such findings is that making a record in a diary requires more than noticing but a higher level of self-awareness (awareness that one has noticed and needs to make a record of that noticing), which no theory claims to be necessary for learning.

Alanen (1992) conducted an experimental study of the learning of semi-artificial Finnish as a second language, in which the learning targets were two locative suffixes and a rule of consonant gradation. Learners were randomly assigned to one of four treatments: rule-oriented subjects were given explicit metalinguistic descriptions of the target structures; a second group received enhanced input in which the target structures were italicised, a third group received rules plus input-enhancement and a control group was simply exposed to input containing the target structures. Alanen hypothesised that subjects given explicit rule statements would learn best but that those receiving enhanced input would also learn better than controls, because the italicisation of target structures would capture their attention and cause them to notice target forms. The first hypothesis was supported, but the evidence for the role of attention and noticing was mixed. When subjects were scored for their ability to produce the correct target suffixes -lla and -ssa after training, there were no statistically significant differences between those in the enhanced input condition and controls, although an analysis of the productions of the two groups showed that subjects in the control group were likely to omit the suffixes altogether, whereas most subjects in the enhanced input condition produced incorrect variants such as -ous, -ous, -osi, -ossi, -asso, -ass, and -sa (all for -ssa), suggesting that italicisation had caused them to notice the presence of the suffix but was insufficient for them to be sure of the exact form. However, some subjects in the control group produced correct suffixes, indicating that they may have noticed the forms without enhancement of the input. This possibility cannot be confirmed directly from the
data for every example, but Alancen found positive correlations between the performance of all subjects on post-tests and the number of comments in think-aloud protocols, indicating that target forms were noticed when processing the input.

Hulstijn (1989) has reported the results of two experiments, one using natural Dutch input with second language learners of Dutch as subjects and the other using semi-artificial Dutch with native speakers as subjects, that provide evidence for the claim that attention to form at input encoding is a sufficient condition for learning structural elements of language, but only modest and inconclusive evidence that exclusive attention to meaning inhibits the acquisition of structure. Again, the problem appears to have been that the treatment was not delivered precisely as intended. Hulstijn had one group of subjects (meaning condition) respond during training by indicating whether they agreed or disagreed with the content of the language presented (e.g., whether eating French fries should be allowed in street cars and buses). Another group (form condition) had to carry out an anagram task that directed their attention to word order and did not require the encoding of sentence meaning. As expected, the form group performed better on post-tests focusing on grammatical structure and the meaning group performed better on tests of content, but there was evidence that the attention to meaning group also learned some structure. It seems likely that this was because the target structural elements found in such utterances as Would you say tech in every big town may eleconstruc barden ra a subway? (an English equivalent of the kind of semi-artificial Dutch used in the experiment) would capture the attention of subjects even when carrying out a task intended to focus their attention exclusively on meaning.

A number of factors that influence what learners notice have been identified by Schmidt (1990). Bardovi-Harlig (1987) found that ESL learners learned preposition stranding (e.g., the person that I gave the book to) before pied-piping (e.g., the person to whom I gave the book), even though the former is more typologically marked, and suggested that this might be because stranded prepositions are frequent and perceptually salient in English. Sorace (1993) found that the linguistic intuitions of French L1 and English L1 near-native speakers of Italian concerning Italian unaccusativity could not be accounted for by a simple transfer strategy, but that the propensity of learners to notice or fail to notice the occurrence of a given property in the L2 input seemed to be related to the status of the L1 with respect to that property. Several researchers have investigated whether form and meaning are in competition for attention during input processing (Bransford, 1992; Mangubhai, 1991; VanPatten, 1990), and VanPatten (1992) has proposed several hypotheses summarising existing findings and framing questions for future research: (1) learners process input for meaning before processing it for form (e.g., lexical items have priority over grammatical morphology and more meaningful morphology has priority over less meaningful morphology); (2) in order for learners to process form that is not meaningful, they must be able to process informational content at no little or no cost to attentional resources.

These issues are important for SLA theory as well as for second language pedagogy, but the question of attended vs. unattended learning and the noticing hypothesis are separable from the main issues involved in implicit learning studies. Noticing is used here as a technical term to refer only to registration of the occurrence of a stimulus event in conscious awareness and subsequent storage in long term memory, not the detection of form/meaning relationships or inductive formation of hypotheses or other processes that may lead to the organisation of stored knowledge into a linguistic system (Slobin, 1985; Chaudron, 1985). In MAG studies of implicit learning, the stimulus sentence strings were fully attended to under both rule-search and memorisation instructions. The results of such experiments do not provide any particular support for a concept of implicit learning that includes subliminal or unattended processing of input and are compatible with the hypothesis that attention to form is prerequisite for implicit learning (Hartman, Knopman & Nissen, 1989).

INTUITIVE JUDGEMENTS AND SPONTANEOUS PERFORMANCE

In SLA research as in MAG experiments, the use of grammaticality judgements to assess learning is based on the belief that researchers should do more than describe learner utterances (productions), but also "find out something about mental structures and processes that make learning possible, and about their interaction with the learner's input and environment" (Bley-Vroman, Felix & Ioup, 1988). However, several points need to be made briefly with respect to Reber's claim that spontaneous, unreflective judgements are a key characteristic of implicit learning and the assumption that such judgements are a reliable guide to the learners' developing competence.

First, the basic question of the kind of knowledge that grammaticality judgements arise from has recently been reopened in SLA. Birdsong (1989), Carroll and Meisel (1990), and Jordens (1991) have pointed out that acceptability judgement tasks are a particular kind of performance whose nature is not well understood. Ellis (1991) points out that such judgements can arise from either explicit knowledge (if there is time) or implicit knowledge and reports the results of a study in which Chinese ESL learners appeared to rely primarily on intuitive judgements but
provided inconsistent responses in a standard grammaticality judgement task and in a think-aloud protocol. Schachter and Yip (1990) demonstrate that grammaticality judgements can reflect a compound of both grammatical and processing factors, and Jordens (1991) proposes that L2 learners who are asked to give grammaticality judgements will use all types of knowledge available to them, including L1 intuitions, intuitions of markedness, analogies to familiar sentences in the L2 and use of a strategy of rejecting unfamiliar sentences that have no associations with either L1 or L2 constructions.

Second, it is easy to think of skills such as knitting, learning a dance step, playing a piece of classical music on a piano or mastering the game of chess (Dreyfus & Dreyfus, 1986) that require close attention and deliberate rule-following in the early stages of skill acquisition but can be performed spontaneously and intuitively when sufficiently practised. A standard observation about the acquisition of skill is that the involvement of consciousness in performance diminishes with increasing skill, and most skilled performance is intuitive, no matter how the underlying knowledge was established to begin with. This suggests that the issue of intuitive performance is dissociable from the question of how such knowledge underlying such performance is established in the first place and from the key issue of whether implicit learning occurs without awareness at the time of learning.

Abstractness, Expressibility and Unconscious Induction

Unconscious Induction and MAG Learning

The basic strategy for arguments that implicit learning proceeds by unconscious induction is similar in artificial grammar experiments and in SLA: (1) establish that the system rests upon complex, abstract rules; (2) assess the performance of learners to establish that exposure has led to reasonably good performance in manipulating the outputs of the underlying grammar, including novel strings not encountered during training; and (3) assess learner awareness to establish lack of awareness of the underlying rules. If all three conditions are met, the conclusion that some kind of unconscious abstraction is operative seems reasonable. To cast doubt on the reality of unconscious induction, one may attempt to show that (1) learners have more awareness than they have been given credit for, often for methodological reasons or (2) the underlying knowledge is not abstract as initially assumed.

With respect to learning MAGs, the essence of the claim that implicit learning proceeds by an unconscious process of abstraction is that the experimenter's grammar has been internalised by learners without awareness. However, this claim has been challenged frequently, beginning with Dulany, Carlson and Dewey (1984), who carried out an MAG experiment and then had subjects introspect their reasons for rejecting ungrammatical strings. Dulany et al. reported that subjects exhibited personal sets of conscious rules of much more limited scope than those of the Markov grammar used by the experimenter to generate strings and that these personal rules predicted the judgements of grammaticality on novel test strings without significant residue, eliminating the need to posit any more abstract rules operating below the level of consciousness. This analysis was rejected by Reber, Allen and Regan (1985), but a number of recent MAG learning experiments have provided additional support for the claim that what is acquired is not abstract rules per se but more concrete knowledge, specifically knowledge of the likelihood of specific letter chunks appearing in grammatical strings (Brooks & Vokey, 1991; Dienes, Broadbent & Berry, 1991; Perruchet & Pacteau, 1990; Servan-Schreiber & Anderson, 1990).

The same strategy has been used by Perruchet, Gallego and Savy (1990) to reappraise the results of an experiment conducted by Lewicki, Hill and Bizot (1988) in which subjects had to identify the location of targets determined by multiple second-order dependency rules: on each block of trials, the first two locations of the target were randomly distributed, and the last three locations were determined by complex rules. Performance improved within each block of trials, although subjects were unable to verbalise anything even approximating the pattern of exposures when questioned in an extensive post experimental interview and were not even aware that the trials had been partitioned into logical blocks. Perruchet et al. point out that the argument for implicit learning rests on the assumption that the rules determining the location of targets were in fact internalised in some fashion and governed the observed behavior, but if improvement in performance is unrelated to the knowledge claimed by the experimenter, then the claim concerning unconscious learning does not hold. Perruchet et al. demonstrated that the results of the experiment could be accounted for by the relative frequency of a few simple sequences of target locations, and that this alternative explanation alone correctly predicted some features of fine-grained performance in the experiment, concluding that the pattern of performance did not require the assumption that any tacit rules were acquired.

The question of whether learning in MAG experiments and other implicit learning paradigms rests upon the unconscious abstraction of rules (Lewicki, 1986b; Reber, 1989; Winter & Reber, this volume) or
much simpler forms of learning based on specific examples (Brooks & Vokey, 1991; Mathews et al., 1989; Medin & Ross, 1990; Perruchet & Pacteau, 1990, 1991) is currently the subject of lively debate. However, there is also a substantial core of agreement concerning the mechanisms of implicit learning in MAG experiments. Reber's position is that the knowledge acquired in MAG experiments is abstract and that subjects can be said to have acquired knowledge of the underlying finite-state grammar "in some sense" (Reber, 1989, p. 221), but concedes that such knowledge is probably represented functionally in terms of sets of bigrams and trigrams, not as a formal Markovian system (p. 226). Perruchet and Pacteau (1991) reject neither human abstraction ability nor the existence of unconscious processes, but argue against unconscious abstraction on the grounds that abstraction is associated exclusively with explicit, conscious cognitive functions such as logical reasoning. They accept the existence of implicit learning, but argue that it rests upon the gradual accumulation of frequency information (Hasher & Zacks, 1979, 1984; Hintzman, 1976), rather than the ability to unconsciously abstract the complex rules used by the experimenter to produce the stimulus array. Abrams and Reber (1988), Hayes and Broad Honest (1988) and Lewicki (1986a) have all suggested that implicit learning should be viewed as a complex, covariational form of frequency counting. Mathews et al. (1989) hold the view that implicit learning is an automatic, memory-based process for detecting patterns of family resemblance among exemplars, assumed to take place through pattern recognition mechanisms similar to those used in connectionist models.

Unconscious Induction and SLA

Turning to implicit and explicit learning mechanisms in SLA, consider the following example of two learners apparently figuring out something about the target language through conscious analysis, including the formation and testing of hypotheses:

While living in Spain, an English-speaking friend and I noticed that many times, after we had been talking at length with Spaniards, they would say Pues nada. At first, we felt a little insulted, since translated, it meant "Well, nothing," as if what we had been saying was worth nothing. Due primarily to our aggravation, which slowly turned into curiosity, we decided we were going to figure out what it meant. We therefore began taking mental notes of the times we heard it and reported back to each other our findings. We finally narrowed it down to the fact that it was used whenever there was a lengthy pause in a conversation. Having realised this, we decided that the next time we were out with Spaniards, we would say it whenever such a pause occurred. When we did, the mystery unravelled itself, for every time we used it, without fail, a new topic of conversation was begun. Pues nada was a way of closing one topic and moving on to another. (Hribar, personal communication cited in Hatch & Hawkins, 1989, p. 349.)

Schmidt and Frota (1986) report numerous similar instances in which a learner's developing conscious understanding of the forms and functions of Brazilian Portuguese (recorded in a diary) matched the learner's performance in recorded interview data, including cases in which incorrect use could be traced to specific misanalyses of what was heard in input. However, many SLA theorists reject the "learner as linguist" view of acquisition sketched here, arguing that learners do not construct their internal grammars of the target language through conscious analysis and hypothesis testing (Eubank, 1991; White, 1981), but assuming that learners do construct a theory of the language they are learning unconsciously (perhaps under the influence of an innate acquisition device) and that the learner's unconscious theory closely resembles the theory that the linguist constructs through conscious analysis of the distribution of possible and impossible sentences of the language, paraphrase relationships, and so forth. Parallel to assertions that MAG experiments demonstrate unconscious learning, claims for unconscious induction of an abstract underlying rule system in SLA also rest on the argument that there is a significant dissociation between what learners are aware of and the more abstract rules that linguistic theory holds govern the behaviour of learners.

It may be helpful to consider some examples of unconscious rules of language that have been proposed in the literature, before assessing the evidence for unconscious induction in SLA in general:

- In most dialects of English, there is a difference between the pronunciation of the ng in finger (ng) and in singer (ng). In standard generative theory, the derivation of words like singer and finger is said to entail two ordered rules, an assimilation rule that changes an underlying /n/ to /g/ before /g/ or /k/ and a rule that deletes /g/ before /l/. If and only if the ng word is derived from a verb. Block (1990) points out that one piece of evidence that such internally represented rules govern behaviour is that if you ask a speaker of such a dialect what you would call someone who blings, they will respond /ng/er. Imagining two species of people who speak the same dialect, the More Conscious People, who are conscious of using the nger rule, and a Less Conscious People who are not (or native and non-native speakers of English who have taken a course in phonology and those who have not), Block argues that the internally represented (unconscious) rule governs behavior in both cases.
- Freidin (1990) gives the example of the prohibition in English against split infinitives as an example of unconscious rule-governed behaviour:
An explicit formulation of this rule requires a grammatical analysis of structures. Thus we must somehow distinguish the infinitival "to" from the preposition "to," which is identical both phonologically and orthographically. Exactly how this rule operates will depend on structural analysis of the infinitival "to" and the verbal form that follows (i.e., either a so-called main verb or an aspectual auxiliary verb (perfective "have" or progressive "be"). The crucial point is that these structural analyses are inaccessible to consciousness. (Freidin, 1990, p. 605)

- Freidin also claims that the same argument holds for the subject/verb agreement rule in English, which requires that the tensed verb or auxiliary of a finite clause agree in number and person with the subject. Note that the explicit characterisation of what constitutes the subject involves the postulation of quite abstract structures, structures which are inaccessible to consciousness. (Freidin, 1990, p. 606)

- Higginbotham (1990) discusses the following examples:

1. (a) I consider him a traitor
   (b) I consider him traitors
2. (a) I consider them traitors
   (b) I consider them a traitor

Native speakers will agree that the (a) sentences are grammatical and the (b) sentences are ungrammatical. Higginbotham argues that the standard explanation for this is that:

our judgement is consequent upon our tacit knowledge that predicates in English agree in number with their subjects. The explanation is thus of the same sort as ordinary explanations of judgement based upon knowledge, except that the knowledge is tacit rather than explicit, unconscious rather than conscious. (Higginbotham, 1990, p. 608)

- Chomsky (1990) presents an argument based on a hypothetical speaker of English named Mary, who is presented with the expressions:

1. John is too clever to catch
2. John is too clever to be caught
3. John is easy to catch
4. John is easy to be caught

She tells us that (1) and (2) are true if John is so clever that one cannot catch him, and that (3) — but not (4) — is true if it is easy to catch John; the obvious analogy falls for (4), which she furthermore regards as somehow deviant. Proceeding in the manner of the sciences, we will seek an explanatory theory in whatever turns out to be the appropriate terms. A rather successful theory...

- Seliger (1979) tested monolingual and bilingual children and adult ESL learners for their use of the a/an allomorphs of the definite article and their ability to verbalise the rule underlying their performance, finding no relationship between performance on the task and having a conscious rule.

- White (1991a), in a study to be reported more fully in the following section, investigated the effects of instruction on the learning of adverb placement restrictions by LI French learners of English. White reports that many students acquired unconscious knowledge of a difference between manner and frequency adverbs. Manner adverbs usually sound better at the end of a VP (John opened the door carefully), while frequency adverbs sound better in the SAV position (e.g. Mary often watches television). This point was not covered in instruction, but learners showed evidence of their unconscious understanding of the frequency/manner distinction in subsequent grammaticality and preference tests.

Once again parallel to the arguments concerning implicit learning in MAG experiments, most of these arguments for implicit learning and knowledge can be challenged on the grounds that they either underestimate what learners know consciously or overestimate what learners "know" unconsciously. The first criticism applies to Higginbotham's example of agreement between him/traitor and them/traitors and to Freidin's examples of subject-verb agreement and the prohibition against split infinitives. These are standard textbook examples, and it is ironic that the prohibition of split infinitives is a prescriptive rule that even native speakers must learn consciously and that requires monitoring before it becomes automatic. The claim that unconscious learning is even a possibility in these cases rests upon the assumption that there must be learners who belong to the Less Conscious People who never become aware of the principles underlying these examples but who do produce the correct forms — an assumption for which no evidence is presented because the argument is considered to be a purely logical one.

The second criticism, that theoretically motivated linguistic accounts may overestimate what learners "know" unconsciously, applies to Block's example of the English a/n rule and Seliger's and White's examples. The argument that there is an underlying /g/ in signer and a g-deletion rule that applies after nasal assimilation is based on the principle that underlying representations are chosen in linguistic theory to maximise the value of the grammar by capturing the greatest possible generalisation and avoiding duplication, which is a proper constraint on scientific theorising but which may not be a valid principle of psychological organisation (Dresher, 1981). If one does not believe that
there is a psychologically real underlying /g/ in singer, the argument for unconscious learning in this example vanishes. Seliger's a/an experiment did not show that learners had any productive implicit rule, because all the test items were commonly occurring nouns and lexical knowledge could account for the results. White's assumption that a distinction between frequency and manner adverbs must have been acquired unconsciously because the distinction was not taught is unconvincing, because only eight adverbs were tested, four each of manner and frequency, and these were a subset of those included in the teaching materials, so any learning that occurred could have been purely lexical rather than based on categories of adverbs. No information is provided regarding whether or how often frequency adverbs appeared in SVAO position or manner adverbs in SAV position in the instructional materials or other input. Subjects did not acquire other distinctions that might have been possible without the benefit of instruction, such as the difference between VO and VPP structures or between manner and frequency adverbs in the VPP case. Instead, they made what White believes to have been a conscious over-generalisation: adverbs must not appear between the verb and other categories. Since there do not appear to have been any attempts made in this study to ascertain from the children directly what they were or were not aware of, there are few grounds for assuming that some of their preferences were conscious and others unconscious.

Chomsky's example is much more problematic. Unconscious knowledge of some kind seems to be involved, because many native speakers are unable to give any explanation at all of why they reject John is easy to be caught. Although other native speakers suggest that it is the sequence easy to be caught that is offensive, it cannot be the case that native speakers (and non-native speakers with native like intuitions) have merely accumulated more knowledge about permissible collocations in English through an essentially associationist kind of learning, because the sentence It's easy to be caught is grammatical. It is, however, a long stretch to argue that the contrast between John is too clever to be caught and John is easy to be caught requires all the apparatus of generative theory in its Government and Binding instantiation for its explanation or that the theory has thereby been shown to have psychological reality and to govern learning. A similar objection has been raised by Braidi (1988) against an account of implicit learning by Liceas (1986). With respect to Spanish sentences such as Ese es el chico que/quiéen vino ayer, Liceas suggested that a second language learner "may not be able to decide whether it is PRO or a wh-phrase ... that is moved to COMP in Spanish nonoblique relativization" (p. 85). Braidi argues against this interpretation, pointing out that Liceas assumes that a learner is making an abstract decision about categories derived from linguistic theory when there is little evidence that this is the best characterisation of the problem. Instead, learners may be concerned with simple lexical selection (que or quien) and may be influenced by such mundane factors as the frequency of lexical items in input or transfer of relativization strategies from the L1. Meisel (1991) has suggested that L2 learners encode functionally transparent concepts such as personal reference, number, and the like, rather than abstract grammatical relations, and that it remains to be seen whether these encodings can be described as grammars in the sense assumed by UG theories.

As Brewer (1974), Dawson and Schell (1987) and Ericsson and Simon (1984) have pointed out, many illegitimate claims for implicit learning arise either when awareness is insufficiently assessed (ignorance is assumed rather than demonstrated) or when the experimenter's (or linguist's) concept of what has been learned is not required to produce the observed behaviour. Nevertheless, there is a case to be made for implicit learning in SLA from studies in which learner awareness has been investigated. Hulstijn and Hulstijn (1984) assessed second language learners' awareness of two Dutch word order rules, finding that learners with explicit knowledge had significantly higher performance scores but that learners who were unable to formulate the rules performed at better than chance levels on one of the structures tested. A recent study by Green and Hecht (1992) provides evidence that there is a dissociation between awareness and performance even concerning pedagogical rules, not very abstract when compared to theoretically grounded analyses, and under a liberal view of what constitutes a correct expression of the rule. In this study, a sample of 300 German learners of English and a control group of native speakers were asked to correct twelve common errors and state the rules that were violated. Results indicated that if learners had a correct rule available, they could produce a correction in nearly every case, suggesting a link between rule knowledge and performance. However, formal grammar teaching did not guarantee that learners would learn the rules that were taught, and learners produced many corrections even when they could not articulate the rules or gave incorrect rules. Green and Hecht also found that some pedagogical rules were relatively easy to learn, including those that referred to easily recognised categories and could be applied mechanically. Rules that were more difficult to learn involved aspect or other subtle semantic distinctions and rules not governed by the immediate linguistic context. These findings support the proposal of Andersen (1988, based on Slobin, 1985) that learners will discover form/meaning relationships that are transparently and uniformly encoded in the input earlier than those that are not so encoded and will perceive the function of functors that are attached to or positioned close to the content words to which they apply earlier than those that are more distant.
Symbolic Processing and Connectionist Accounts of Implicit Learning

If the existence of implicit learning has been demonstrated, we may ask whether explicit and implicit learning are alike in the sense that both involve problem solving, the formation and testing of hypotheses, analogical, inferential, and deductive reasoning, and so forth, all resulting in the establishment of propositional knowledge, the only difference being that these are conscious in one case and unconscious in the other, or whether more basic architectural differences are involved so that implicit learning in SLA as in MAG experiments can best be described as a gradual, complex, covariational form of frequency counting. This is the essence of the raging battle between connectionists and proponents of the more traditional symbolic processing school of cognitive science, which includes most linguists.

Symbolic Processing Accounts of SLA: Parameter Setting

Influenced by Chomsky’s position that “cognizing has the structure and character of knowledge but may be and in the interesting cases is inaccessible to consciousness” (1980, p. 70), SLA researchers who take a theoretically oriented linguistic perspective to acquisition generally do not hesitate to say that learners start with certain initial assumptions and, faced with certain data from the input, make deductions and draw conclusions, sometimes abandoning their initial beliefs and forming new hypotheses, all unconsciously. Sometimes it is not the learner who is said to do this but an internal device, e.g. that “the language acquisition device seeks to determine the combinatorial properties” of language (O’Grady, 1991, p. 342), or “the parser must decide” how input is to be interpreted (White, 1991b, p. 169).

This view of implicit learning is most clearly expressed by those investigating SLA from within the UG paradigm, which assumes that learners are preprogrammed to consider certain types of grammars but not others. It should be noted that the scope of UG-derived claims concerning explicit learning is limited. Schwartz (1986) has claimed that Fodor’s (1983) concept of modular, domain-specific input systems that are unaffected by conscious knowledge (encapsulated) supports Krashen’s non-interface position (conscious learning and subconscious acquisition are unrelated) and that both the grammar of a language (which constitutes a module) and the uses of language (which do not) are acquired unconsciously. Gregg (1988) points out that this misinterprets both Chomsky and Fodor, whose claims concerning input systems refer only to hard-wired systems, e.g. the innate principles of UG, not to knowledge of the individual rules and structures of a specific language, let alone sociolinguistic rules and other aspects of language that are not part of the language module. Within the proper scope of its relevance, however, UG makes very interesting predictions concerning implicit learning:

(1) The assumption that UG is available to all language learners means that SLA learners already know a great deal about the target language before exposure and predicts that grammars of L2 learners will not violate UG principles, that interlanguages must be natural languages and not be describable as “rogue grammars”. If UG is available in SLA, then L2 sentences that violate universal principles should also be judged ungrammatical without the need for any explicit knowledge of the principles involved or even any evidence from the L1 (Bley-Vroman, Felix & Ioup, 1988; Finer, 1991). This is an interesting claim in itself, and one for which there is some evidence (Bley-Vroman, Felix & Ioup, 1988), but since it concerns unmodified pre-existing knowledge it is not specifically relevant to the issue of implicit learning.

(2) If parameter setting or resetting is a part of L2 acquisition, then the theory predicts that where a cluster of structural properties represents a single parameter, all properties associated with that parameter setting should be acquired simultaneously (Finer, 1991). The parameter setting hypothesis is often presented as a claim about implicit learning: “Essentially, the [learner] ‘notices’ a triggering property in the input and then deduces that all the other correlated properties must also be present” (Bley-Vroman, 1989, p. 64).

In UG theory, parameters are abstract properties of grammar that cannot be directly equated with such surface-level phenomena as patterns or structures, and in the most interesting case a single parameter is held responsible at some deep level for seemingly unrelated surface properties. For example, by one account, the parameter of pro-drop includes the ability to omit subject pronouns, subject-verb inversion and trace effects when subjects are extracted from clauses containing complementizers (White, 1985). If it could be shown that one aspect of a parameter serves as the trigger for automatic adjustment of all other aspects of the parameter, this would constitute powerful evidence for implicit learning, because the proposed principles controlling generalisation not just to different lexicalizations of a single structure but to completely different structures are so abstract that learners certainly never become consciously aware of them. If, on the other hand, each aspect of a parameter requires separate evidence, then no particular
conclusions can be drawn concerning unconscious induction. Hyams (1983) argues that simultaneous acquisition of the different aspects of the pro-drop parameter occurs in L1 acquisition. Parameter setting occurs when the child encounters expletives such as *it and there (as in *it is raining) in the input, which cause the child to realize (unconsciously) that pronouns are obligatory in English. This in turn triggers the emergence of modal auxiliaries, another surface manifestation of the abstract pro-drop parameter.

White (1985, 1989, 1991a, b) has attempted to show how such parameter resetting may work in second-language acquisition. In a recent study, White (1991a) examined the effects of instruction on the learning of adverb placement restrictions in English by native speakers of French. In both French and English, adverbs can occur in a different number of positions, including at the end of a VP and in pre-subject position. However, French, while permitting sentences such as Marie regarde souvent la télévision, with the adverb placed between the verb and its direct object, does not permit sentences such as *Marie souvent regarde la télévision, in which the adverb appears between subject and verb. English, by contrast, does not permit sentences of the first type (*Mary watches often television) but does allow those of the second type (Mary often watches television). Moreover, it has been argued that these similarities and differences between English and French fall out from a parameter of UG (whether or not finite verbs are raised to INFL) that links a cluster of properties in each language, including negation, question formation and quantifier placement. White hypothesised that L2 learners would initially assume that the L1 (French) parameter settings are appropriate for English, that specific teaching on English adverb placement would destabilize this assumption, and that learners would show evidence of a clustering of properties in accordance with the parameter, i.e. maintaining the French value or resetting to the English value.

In order to test these hypotheses, francophone learners of ESL in grades 5 and 6 in Quebec were given two weeks of explicit instruction on English adverb placement, concentrating on frequency and manner adverbs. A control group was given no information on adverb placement, but was instructed in question formation (results for this group are presented and discussed in White, Spada, Lightbown & Ranta, 1991). Both groups were tested immediately after the teaching period, and the grade 5 students were retested a year later. The results revealed clear differences between the adverb and question groups. Before instruction, both groups accepted sentences in accordance with the French setting of the parameter, accepting SVAO structures as a possible English word order. After instruction, the adverb placement group learned that such sentences are not permitted in English and the question group did not, showing that instruction including negative evidence can accomplish what input alone cannot, although this effect had disappeared when subjects were retested a year later. Hypotheses relating directly to the abstract parameter setting were not supported. That is, learners did not show a cluster of properties related to either the French or the English value of the parameter consistently. According to the parameter, SVAO (permitted in French only) and SAV (permitted in English) should not occur together. In fact, they did co-occur in the grammars of most subjects.

The claim that abstract parameters structure unconscious inductions across superficially unrelated aspects of grammar was not supported by this study. Changes in one aspect of adverb placement did not lead automatically to other changes, and instruction in question formation (assumed to be another aspect of the same underlying parameter) did not trigger an unconscious induction concerning adverb placement. It is possible that the parameter investigated in this study was simply incorrectly formulated and that a revised version of the parameter may be supported by data from second language learners in the future. But in the absence of clear supporting evidence from this study or from any other SLA study in the literature to date, it appears less and less likely that abstract parameters serve as the basis for a powerful kind of unconscious induction that goes far beyond the evidence encountered in input.

UG predictions concerning implicit learning in SLA may be incorrect not only because the level of abstraction is too high but also because it may be an error to assume that implicit learning is essentially a matter of unconscious induction. Searle (1990) has presented a number of counter-philosophical arguments against this assumption, which he considers a form of pre-Darwinian thinking: Naively, we tend to think of unconscious mental states like furniture stored in the dark attic of the mind or like fish deep beneath the surface of the sea. The furniture and the fish have the same shape when invisible that they have when visible; it is just that it is impossible to see them in their unconscious form. (p. 586)

Searle argues against all accounts of unconscious beliefs, unconscious rule-following and unconscious induction, on the grounds that these notions are inseparably bound up with consciousness and that to speak of unconscious rule-following makes no more sense than saying that grass sucks up water because it is thirsty, the stock market rises because it is happy, or that a stone that is dropped falls because it is trying to reach the centre of the earth and in so doing follows the rule $S=1/2gt^2$. Searle's view is that:

In our skulls there is just the brain with all of its intricacy, and consciousness with all its colour and variety. The brain produces the conscious states that are
cells filled by the six forms. The result is that no form defines a unique combination of features, e.g. der marks the masculine nominative singular, the feminine genitive and dative singular and the genitive plural. Gender assignment is so complex that some observers have concluded that there are no rules, but others have discovered 38 cues to gender, some phonological, some morphological and some syntactic, some absolute and some probabilistic. The dimension of plural maps directly onto nouns, but there are eight different ways to mark plural. Cues to case occur on the morphological, syntactic and semantic level. MacWhinney et al. developed three simulations that successfully learned the article system. Two of these included various cues to gender. The third included only the raw phonological features of the noun stem. All three models learned the system and showed a good match to the 1.1 developmental data, but the third—the most brute and blind of the three—outperformed the others in both training and generalisation.

Connectionist models are also good at learning aspects of language that are normally considered rule-governed but without including any rules in the system. Rumelhart and McClelland (1986) argue that such simulations show that there is no unconscious induction problem in implicit learning. A learner need not figure out what the rules are, either consciously or unconsciously, or even that there are rules. A connectionist model recently reported by Lee and Gasser (1992) successfully simulated the learning of the allomorphs of the regular plural morpheme -en/-s and -en/az by abstracting the generalisation from exemplars onto the connection weights. What looks like rules in this case is only the generalisations embodied in those weights, and the simulation eliminated the need for presupposing either abstract underlying representations or rules, the standard assumptions of generative phonology.

Connectionist models of implicit learning have their own limitations, however, which have led recently to a number of proposals for hybrid, implementational and interactive systems that incorporate both symbolic and subsymbolic processing (Dinsmore, 1992; Smolensky, 1988). Two objections to connectionist models of learning are especially relevant to this discussion of implicit learning, both of them related to the fact that one of the merits of connectionism, its gradualism, is also its greatest weakness. Connectionist networks simply learn too slowly to accurately reflect human learning. Grossberg (1990) argues that this is because connectionist models do not adequately account for the role of attention in learning, and has proposed an adaptive resonance theory (ART) in which top-down learned expectations focus on bottom-up information in ways that enable new learning to be automatically incorporated into the total knowledge base. Loritz (1991) has argued that connectionism models only the learning principles of the cerebellar cortex, but that language is principally learned by cerebral cortex, and that

Connectionist Models of SLA

Connectionist models are especially good at simulating exactly those aspects of language and language learning that rule-based systems are ill-equipped to handle, the gradual learning of areas of grammar for which no clear distinction can be made between regular and exceptional cases. Sokolik and Smith (1992) describe a computer-based connectionist network that learned to identify the gender of a set of French nouns based on the phonological shape of the noun and to generalise to new examples. Gender acquisition in French was previously identified as a classic case of implicit learning (Schmidt, 1986), because no rules for distinguishing gender classes are taught to children, and native speakers cannot formulate coherent or consistent rules, and the “rules” of gender assignment are more like fuzzy regularities than categorical rules in any case. Sokolik and Smith propose that connectionist networks are especially appropriate for modelling implicit learning in SLA. MacWhinney, Leinbach, Taraban and McDonald (1989) have provided an even more impressive connectionist model by successfully simulating the acquisition of the German definite article. There are six different forms of the German definite article (der, die, den, dem, des, das), but since articles mark gender, number and case, there are sixteen different
ART provides a way of integrating language learning theories with each other and with a better account of the neurobiological facts of learning.

A second, related objection to connectionism is that it provides no mechanisms that can account for the extremely rapid acquisition by humans of complex information through explicit rule-following, for example, successful application of the spelling rule “i before e, except after c,” or Gregg’s (1984) account of rapid mastery of aspects of Japanese verbal inflections after explanation and brief practice. Current connectionist models also can provide no account of cases in which rapid restructuring follows “clicks of comprehension” (McLeod & McLaughlin, 1986). Connectionism provides a very different account of implicit learning than Ug accounts, but is like Ug in only being concerned with implicit learning. Smolensky (1988) suggests that hybrid systems that coordinate and integrate a rule interpreter and an intuitive processor are necessary to understand the interplay between explicit and implicit processing and learning.

The Effects Of Instruction On Implicit Learning

The issue of interaction between implicit and explicit learning has been addressed in several MAG experiments and is probably the central question of applied linguistics. Which rules of language (if any) should be taught? When? If rules are not taught explicitly, what kinds of input and what types of interaction can be expected to lead to either conscious recognition of the regularities of the target language or implicit learning of these regularities?

Mathews et al. (1989) have reported a series of experiments indicating that some types of MAGs (finite state grammars) are best learned implicitly, but that implicit learning processes were inadequate for learning a grammar based on simple logical rules based on letter correspondences (e.g. if there is an A in the first position, there must be an X in the fifth position, analogous to agreement rules in natural languages). Mathews et al. also report a positive interaction between implicitly and explicitly acquired knowledge and some evidence that the most effective learning route is to develop an implicit learning base before beginning to generate an explicit model of the task, although they caution that the generality of this effect is unknown. Reber et al. (1980) reported a number of experiments in which subjects were given precise information about the stimulus display at various points during an implicit learning task, concluding that the key finding was that the earlier during the training explicit instructions were given the more effective they were and suggesting that the function of providing explic-
tion rather than simply a part of classroom discourse. This does not mean, however, that the focus of learner attention can be easily manipulated according to a predetermined instructional plan, because (1) many of the topologized items that were noticed by students were not planned to be the target of instruction but arose during the joint construction of discourse by students and teacher; (2) many items that were topologized by the teacher were not taken up, with error corrections constituting the largest class of bled items; (3) learners were more likely to report uptake of items that were focused upon by their peers than those topologized by the teacher; (4) uptake is highly idiosyncratic, with each learner apparently attending to a different subset of the items made available through topologization and (5) eleven percent of the topologized items occurred as a part of classroom discourse without receiving any attention in the form of topologization, providing further evidence for learner autonomy and internal criteria of relevance.

Experiments by Morgan and Newport (1981) and Morgan, Meier and Newport (1987, 1989) using a miniature language system with correlated cues to grammatical structure seem to indicate that although most aspects of syntax could (logically) be induced from distributional evidence alone, the language learning mechanisms are not that powerful, and language learning operates most successfully on input that contains multiply correlated cues. The predicted extent of preprogramming for language acquisition may be reduced if grammatical structure is elided in input “in a fashion that a suitably perceptive learner may exploit” (Morgan, Meier & Newport, 1987, p. 499), suggesting that consciousness in some sense is involved. However, Morgan and Newport (1981) argue that the knowledge derived is not necessarily available to introspection, reporting that subjects in structured input induction experiments developed sophisticated intuitions but were not able to verbalise on what basis they had made their grammaticality judgements. This conclusion does not seem to be particularly well supported by their experiments, since the methods sections of the various articles reporting these experiments indicate that no systematic attempt was made to assess learners’ conscious awareness of structural regularities. However, if these claims are taken at face value, they are compatible with a position that learners must attend to and notice the relevant cues in input, but need not be aware of their significance. Perhaps learners analyse these cues to arrive at conscious hypotheses and build mental models, but perhaps they do not.

Similar unanswered questions remain concerning the results of an experiment conducted by Doughty (1991), who investigated the learning of English relative clauses within the context of a computer-assisted reading lesson. ESL learners were randomly assigned to one of three treatments: a rule-oriented treatment, including explicit rule state-ments and on-screen sentence manipulation; a meaning-oriented treatment, including highlighting and capitalisation of target forms or control (exposure only). Results indicated that increasing the salience of target forms was as successful as providing explicit metalinguistic descriptions in fostering acquisition of relative clause structures. The meaning oriented group outperformed both the rule-oriented group and controls in comprehension of the texts read during the experiment, suggesting a dual advantage for the instructional technique of focusing learners attention on linguistic forms in context. This study is compatible with the idea that noticing is sufficient for learning (that understanding is not required), but does not require that conclusion, because it is unclear whether any implicit learning occurred in the experiment. Learner awareness was not assessed, and it is possible that learners in the enhanced input condition may have formulated hypotheses that would account for their performance.

The experimental research reported in this chapter provides general support for input-based approaches to language teaching and learning (all MAG experiments investigate learning through input processing), in connection with consciousness-raising in some form to focus attention and raise awareness to facilitate implicit learning. How learner attention can best be focused in SLA is an important issue for which MAG experiments provide little direction. For example, the experimental literature by itself provides no clear basis for choosing the approach of Loschky and Bley-Vroman (1990), who recommend the construction of closed communicative tasks that require attention to the target grammatical structures, that of Ellis (1993), who suggests that consciousness-raising considerations justify a return to a structural syllabus as long as it is understood that this cannot serve as a complete course or that of Long (1991, forthcoming a, b), who rejects any kind of structural syllabus as well as attention to linguistic forms out of context, advocating instead a task-based syllabus in which tasks are not designed with any specific linguistic focus, but teach something else (biology, mathematics, automobile repair, geography). In Long’s task-based approach, attempts to make learners notice language arise incidentally, through a focus on form that is triggered by the interaction of learners with tasks.

MAG experimental research is similarly silent with respect to the important issue of the possible role of feedback in implicit learning, including negative evidence or error correction, simply because there appear to have been no experiments using the MAG paradigm that have incorporated such feedback. On the other hand, it may be more than fortuitous that the “implicit learning condition” in MAG experiments is a treatment in which subjects are told to attend to and memorise examples of the target grammar strings. If in fact the essence of implicit learning is that it is based on mechanisms for unconscious gen-
eralisation from a well-established base of specific exemplars in memory (as suggested by connectionist models), this would have many yet to be explored consequences for second language pedagogy.

CONCLUSIONS

The following claims seem justified on the basis of the literature reviewed in this chapter:

1. The essence of the distinction between explicit and implicit learning is the contrast between learning based on conscious understanding at the point of learning and learning without awareness. It appears that both types of learning occur in laboratory experiments and both are probably operative in SLA, although the evidence for implicit learning in SLA is weaker than often claimed, because it rests almost exclusively on claims of a dissociation between what learners can express and what they seem to know after prolonged study or exposure. It is remarkable that the few studies adapting the MAG paradigm to incorporate natural language material (Alanen, 1992; Ellis, in press) have found very little evidence of implicit learning. There is a dearth of studies in SLA that attempt to investigate the development of linguistic competence and learner awareness longitudinally in order to find out whether restructuring in the underlying grammar is closely associated with changes in awareness or happens independently of any conscious reflection on the target language, and the only study to attempt this (Schmidt & Frota, 1986) also found little evidence for learning without awareness.

2. Attention to input (not mere exposure to comprehensible input) is a necessary condition for explicit learning and may be both necessary and sufficient for implicit learning. No learning in either mode is based on unattended stimuli or features of stimuli. Learner attention can be partly controlled through experimental instructions, tasks and pedagogic focus, but only partly (Van der Heijden, 1992).

3. Intentional learning, including the attempt to form and test conscious hypotheses, is important for some types of artificial grammar learning and not others, and probably for learning some features of natural languages and not others.

4. Positing a language-specific acquisition device seems to explain little about implicit learning. The principles and parameters model of UG makes some interesting predictions regarding implicit learning, but the evidence to date indicates that those predictions are false. Implicit learning seems to be based instead on some very general mechanisms of human learning.

5. The notion of unconscious induction is suspect, and the knowledge gained through implicit learning of both artificial grammars and natural languages is probably less abstract than is typically assumed in SLA. Memory is probably the basis of implicit learning, and human decisions that appear to be rule based may be based on either similarity to individually stored instances or automatic, memory-based pattern recognition mechanisms (e.g., connectionist networks).

6. Instruction facilitates both explicit and implicit learning, but probably in different ways. The mechanisms involved can be partly specified, but only very general implications for language pedagogy can be drawn.

7. Continuing progress in understanding implicit and explicit learning and the interactions between them depends partly on the careful separation of the issues involved. It should not be assumed that incidental instructions trigger implicit learning processes, that rule-search instructions result in explicit knowledge, that uninstructed second language learners learn implicitly or that learners in form-focused classes do not learn implicitly. It is important to investigate the effects of explicit instruction in SLA, but claims concerning implicit and explicit learning essentially refer to learner-internal processes and can only be directly supported when learner awareness is investigated.

NOTES

1. Those working with different experimental paradigms have proposed similar but not identical accounts of implicit learning. Hayes and Broadbent (1988) report the results of a number experiments in which subjects learned to control of some computer-implemented system, e.g., a city transportation system or a model of the British economy (see chapter by Berry, this volume). Hayes and Broadbent theorise that different systems require different modes of learning. “S-mode learning” takes place by means of working memory and is selective and reportable. “U-mode learning” occurs outside working memory and outside awareness; it is unselective and unavailable for verbal report. A number of studies have shown the double dissociation of U-mode learning and the ability to verbalise what is known. Some studies have shown that people can learn through practice to make better decisions without improving their ability to verbalise their knowledge (Broadbent & Aston, 1978), while other studies have shown that instructions can improve one’s ability to answer questions without improving their ability to make correct decisions (Berry & Broadbent, 1984). U-mode learning shares several relevant characteristics with implicit learning as described by Reber. The product of learning is unconscious in the sense that what is known exceeds what can be articulated, and the process of learning is unconscious in the sense that it has no initial reportable encoding (Hayes &


Schwartz, B.D. (1986). The epistemological status of second language acquisi-


