Paradis, M. (1994) Neurolinguistic aspects of implicit and explicit memory: implications for bilingualism. In N. Ellis (ed.), *Implicit and explicit learning of Second Languages*. London: Academic Press. 393-419.

The question of whether a second language is learned, represented, or processed in a different way from a first language will be examined from a neuropsychological perspective. It will be argued that explicit and implicit memory, each relying on different cerebral systems, are differentially involved during the acquisition/learning of a foreign language, depending on which method is used. Evidence from double dissociation between amnesia and aphasia will be used to show that the memory system that subserves the formal learning of a second language (declarative memory) is neurofunctionally and anatomically different from the one that subserves the first language or a foreign language acquired in conversational settings (procedural memory). It will also be argued that metalinguistic knowledge formally learned in school is not integrated into linguistic competence and does not become available for automatic use. It is therefore plausible to expect that some paradoxical recovery patterns among bilingual aphasic patients may be due to their available metalinguistic knowledge of the language they mastered least well before insult, in the context of severely impaired implicit linguistic competence.

Definitions

In the following discussion, *implicit competence* refers to the knowledge inferred from individuals' performance, even though the individuals themselves are not aware of the nature of this knowledge (Lewandowsky, Dunn & Kirsner, 1989). It is implicit in the sense that it is not overt. It is hypothesized in order to account for the systematic behaviour of the subjects. Thus, for example, speakers, through their rule-governed behaviour, demonstrate the existence of an internalized implicit system that allows them to use the plural or the past tense marker in the appropriate contexts. The behaviour is such that it can be described in terms of the application of a rule, but there is no guarantee that it is indeed the result of the application of this particular rule—or in fact of any rule, as it might be the result, for example, of parallel distibuted processing (PDP). We can only observe that the systematic behaviour of the speaker is compatible with the application of a particular rule. This is what the linguist infers to be linguistic competence. But since a given behaviour can be explained as the result of the application of different rules—or even of no rule (e.g., PDP), the form in which linguistic competence is actually represented is not known. This competence is acquired incidentally (i.e., by not focussing attention on what is being internalized, as in acquiring the form while focussing on the meaning), stored implicitly (i.e., not available to conscious awareness), and used automatically (i.e., without conscious control). *Explicit knowledge* refers to the knowledge of which individuals are aware, and that they are capable of representing to themselves and of

verbalizing on demand; hence its characterisation as declarative memory (Cohen, 1984). It can be consciously (even effortfully) learned, by focussing on that which is to be retained in memory. Its contents can later be recalled into conscious awareness and verbalized. When something declarative cannot be verbalized, one is nevertheless aware of the contents of one's knowledge. Even if we are not able to describe verbally, say, the difference between two wines, we may verbally report that we perceive (and hence know) that there is a difference (Schmidt, 1990). On the other hand, one does not know—is not aware of—the contents of implicit competence. Whereas explicit memory entails conscious recollection of an event, implicit memory refers to the change in the subject's behaviour attributable to such an event, without conscious recollection of the event (Cork, Kihlstrom & Hameroff, 1992). Implicit and explicit memory have been dissociated experimentally in numerous tasks (e.g., Reber, 1976; Reber, Kassin, Lewis & Cantor, 1980; Graf & Schacter, 1987; to cite only a few).

Implicit memory is much more fundamental and more pervasive than explicit memory which it precedes phylogenetically and ontogenetically (Sherry & Schacter, 1987; Lockhart, 1984). Implicit memory may in fact be considered the norm, and explicit memory as the specialized capacity of only the most evolved species (Lockhart & Parkin, 1989; Nelson, 1988; Parkin, 1989; Schacter and Moscovitch, 1984; Tulving, 1983). During the first 12 months of life, the child possesses only implicit memory, explicit memory emerging only later (Schacter & Moscovitch, 1984). Three-year-old children exhibit an implicit memory still considerably superior to their explicit memory (Parkin & Streete, 1988). This explicit memory continues to develop with age (Parkin, 1989).

The implicit competence which underlies the performance of motor and cognitive skills is said to be *procedural* (Cohen, 1984), because it relates to internalized procedures, genuine behaviour programmes, which eventually contribute to the automatic performance of the task. Procedural memory is then contrasted with *declarative* memory, which concerns everything that can be represented at the conscious level, and which groups together the individual's general knowledge, as well as what Tulving (1983) called "episodic" memory, and Penfield termed "experiential" memory (Penfield & Roberts, 1959).

A typical example of procedural competence would be one's ability to play a musical instrument "by ear", or the inferred underlying grammar which allows the comprehension and production of utterances. A typical example of declarative memory would be one's knowledge of geography and chemistry, but also what one had for breakfast in the morning, as well as the explicit knowledge of the pedagogical rules of grammar which results from deliberate learning by focalized attention. In other words, declarative memory comprises one's encyclopedic knowledge (all knowledge about the world) and one's episodic memory (knowledge of one's past experiences).

While declarative memory is very flexible in that it integrates information from various modalities, procedural memory is available only for very specific tasks, it is inflexible (each motor or cognitive skill is subserved by its specific procedural memory; deficits relating to procedural memory are clearly task-specific: aphasias and apraxias occur independently of each other, each susceptible of further specificity, such as constructional apraxia, dress apraxia, gait apraxia, and phonological, morphosyntactic, or lexical impairments in aphasia), its contents remains opaque to introspection, and it improves with practice (Cohen, 1991).

While attention is an essential factor in the memorization and recall of explicit information, it is not necessary for the acquisition of action programmes or procedures. On the contrary, it would seem that attention focused on the form to be acquired reduces the efficacy with which it is acquired (by treating it as explicit and hence not internalizing it).

The memory system that most directly concerns us here is the one that underlies the acquisition and use of language. We will then ask the question as to whether the memory system that subserves the learning of a foreign language is the same, or of a different kind than the one that subserves the acquisition of a first language or of a second language in conversational settings, and if so, consider what implications this may have for differential recoveries in bilingual aphasic patients.

Empirical clinical evidence: amnesia/aphasia, declarative/procedural dissociations

Lesions in the hippocampal and amygdalar system as well as in parietal-temporal-occipital and frontal association cortices compromise recognition and recall, and cause selective anterograde impairment of declarative memory while preserving procedural memory such as the acquisition and execution of complex skills. On the other hand, lesions in the basal ganglia, cerebellum, and other non-limbic-diencephalic sites, as well as circumscribed neocortical lesions, selectively affect learning and memory for skilled, automatized functions (Mayes, 1988) such as language (aphasias) and well practiced voluntary movements (apraxias). In other words, focal lesions in specific neocortical sites cause deficits in "knowing how", but not in "knowing that".

Implicit and explicit memory have been doubly dissociated in patients with Alzheimer's Disease (Gabrieli, Reminger, Grosse & Wilson, 1992), alcoholic Korsakoff's syndrome (Cavanan, Hömberg & Stelmach, 1992; Parker, 1992), anterograde amnesia (Corkin, 1992; Keane, Clarke & Corkin, 1992), Parkinson's Disease (Saint-Cyr, Taylor & Lang, 1987), aphasia and apraxia, as well as by anesthetic techniques (Cork, Kihlstrom & Hameroff, 1992). Patients with Alzheimer's Disease, Korsakoff's syndrome, or amnesia have impaired explicit memory but intact implicit memory; patients with Parkinson's Disease demonstrate a selective impairment of procedural memory; patients with aphasia have impaired implicit memory for language (or of the

automatic use thereof), and patients with apraxia have impaired implicit memory for learned movement, without loss of explicit knowledge. Anesthesia with isoflurane/oxygen spares implicit memory (Kihlstrom, Schacter, Cork, Hurt & Behr, 1990), but not with sufentanil/nitrous oxyde (Cork, Kihlstrom & Schacter, 1992). Neither spares explicit memory.

Anterograde amnesics, probably the most extensively studied group, retain the ability to acquire new cognitive as well as motor skills. Thus patient H.M. who, after 40 years post-onset of a severe anterograde amnesia, is not able to remember his age (since it changes every year), nor his new address (any more than the mere fact that he moved), is nevertheless able to acquire new skills such as the recognition of objects from a fragmented picture, the resolution of the Tower of Hanoi problem, the reading of a text from right to left, mirror drawing, or the recognition of the direction of the symmetrical axis in complex geometric figures (vertical, horizontal, right diagonal, or left diagonal), not to mention motor tasks. Yet, he remains incapable of learning new words, whether the names of people he meets every day or vocabulary unknown to him before insult (Cohen, 1991). While some amnesics with a less expansive lesion have been shown to be capable of learning a few new words after repeated trials (Van der Linden, 1991), they nevertheless remain significantly inferior to normals. These observations suggest two things. One (1) is that implicit and explicit memory are subserved by neurofunctionally different systems; the other (2) is that the lexicon is at least in part subserved by declarative memory while morphosyntax is subserved by procedural memory.

Implications from clinical data

(1) Two neurofunctional systems

Cohen (1984, 1991) proposes a fundamental distinction between the two memory systems. According to him, declarative memory and procedural memory are subserved by neuroanatomically distinct systems. While declarative memory depends on the integrity of the hippocampal system and is stored diffusely over large areas of tertiary cortex, procedural memory is linked to the cortical processors through which it was acquired. Keane, Clarke & Corkin (1992) have further demonstrated that cortically mediated implicit memory systems are independent of the limbic-diencephalic system that supports recall and recognition. Different tasks, as well as different components of a given task, call upon different memory systems. The double dissociation observed between the implicit and explicit components of a task (Parkin, 1989) reflects the activity of two independent systems. This does not mean however that they cannot be interactive. Because they are independent, they are selectively susceptible to impairment. Yet, in the course of the normal use of language, for instance, the two systems can

interact to the extent that explicit knowledge can control some aspects of production. First, when we speak, we speak about something. What we talk about must be explicitely evoked before it can be encoded by implicit automatic processes. In addition, in adults, and in particular in educated adults, implicit linguistic competence is coextensive with at least a partial explicit grammar. The latter may be used during the production of utterances, especially in formal circumstances during which speakers use constructions not habitually used by them. In general, their explicit knowledge of the grammar is only used to control the acceptability of their production, itself being the result of automatic processes. To the extent that the automatic microgenesis of an utterance falls under the speaker's conscious control, fluency decreases. Note that in such cases the speaker alternately uses automatic implicit competence and controlled explicit knowledge but never both as part of the same process.

(2) Lexicon/morphosyntax dissociation

All characteristics of procedural memory are compatible with the acquisition and use of morphosyntax and phonology, while at least some aspects of the lexicon would seem to be mainly within the purview of declarative memory. Words can be recalled at will, the speaker explicitly knows their (written and/or phonological) form and can describe their meaning. Given the spoken word, speakers are able to point to its referent (or give a description of it). Presented with a referent, they are able to name it (i.e., to explicitly state the corresponding phonological form).

Recent evidence from event-related potentials (ERP) confirms the observation that the acquisition of vocabulary is less sensitive than morphosyntax to age of first exposure. Decreased competency in ultimate attainment of morphosyntactic proficiency has been associated with changes in the pattern of cortical organization. Patterns of cortical organization associated with the processing of morphosyntax are altered as a function of age of acquisition to a greater extent than those associated with the processing of vocabulary. Morphosyntax, but not vocabulary, appears to be affected by maturational constraints imposed on procedural memory (Weber-Fox and Neville, 1992). Neville's (Neville, Mills & Lawson, 1992) ERP experiments on open and closed class words provide additional evidence suggesting that nonidentical neural systems with different developmental vulnerabilities mediate the lexicon and the morphosyntax. Thus both proficiency and ERPs in a second language set apart vocabulary from the rest of language structure. Similarly, Conrad (1979) reports that deaf individuals who have acquired Sign Language as a first language, and subsequently learn English, typically acquire large vocabularies but do not fully acquire the grammar of English.

There are in fact two aspects to lexical items: their acquisition, which is conscious (one is made aware of their pronunciation and meaning), and their use in context, which is automatic (one is not aware of the access mechanisms that select the items during the microgenesis of an utterance: words under normal circumstances automatically "fall into place" without conscious control). In fact, one is so unaware of how one verbally encodes the message that one is generally unable to repeat verbatim what one has just said, if the utterance exceeds, say, 25 words. Yet, one is very much aware of the message that was verbalized, and one is prepared to verbalize it again, albeit not necessarily in an identical fashion.

Because knowledge of the lexicon is to some extent explicit, the selection of particular lexical items can sometimes be controlled. While all other aspects of the microgenesis of an utterance are under way in an automatic fashion, conscious selection of one lexical item over another may occur, with or without noticeable slowing down of the flow of speech. This may occur as part of monitoring inner speech before it is acoustically realized (i.e., speakers check the as yet not acoustically realized output of the automatic utterance production system against their perceived appropriateness in the sociolinguistic context).

Linguistic competence/metalinguistic knowledge

Numerous researchers in Applied Linguistics (Lamendella, 1979; Bialystok, 1981a; Krashen, 1981) have drawn attention to the fact that some students who obtain excellent results on school tests are nevertheless incapable of following a conversation in a natural environment, and conversely, other students who obtain poor grades in school manage to function effectively in the second language in daily life. One quickly reached the conclusion that there was a grammatical competency which was acquired in school and a communicative competency that was acquired on the street. But what is it that makes the difference?

Contrary to implicit linguistic competence, explicit grammatical knowledge is not available automatically in the unconscious processes involved in the microgenesis of a sentence. Grammatical knowledge can only be used consciously, and hence deliberately. It can serve to check the correctness of the utterances produced automatically, but could not be used as part of the automatic production process. The production of utterances from conscious and deliberate application of explicitly known grammatical rules could not be performed on-line at the normal rate of speech while at the same time selecting the lexical items and applying phonological rules. One would have to consciously keep track (in working memory) of several sets of rules at the same time and apply them concurrently.

This does not mean that speakers cannot possess some explicit knowledge of some of the rules that they use automatically. What it means is that in this case they possess two sources of

knowledge, one implicit, the other explicit; that utterances are normally produced by the use of implicit competence and that explicit knowledge can only be used to slowly construct sentences or to check the grammaticality of what has been produced automatically. In very formal situations, fluency may indeed be reduced by the sporadic conscious application of an infrequently used construction. The observation that two sources contribute to the normal use of language is no argument against the existence of two different types of knowledge differently available. On the contrary, two sources of grammatical knowledge exist, and according to circumstances, one or the other is tapped. To the extent that an utterance is produced on-line without deliberate control over the structures, that is to say in natural conversational settings, the production of the utterance remains non conscious. To the extent that speakers consciously control their production, the latter slows down as a result of the automatic microgenesis being replaced by explicit processes, as production becomes controlled. An extreme case is the behaviour of speakers who express themselves in a second language which they master explicitly but which they have never had an opportunity to use in conversational settings and who construct their utterances laboriously, with long pauses between phrases, and who are quite incapable of understanding a sentence produced at normal speed. At the other end of the continuum are the three- to four-year-old children who produce all their sentences without the slightest explicit grammatical knowledge. What seems particularly difficult in the case of controlled production is that a number of different systems, each with its own set of rules, must be simultaneously integrated and encoded (or decoded). Attention can then not focus on all relevant parameters (phonology, morphosyntax, the lexicon) at the same time. If attention is selectively concentrated on one of these aspects, the others must necessarily wait. Automatic processes, on the other hand, do not interfere with each other. While controlled processing cannot be carried out concurrently with other controlled tasks, tasks that rely on automatic processes do not require attention and can operate in parallel (Schmidt, 1990).

Recognition of an utterance as unacceptable (i.e., ungrammatical) is no unequivocal evidence of metalinguistic knowledge. Nor is it unequivocal evidence of linguistic competence. In the first instance, a four-year-old may reject a sentence as unacceptable without having a clue as to what rule has been violated (that is simply "not the way to say it"). In the second instance, foreign language learners may reject an ungrammatical sentence on the basis of metalinguistic knowledge, even though the correct form is not part of their linguistic competence (they do not produce it on-line). Monitoring, therefore, may involve knowing that an utterance, or part thereof, is wrong (i.e., ungrammatical) because "you don't say it that way" (implicit competence), or because "the preceding direct object is feminine" (explicit knowledge). Both types of monitoring are available to most adult speakers, and the second is a function of the degree of the speaker's formal education.

Researchers generally agree on the observed distinction between two types of performance and on their double dissociation in learners of a second language: explicit metalinguistic knowledge in the absence of implicit linguistic competence on the one hand and linguistic competence in the absence of explicit metalinguistic knowledge on the other. What is controversial is whether metalinguistic knowledge is gradually automatized so as to become available on-line.

Metalinguistic knowledge does not become procedural

It appears that what has been acquired incidentally is stored implicitly and can only be evidenced through behaviour (performance). On the other hand, some deliberately learned tasks seem to gradually become automatic through prolonged practice (Parkin, 1990:40). With respect to language, the answer seems at first sight to be different depending on whether we consider the phonological or morphosyntactic aspects. Learners are conscious of the sounds they attempt to produce and they practise until they are satisfied that their performance sufficiently approximates the intended sound. The articulatory (and hence motor) gestures, when often repeated, end up leaving proprioceptive kinesthesic traces, i.e., automatically available articulatory movement programmes. But even in this borderline case, although the sounds are consciously practised, it is the proprioceptive data (i.e., the cortical record of the position of each organ involved, from the position of the tongue relative to the palate, the teeth and the lips, to the movements of the vocal cords) that are stored in implicit memory. The speaker is not really aware of the simultaneous or sequential position of all the phonatory organs. The speaker is only conscious of the result obtained, not of how it is obtained. The organs' position, of which the speaker is not conscious, is what is stored implicitly and becomes automatic through practice, just as with any other motor skill. What the speaker is conscious of, is the sound that is produced and practiced.

The phenomenon is somewhat different with respect to explicit knowledge of morphosyntax, namely the rules of grammar consciously learned. In this case, the formulation of the rules is what is stored in memory. What is automatized is not the explicit knowledge of the rule, its formulation, as it is known, but its application (or the application of any other process that yields an utterance that is consonant with the application of the rule, i.e., that can be described in terms of that rule, whether or not it is actually used to attain the surface string). What is automatized is the ability to produce the correct sequence of words in their proper inflectional form, whatever processes have been used to reach this result. These remain in fact for ever opaque to introspection. We do not know the rules that underlie most of our utterances (nor even, as we have seen, whether indeed they are derived by rules or arrived at by PDP). Professional linguists are far from agreeing on the description of the underlying grammar, and within a same school of

thought, descriptions have continuously evolved over the past quarter of a century. Chomsky himself, to name only one, has on several occasions drastically changed his description of syntactic structure, from his transformational grammar of the 60's to government and binding and principles and parameters of the 80's, to the recent elimination of deep structure and surface structure altogether, to keep only LF, the logical form, PF, the phonological form and the lexicon, in the minimalist program (Chomsky, 1993). It is therefore extremely unlikely that the language system is represented in any of the ways that have been suggested until now and that continue to be modified month after month. (In fact Chomsky has never claimed any psychological, let alone neuropsychological, reality for any of his successive attempts at characterizing the underlying structure of the various constructions of the language, and McCawley (1983) forcefully stresses that we do not "execute" rules of grammar when we comprehend or produce sentences). It is just as unlikely that the language system should be represented in the very form that is taught in schools in pedagogical grammars, and that it would suffice to automatize these rules (of which subjects are conscious, that they can recite, and even possibly apply efficiently to the production of a written text, or to an oral text at reduced speed).

While most theories assume that skilled behaviours begin as controlled processes and gradually become automatic through practice (Schmidt, 1990), it is important to realize that what becomes automatic is not what the learners focus their attention on, or are even aware of. In the case of learning to produce new sounds, what speakers are aware of is the result, i.e., how closely their production approximates the intended acoustic target, but what is stored in procedural memory and will allow the speakers to produce the sound automatically, is proprioceptive feedback, of which the speaker is not cognizant. Likewise, children "practise" extracting information from utterances produced in context, until they have internalized a competence that allows them to produce utterances which integrate competences from various sources (lexical, morphosyntactic, phonological). But while they are eventually able to produce (grammatically and phonologically) correct sentences, they nevertheless remain unaware of the mechanisms that allow them to do so (including the content of the linguistic competence which the linguist may infer from their performance).

Not only do children acquiring their native language have no notion of explicit grammar, but even adults, and even educated ones, do not know the rules that govern their production. Thus the implicit use of the subjunctive in French may depend on the immediate context, and not from the application, even very quickly, of the rule that stipulates that such and such conjunctions and such and such verbs are followed by the subjunctive when certain specific conditions are met (e.g., when the subject of the first and the second verb are not co-referential). Any native French speaker who taught French to speakers of another language had to refer to the grammar book the first time they were asked the inevitable question: "Why do you use the subjunctive in this

sentence?" Before checking, the answer of course is "I don't know; it simply wouldn't sound right otherwise." "But why?" "Well, I don't have the faintest idea. I've been using the subjunctive in this context for 25 years, but I can't explain why." Whereupon the teacher quickly makes up a rule. Once you have looked it up, you teach that there are 6 expressions that are followed by the subjunctive, whether the subject of the verb that precedes is or is not co-referential with the subject of the verb that follows, and that another 6 expressions are followed by the subjunctive only if the subject of the first and of the second verb are not co-referential, for if they are, then the second verb must be in the infinitive. This is the metalinguistic knowledge of the average grade 10 Canadian English speaker learning French. Are they really going to automatize this knowledge so as to use it in conversational situations, or only use it to obtain good marks on a test where they will have ample time to recite it to themselves?

In fact, explicit representations (in declarative metalinguistic memory) rarely—if ever—correspond to the implicit representations (in linguistic competence, available for automatic use). Explicit representations are nonexistent in children, vary from pedagogical grammars to linguistic theories, and change weekly within some linguistic theories. Yet children, parents, and linguists all speak the same language. Automatic processes are by essence not consciously controlled (or controllable).

Practice does not *convert* explicit knowledge to implicit competence. The explicit knowledge is the knowledge of the rule, as it is enunciated (e.g., "make the past participle agree with the preceeding direct object") or of vocal production parameters (e.g., place of articulation, voice-onset time, vowel duration, stress pattern, etc.). "Practice" is not practice of the rule. (Practice of the rule, i.e., its repetition, leads to knowledge of the rule such that one can recall it on demand: "the past participle agrees with the preceding direct object", not to the ability to make the agreement in the appropriate contexts.) "Practice" is the practice of utterances in which the rule is implemented, whether or not the speaker has explicit knowledge of the rule. Moreover, the automatic production (or comprehension) of an utterance cannot *concurrently* involve controlled processes such as the use of metalinguistic knowledge. While practice improves procedural learning, attention is focussed on the result, not on the process. The process (which is not open to introspection) is what is practiced; the linguistic data or metalinguistic rule is what is known. Similarly, knowledge of phonetic parameters is for example the knowledge that the voice-onset time of a particular vowel in one language is 50 milliseconds longer than its homologue in the other language, and that it is produced three millimeters higher in the oral cavity. That is hardly a piece of knowledge that can be used in the automatic production of a syllable containing the vowel in question as part of a word in a given utterance.

The speaker may *either* use automatic processes *or* controlled processes, but not both at the same time. This is not to say that metalinguistic knowledge cannot serve as material for repair of

an automatically produced utterance. But the utterance must be automatically produced before it can be repaired. Automatic production is unconscious on-line use of competence. Metalinguistic knowledge can only be used off-line, in a conscious controlled manner, either to repair what has been automatically produced, or to construct an utterance by the deliberate application of explicit knowledge. Morphosyntactic metalinguistic knowledge may be applied while the phonology (whatever its degree of approximation of the target) is automatic, or it too can be produced with deliberate effort, but independently of the conscious application of morphosyntax, and hence *subsequently*.

Even if one were able to produce an utterance automatically while at the same time accessing metalinguistic knowledge, that metalinguistic knowledge could not be integrated into the automatic microgenesis of the utterance. An attempt to do so would interfere with the automatic process, and the process would break down. One cannot voluntarily combine something explicit with something implicit (since, by definition, one is not aware of its content). Implicit competence cannot be placed under the conscious control of explicit knowledge.

The aspect of practice which is useful, i.e., conducive to improvement of competence, is not the aspect(s) of which the speaker is aware. The aspect of which the speaker is aware does not get automatized, transferred or converted into what is stored in procedural memory—and what *does* get stored is not within the speaker's awareness. Practice of language, i.e., the use of utterances, is what is directly conducive to improvement of implicit competence. Knowledge of the rules is not. In fact, functional practice, or general exposure to the language in communicative situations, has been found to be the most important factor responsible for achievement on all language tasks—formal as well as functional (Bialystok, 1981b). Indeed, learned knowledge is not transferred to acquired competence. The learner has on the one hand learned the rule (knowledge), and has on the other hand independently acquired the means to behave in ways that can be described as the use of the rule in question, whether or not (more likely not) the rule in question is indeed the form in which underlying competence is represented (see Sharwood-Smith's (1981) discussion of Krashen's assumptions).

Functional practice is not a function of the context in which it is used (i.e., classroom or movies) but of the type of activity that is performed. No doubt there is much more opportunity for functional practice in talking to native speakers at a party than in the classroom. This does not mean that no functional practice can take place in the classroom. To the extent that the teacher addresses the students in the target language, and to the extent that the students respond in that language, some functional practice takes place. In fact, it is that portion of classroom activities that leads to whatever acquisition of competence does take place. Hence the fact that some acquisition takes place in formal settings must not be taken as evidence that metalinguistic

knowledge—which may account for up to 80% of what goes on in the classroom, depending on the method used—becomes linguistic competence.

Not only are implicit and explicit knowledge of language subserved by different cerebral memory systems, but they have different contents, and hence one cannot become the other, or be "converted" to the other, or be "transferred" to the other. This does not mean that metalinguistic knowledge cannot be useful in the process of learning another language, whether by focussing attention on some aspect of the linguistic data that would otherwise have gone unnoticed, or by allowing one to check one's output, or to deduce who does what to whom through a conscious identification of case markers, and thereby improving one's practice. But it is the practice, not the metalinguistic knowledge, which improves automatic performance (and by implication, linguistic competence).

The limbic system

The human brain contains not only the most recently evolved structures, the neocortex, certain areas of which subserve the higher cognitive functions, but also, as in less evolved animals, a brain stem responsible for vital functions, vigilance and tonus, and a limbic system, responsible, among other things, for emotions.

Lamendella (1977a) proposed that acquisition in a natural environment, as opposed to formal learning, involved subcortical structures, in particular those parts of the limbic system responsible for drives, desires, and motivation. He postulated that language acquired in natural settings was integrated into the phylogenetically and ontogenetically prior communication system which is based in the limbic system (and which we share with all mammals), while formal learning, whatever the method (from the grammar-translation to the structural drills of the audiolingual method), did not involve the limbic system, but functioned like the learning of any other explicit knowledge, such as knowledge of chemistry or geography.

Lamendella (1977b) described in detail the limbic system as containing several functional subsystems, each providing its own contribution to communication functions. The various limbic subsystems are involved in the hierarchical organization of the communicative functions. Every limbic subsystem continues to exert control over its domain of human communicative activity. Each subsystem depends on the one that precedes it. The cerebral communicative functions thus depend on the entire hierarchy. Communication functions of the brain are best viewed as distributed over the entire limbic-cortical hierarchy. When symbolic activities develop over neocortical areas, and when new types of verbal and nonverbal communication appear, leading to language, the limbic participation to the communication system does not cease. The limbic communication systems continue to serve their special functional roles in concert with both

higher and lower levels of neural organization. Speech is embedded within a matrix of behaviour patterns regulated by the limbic system. The various components of the communication system, while they constitute autonomous physiological systems, nevertheless work together as part of a neurofunctional metasystem, each component bringing its own contribution. The limbic system is the centre of the communicative functions network in primates, even though higher levels of cerebral organization are involved in the behavioural complex. The limbic system continues to play an important role in humans.

For example, every utterance of a normal speaker starts from an intention to communicate a message. Therefore, at the basis of every utterance there is limbic participation. This phenomenon is also true during the acquisition of language: children are strongly motivated to say what they say and to understand what is said to them. The involvement of the emotional/motivational components of the limbic system in the microgenesis of an utterance during the period of language acquisition may, as a consequence, focus the individual's attention on the message to be understood or communicated and hence away from the form, and thus facilitate the development of procedural memory for language.

Context of acquisition/learning and use—teaching methods

(1) The participation of the limbic structures

It is precisely this limbic dimension that has been missing in all foreign language teaching methods. It was obviously absent from traditional grammar-translation methods. "*La plume de ma tante est sur le bureau de mon oncle* —my aunt's pen is on my uncle's desk" does not carry a particularly urgent message, nor is its utterance particularly motivated, except for the acquisition of a structure in the absence of any context. The audiolingual methods that followed placed emphasis on structural drills without paying much attention to the meaning of the sentences used, and even less to the context in which they were used. This context was in fact totally lacking in substitution and transformation drills which were conducted on the basis of sentences of identical structure but having no semantic connection between them. Audiovisual structuroglobal methods added the semantic and pragmatic dimensions by insisting that every utterance be used in a situational context, which was provided by a picture. Learners were thus supposed to always be aware of the meaning of what they were saying as well as of the context appropriate to the use of their utterances. For example, it was necessary for them to look at the map in order to answer the question "Where is the pharmacy?" But nevertheless, the answer to this question, and the question itself, were motivated only by the fact that it was the student's turn to ask a question or to answer it. The question was not asked because someone had a headache and wanted to get a

pain-killer. In order to be able to answer, the student had to understand the question, and not only use phonology, morphology, syntax and the lexicon, but take pragmatic aspects into consideration and check the facts on the map before answering. This was indeed quite a step forward beyond preceding methods. But it nevertheless still lacked the very first phase of every normal utterance, namely, the intention to communicate a message in order to satisfy a precice need, and consequently the involvement of the limbic system. The first stage of the microgenesis of an utterance was thus absent from all foreign language teaching methods until the advent of communicative methods. Indeed, the latter emphasises the fact that learners be placed in situations of wanting to communicate. In games or all kinds of activities, students are placed in a situation where everything they say is motivated by their desire to communicate a particular message at a given moment, where every utterance is produced because of a real need to communicate.

(2) The participation of implicit memory

The grammar-translation method of the forties, as well as its adaptation in the form of the cognitive code learning approach of the seventies, deliberately relied on explicit memory. The fundamental principle of the cognitive code learning approach was that deductive learning was superior to inductive learning, and that the learner should explicitly know the structure of sentences before putting them to use. It is therefore obvious that this learning involves declarative memory. Rules are learned deliberately and stored in explicit memory so as to be recallable on demand. The structural exercises of the audiolingual method were a step forward in the direction of the implicit internalization of the various levels of linguistic structure, in the sense that pattern sentences were selected on the basis of rules that were not expressed. One can then suppose that a portion of the underlying morphosyntax could eventually become automatic from the repeated use of sentences patterned after a particular construction. The structural exercises of the structuroglobal methods, being drilled under the guise of dialogues, rendered the incidental learning of the underlying structures perhaps even more likely, to the extent that attention was not too obviously focussed on the structure, but on the meaning of the utterances. In contrast to preceding methods, the communicative approach maximizes the occasions of incidental learning since the emphasis is placed on the message to be communicated, not on the form.

Cerebral lateralization of language functions

There has been a highly controversial debate in the literature of the past 15 years over an alleged greater involvement of the right hemisphere in the language functions of bilinguals (Mendelsohn, 1988; Solin, 1989; Paradis, 1990, 1992; Berquier & Ashton, 1992). From the start, the debate suffered from a basic confusion between the grammar (phonology, morphology, syntax, the lexicon) on the one hand, and language use, in particular pragmatic aspects of language use (inference from general knowledge, situational context, mimicry, prosody, etc.), on the other. Experiments typically used syllables, digits, or isolated words as stimuli, and as a consequence the results could not be generalized to language structure in general, nor, a fortiori, could they address the question of language use. In any case, and perhaps unsurprisingly, the results of these experimental studies have been contradictory. Half of them found no difference in lateralization between the first and the second language or between bilinguals and unilinguals. Among the half that did find a difference, some studies found that the increased participation of the right hemisphere applied only to late bilinguals at the beginning stages of acquiring a second language informally (Vaid and Genesee, 1980), while others found that participation of the right hemisphere increased with greater proficiency in a formally learned foreign language (Bergh, 1986). On the other hand, no greater incidence of aphasia subsequent to right hemisphere damage has been observed in bilinguals. Wada tests as well as electrical stimulation of the brain have equally failed to support the claim of greater right hemisphere language representation in bilinguals. Given the lack of concordance between experimental results, and given that all clinical evidence points in the direction of no difference in lateralization of the grammar in bilinguals or polyglots as compared to unilinguals, we may safely assume that the languages of bilinguals are subserved by the left hemisphere, in the same proportion as in unilingual speakers.

This is not to say that speakers of a second language, particularly those whose linguistic competence in the second language is less extensive than in the first, cannot resort to greater reliance on pragmatic aspects to compensate for their weakness in morphosyntactic competence, and consequently rely on right hemisphere strategies to a greater extent (as evidenced by the steadily increasing number of reports of deficits in various pragmatic aspects of language use, e.g., Bihrle, Brownwell, & Gardner, 1988; Bihrle, Brownell, Powelson, & Gardner, 1986: Brookshire & Nicholas, 1984; Brownell, 1988; Brownell, Michel, Powelson, & Gardner, 1983; Dwyer, & Rinn, 1981; Foldi, 1987; Foldi, Cicone & Gardner, 1983; Gardner, Brownell, Wapner, & Michelow, 1983; Heilman, Bowers, Speedie, & Costlett, 1984; Hier & Kaplan, 1980; Hirst, LeDoux & Stein, 1984; Joanette, Goulet, & Hannequin, 1990; Kaplan, Brownell, Jacobs, & Gardner, 1990; McDonald & Wales, 1986; Molloy, Brownell & Gardner, 1990; Ross, 1981, 1984; Tompkins & Mateer, 1985; Weylman, Brownell, Roman, & Gardner, 1989). But such strategies could not possibly be revealed by dichotic or tachistoscopic presentation of words in isolation. These strategies are the same as those used by children in the first years of acquisition

of their native language, who seem to comprehend much more than they can say, through reliance on aspects of the situational context, tone of voice, etc. (Bloom, 1974), i.e., on phylogenetically and ontogenetically prior non-linguistic communicative capacities.

Bilingual aphasia

Some bilingual aphasic patients have been reported to recover one of their languages sooner or better than the other, irrespective of their relative premorbid fluency. Paradoxically, some have had access sooner, better, or only, to the language they spoke the least well before insult and it has been difficult to account for such a phenomenon.

However, once it has been firmly established that linguistic competence and metalinguistic knowledge are two independent systems, each subserved by a different cerebral mechanism and stored in different cortical loci, and given that the extent of metalinguistic knowledge relative to linguistic competence may differ in the two languages spoken by a bilingual individual, depending on the different contexts of acquisition of the two languages, it is not unreasonable to expect that some bilingual aphasic patients, who have lost access to parts of their linguistic competence, will still have access to their metalinguistic knowledge. This knowledge may be more extensive in the language they spoke least fluently before insult.

Indeed, the first language is acquired implicitly. The speaker may then become acquainted with some metalinguistic knowledge in school. In fact Obler and Mahech (1991) report that the lower the educational level of the bilingual aphasic patient, the higher the chances of not recovering the native language tend to be. In such cases, presumably, the speaker with minimum education has little, if any, metalinguistic knowledge. The amount of metalinguistic facts taught depends on the educational philosophy of the school system, and to some extent on the orthography of the language (e.g., when grammatical spelling takes into account morphosyntactic facts not realized orally, such as agreement phenomena in French). In such cases, quite a bit of parsing and clause structure analysis are a standard feature of the curriculum. Thus, the higher the level of education in one's first language, the more extensive one's metalinguistic knowledge of it is likely to be. The same is true of the acquisition or learning of a second language. The more formal the teaching method, the greater the extent of metalinguistic knowledge. Therefore, while in most cases the causes of non-parallel recoveries are to be found in the mechanisms of inhibition/disinhibition affecting the neural substrate subserving linguistic competence (Paradis, 1989), in some cases, what appears to be paradoxical recovery, i.e., better performance in the language spoken the least well before insult, may be due to the use of a compensatory strategy relying on the patient's metalinguistic knowledge of the foreign language. In such cases, linguistic competence is affected in both languages, but metalinguistic knowledge is available for

the foreign language that has been learned formally, and the patients manage to express themselves in that language, albeit slowly and laboriously—which does not seem particularly anomalous for aphasic patients.

To the extent that the lesion is circumscribed to the classical cortical language area, we may expect language deficits without impairment of declarative memory. In fact patients remember episodes distinctly, including their performance on various tasks on the previous day, such as which objects they were able to name on confrontation, and which they were not. This intact episodic memory, however, did not help the patient described by Paradis, Goldblum and Abidi (1982) retrieve the phonological form of the words she remembered having successfully named (or prevent her from naming those on which she remembered having been unsuccessful) the day before.

The two sources of knowledge of the adult speaker of a second language are selectively vulnerable to lesions causing aphasia (affecting implicit competence) or amnesia (affecting explicit metalinguistic knowledge). We should therefore distinguish between spontaneous recovery of a language (disinhibition of procedural competence) and ability to control production through use of metalinguistic knowledge, which corresponds to the use of a compensatory strategy based on preserved explicit memory. Given that what is affected in aphasia is linguistic competence (or the automatic use thereof), we may assume that to the extent that explicit knowledge has been learned through formal instruction, and has not yet been forgotten through lack of rehearsal over the years, patients must have access to their metalinguistic knowledge to help them substitute controlled production for the lack of automatic processing, in the manner of a foreign language learner during the initial phases of formal language instruction.

Also, typically, non-standard dialects, lacking a conventional written form, are acquired implicitly and used throughout life without much metalinguistic awareness on the part of the native speaker. In many cases, speakers of such language varieties learn a second language, often a related standard language, in school (e.g., Alemanic Swiss/Standard German; Québécois/Standard French; Friulian/Italian). Some metalinguistic knowledge of the second language, the language of instruction, is explicitly taught in school as part of the regular curriculum. Since aphasia is caused by a disruption of procedural memory (linguistic competence) subsequent to a focal cortical lesion, metalinguistic knowledge, being subserved by an altogether different neural system, should remain available to the patient.

Thus, in the case of a bidialectal speaker, the amount of metalinguistic knowledge about the standard language used in school as the medium of instruction is likely to be much more extensive than that of the native dialect. The same may be true in the case of a bilingual speaker who has learned a foreign language formally. While the linguistic competence for the second language may be affected to the same extent as that of the first, metalinguistic knowledge

obtained during the learning of the second language may nevertheless be available for conscious, controlled production in that language. To the extent that metalinguistic knowledge in the non-native standard or in the foreign language exceeds that in the native language, the patient may give the impression of having recovered the non-native language better.

Because of the lack of systematic report in the extant literature of the manner of acquisition of the foreign language, it is not possible, at the present time, to verify the hypothesis that patients may compensate their lack of access to linguistic competence by using their metalinguistic knowledge. In most cases of paradoxical non-parallel recovery reported in the literature (Paradis, 1983, 1989), it is not possible to determine the extent of formal instruction. Thus, in the case of Gaston, an 18-year-old Frenchman described by Hegler (1931) who, subsequent to a CVA was able to speak only (somewhat broken) German, a language he had learned only over the previous six months, even when speaking to his brother who had come from France to visit him and who did not understand German at all, the manner in which the patient had learned German, in particular whether he had used grammar books or had attended night school, is not mentioned. The same is true of the soldier reported by Bychowski (1919) who, after cerebral trauma, could only speak Russian, a language he had known only marginally before insult. While the patient had never attended school in his native Poland, he had been taught to read and write Russian in an army commando school. One may assume that a formal method of instruction was used, and the fact that the patient expressed himself in a slow, syllabified manner in Russian is compatible with such an explanation, but there is a lack of sufficient evidence.

Similarly, Byng, Coltheart, Masterson, Prior and Riddoch's (1984) patient recovered English, which had been formally learned at school, better than his native Nepalese. Schwalbe's (1920) German-speaking patient could only speak Hebrew which he had never used colloquially. Sträussler's (1912) German patient recovered French, a language learned in his youth but not much practised since. Gelb (1937) observed that a foreign language, or better still, a classical language, may be recovered over the mother tongue, precisely because it is less automatic. Gelb speculates that the greater mental effort required for the foreign language may stimulate the injured mechanism. It may also be that these patients rely on a mechanism different from the one injured, in this case the intact metalinguistic knowledge, subserved by different cerebral substrates.

Conclusion

In sum, the incidental acquisition of that on which attention is **not** focused (in our case, the grammatical form of utterances and the proprioception for the production of language sounds)

leads to an implicit **competence** that is used automatically and that remains opaque to introspection. Deliberate learning leads to explicit **knowledge** which is recallable, that is, usable in a consciously controlled manner. Formal learning is not rooted in those parts of the brain that subserve the automatized language processes. Explicit knowledge about the structure of the language is within the purview of declarative memory, and like everything that is within the purview of declarative memory, can be recalled to consciousness on demand. On the other hand, the contents of implicit linguistic competence remains unknown. Linguists do not agree among themselves on what the rules are, and they keep changing their own characterization of the grammar (Chomsky, 1965, 1981, 1991). In any case, most linguists do not conceive of the grammar rules they do posit as being executed in the course of comprehending or producing sentences (McCawley, 1983). The grammar, as described by linguists, leaves open the question of what algorithms are employed in language processing (Marshall, 1983). In fact, some claim that linguistic abilities can even be explained without the attribution of any representation of rules governing linguistic behaviour (Stabler, 1983). Metalinguistic knowledge cannot be incorporated into the automatic use of language.

Two neurofunctional systems are called upon to different degrees by the various teaching methods: implicit and explicit memory. However, the presence or absence of incidental memory participation does not a priori determine the best method, the one that must necessarily be selected, whatever the objectives and the circumstances. The individuals' age, their prior experience, their cognitive style, their objectives, the number of students per class, the duration of the course, the budget available for teaching materials, must necessarily guide the language teacher towards a compromise that will maximize the chances of success, given the particular circumstances. The advantage of incidental acquisition is that it leads to implicit internalization and automatic use. Its great disadvantage is that it requires a considerable amount of time.

The question whether L2 is (1) learned, (2) represented, or (3) processed in a similar or different way from L1 may thus be addressed as follows. Both rely—to varying extents—on implicit and explicit memory. However, (1) to the extent that the second language is learned formally, with emphasis on metalinguistic knowledge, the learning process will differ from that of the first. There is increasing evidence that cerebral plasticity for the implicit acquisition of phonology and morphosyntax decreases with age. (2) To the extent that the second language is learned formally, metalinguistic knowledge will be available alongside whatever linguistic competence is developed. The extent of metalinguistic knowledge available for L1 will, to some extent, depend on the degree of education of the speaker. There is no reason to believe that linguistic competence in L2 should be represented under any circumstance in a way different from that of L1. Linguistic competence (i.e. the representation of the language systems, the speaker's grammar, in whatever form), is subserved by the left hemisphere. The exact way in

which the two languages of a bilingual speaker are organized either as a single extended language system, a dual system, a tripartite system, or as independent subsystems within the language system (Paradis, 1981) is not yet known. (3) The way in which L2 may be processed differently from L1 will depend on the extent of linguistic competence in L2. The weaker the linguistic competence is, the more the speakers will have to resort to metalinguistic knowledge to control their production, and/or place greater reliance on pragmatic cues to derive an interpretation of the utterance. L1 speakers rarely need to resort to their metalinguistic knowledge when they speak, except on very formal occasions, but they too have to rely on pragmatic aspects of language use to a considerable extent in normal circumstances. Thus L2 language processing need not differ qualitatively from L1 processing. Only the degree of reliance on metalinguistic knowledge and/or pragmatic aspects of language use may differ (a quantitative difference).

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