John Benjamins Publishing Company

Explaining phenomena of first and second language acquisition with the constructs of implicit and explicit learning

The virtues and pitfalls of a two-system view

Jan H. Hulstijn
University of Amsterdam

This chapter examines to what extent Krashen's (1981) distinction between acquired (implicit) and learned (explicit) knowledge can be upheld from a usage-based view on first and second language learning and in the light of recent advancement in (neuro)cognitive research on artificial grammar learning, statistical learning, and modelling implicit and explicit learning. It is proposed that, generally, two-system theories (e.g. implicit/explicit, declarative/procedural) appear to account for first and second language acquisition. However, given the complexity of language systems, the complexity of the human brain, and the possibility that consciousness should be conceived of as a scale rather than as a dichotomy, it might well be that a two-system view is too simple. The paper ends with partly speculative answers to six fundamental questions concerning implicit and explicit first and second language acquisition and an agenda for their investigation.

Introduction

It is now more than 30 years ago that Krashen (1978, 1981) proposed the constructs of *acquisition* and *learning* of a second language (L2) as part of his Monitor Theory. "'Acquisition' is a subconscious process identical in all important ways to the process children utilize in acquiring their first language, while 'learning' is a conscious process that results in 'knowing about' language" (Krashen, 1985, p. 1). "The fundamental claim of Monitor Theory is that conscious learning is available to the performer only as a *Monitor*. In general, utterances are initiated by the acquired system (…). Our 'formal' knowledge of the second language, our conscious learning, may be used to alter the output of the acquired system, sometimes before and sometimes after the utterance is produced. We make these changes to improve accuracy, and the use of the Monitor often has this effect." (Krashen, 1981, p. 2). Since the early publications of

Krashen (1978, 1981), it is common in the literature on second-language acquisition (SLA) and second-language instruction to speak of implicit and explicit learning and knowledge, referring to "intuitive and unconscious" (implicit) and "metalingual and conscious" (explicit) processes and systems, as is illustrated in one of the first reference books of SLA (R. Ellis, 1994, p. 31 and passim; see also N. C. Ellis (Ed.), 1994).

Fortunately, scientific inquiry has progressed substantially since the launch of Monitor Theory. First, cognitive psychologists have conducted important experimental laboratory research in the areas of artificial language learning, implicit learning and statistical learning, using human subjects (see Misyak, Goldstein, & Christiansen, 2012, for an overview). Second, cognitive scientists have made substantial progress in modelling implicit, unsupervised learning of some forms of language-like elements and arrangements of elements, using various kinds of connectionist networks (see Rebuschat & Williams (Eds.), 2012, for an overview) or systems based on relatively simple principles of associative learning (Perruchet, 2008; Perruchet & Vinter, 1998). Third, cognitive neuroscientists have identified different areas of the brain possibly associated with implicit and explicit knowledge of language (e.g. Paradis, 1994; Reber, Allen & Reber, 1999; Squire & Knowlton, 2000; Ullman, 2004, 2005), albeit that such dissociations in the brain have been challenged (e.g. Poldrack, 2010). Fourth, linguists and psychologists (e.g. Lieven, 2009; MacWhinney, 2011; O'Grady, 2005; Tomasello, 2008) have proposed usage-based, emergentist theories of language acquisition that do no longer necessarily postulate a fundamental difference between competence and performance or a Universal Grammar governing all language acquisition, as most generativist theories do. Given the developments in these areas, it is time to re-assess the virtues (and the pitfalls) of implicit and explicit knowledge and learning in L1 and L2 acquisition as a two-system theory, which is what I intend to do in the present chapter.

After a brief review and assessment of Monitor Theory, I will list some phenomena, potentially related to the implicit-explicit debate, that a theory of L1 and L2 acquisition has to explain. I will then look at six issues potentially playing an explanatory role in these issues. (Each of these subsections is headed by a question.) The next section addresses the question of how many cognitive systems have to be assumed to explain the data, taking the complexity of natural languages and the complexity of human brains into account. Accepting, for the moment, a two-system theory distinguishing implicit/unconscious and explicit/conscious learning and knowledge, I then address the so called interface question in L2 acquisition. In the following section, I return to the list of questions and attempt to explain them in general terms from a usage-based perspective and adopting a two-system approach. The final section of this chapter provides a brief conclusion and a research agenda, ending with what I experience as some of the most frustrating, unsolved questions.

Monitor Theory

Basing himself on earlier work of Corder (1967) and Selinker (1972), Krashen (1981, p. 4–8) proposed the constructs of acquisition and learning, in order to explain (1) individual differences among L2 learners in self correction during speaking or writing, in the absence or presence of explicit knowledge of grammar rules, (2) the fact that, while both language aptitude and L2 attitude are associated with success in L2 learning, aptitude and attitude are not related to each other, (3) the differential benefits of informal and formal learning environments to L2 learning, (4) the similarity in the "natural order" of errors produced by child learners of L2 English and errors produced by adults, if produced in spontaneous, meaning-focused speech, (5) phenomena of L1 influence in L2 production, and (6) differences in speed and ultimate attainment between L1 and L2 acquisition. Actually, it is quite difficult to summarize Monitor Theory because Krashen never makes an explicit distinction between constructs and hypotheses; there is no clear distinction between (1) phenomena assumed to exist and in need of an explanation, and (2) phenomena predicted to exist by the theory's hypotheses. In most summaries that Krashen has provided of Monitor Theory (Krashen, 1982, 1985, 1991), he presents the theory as a list of hypotheses, without first telling the reader which phenomena the theory seeks to explain (as in Krashen, 1981). In other words, the theory (the explanation of the phenomena that need to be explained) and the theory's main constructs (acquisition and learning) are presented simultaneously with the hypotheses (which ought to be derived from, and hence distinct from the theory itself). The main proposition of the theory is that second language acquisition is mainly a matter of what Krashen called subconscious acquisition. What Krashen meant, presumably, is that learners are aware (in the case of learning) and not aware (acquisition) of the fact that they are learning an abstract linguistic system. Monitor Theory claims that learned knowledge (in particular knowledge of grammar rules) can only serve to alter an utterance after it has been produced by the system of acquired knowledge (prior to or after its articulatory delivery), and only when three conditions are met: (1) the L2 user must have time to self correct herself/himself, (2) her/his attention must be focused on grammatical accuracy, and (3) she/he needs to know the rule involved.

   Critics of Monitor Theory (Gregg, 1984; Hulstijn & Hulstijn, 1984; McLaughlin, 1978; Sharwood Smith, 1981) argued that the notions of acquired and learned knowledge and the constructs of acquisition and learning were not defined in a way sufficiently explicit to allow their operationalization, that hence the theory's hypotheses pertaining to these notions could not be tested, and that hence Monitor Theory had to be classified as an untestable theory. This criticism was largely correct, although the hypothesis concerning the three conditions of monitor use, just mentioned, could be

tested at least partially (Hulstijn & Hulstijn, 1984). In retrospect, I believe that this rigid criticism was caused by the fact that Monitor Theory did not sufficiently distinguish between the theory as such (with its abstract constructs of acquisition and learning) and the testable hypotheses that could be derived from it. As so often in science, it is difficult to establish the relationship between the theory's abstract constructs (which have no empirical, observational status) and their parallels as they appear in the theory's hypotheses. Ultimately, this is a matter of subjective agreement in the research community. (For example, the fact that the relationship between the construct of competence and performance in generative linguistics and its behavioural manifestation of grammaticality judgments is rather tenuous does not immediately invalidate generative linguistics). As I will argue below, one of Monitor Theory's main ideas, namely the distinction between acquisition and learning (i.e. between implicit and explicit learning) still stands today as highly plausible in the explanation of L1 and L2 language acquisition.

What needs to be explained?

Most SLA scholars have their individual ideas about the phenomena that a theory of L2 acquisition should minimally be capable of explaining (see, for example, the lists of Towell & Hawkins, 1994, and Van Patten & Williams, 2007). With respect to the notions of implicit and explicit learning, I could think of the following phenomena that every theory of L1 and L2 acquisition should be able to explain. Because of the possibility that phenomena may not be theory-independent, i.e. because of the possibility that theories simply assume or assert certain phenomena to exist without sufficient evidence for such assumptions (Hulstijn, 2013), I formulate these fundamental issues in a conditional form, along the following pattern: "If X is the case, how do we explain X?"

1. *Early L1 acquisition*. If it is true that L1 acquisition up to the age of around five years takes place unintentionally and implicitly, then how do we explain that substantial parts of complex systems in the domains of phonology, lexis and syntax can be acquired ?

2. *Subsequent L1 acquisition*. If it is true that, up to about the age of five, individual differences in L1 acquisition are relatively small while individual differences are large with respect to elements acquired after that age in the domains of morphology, lexis, syntax, pragmatics, and with respect to literacy (Berman, 2007), how do we explain these differences?

3. *Output variability in L2 learners*. If it is the case that most L2 learners, at any given point in the acquisition of an L2, produce correct utterances one moment and

incorrect utterances the next (with respect to the same feature of the L2), how can we explain this variability?

4. *Informal versus instructed L2 learning.* If it is true that differential benefits occur in informal and formal L2 learning environments, how do we explain these differences?

5. *L1 transfer in L2 acquisition.* If it is the case that L1 transfer is more difficult to inhibit in L2 pronunciation than in other linguistic domains of the L2, how do we explain this differential effect?

6. *Differential effects of explicit instruction and learning.* If it is true that explicit instruction does not positively affect the acquisition of some L2 elements while it does positively affect the acquisition of other elements, how can we explain these differential effects?

Six matters to take into account

In the following six subsections, I look at some linguistic and neurolinguistic matters that have to be taken into account in the explanation of the questions listed here.

1. What is language?
The term 'natural language' refers to an extremely complex construct, that textbooks of linguistics describe in terms of: subtle classifications in acoustical and articulatory phonetics; complex systems of phonemes, syllables and free and bound morphemes; and a complex system of morpho-syntax pertaining to subtle form-meaning constructions, involving not only adjacent linguistic forms but also non-adjacent forms within clauses, beyond clauses and even beyond utterances. Furthermore, with a large number of linguistic forms an almost indefinitely large number of meanings and pragmatic functions can be expressed, such that there is no one-to-one mapping of forms and meanings; almost every linguistic expression can be interpreted in different ways (ambiguity) and almost every semantic/pragmatic message can be expressed with different linguistic means. Thus, most schools in linguistics account for the complexity of form-meaning mappings in natural languages with a large number of categories and a large number of rules, constraints or procedures operating on categories.

The usage-based, constructionist, and emergentist theories in linguistics of the last twenty years or so (henceforth collectively referred to as the UB school) have provided us with two fundamental insights of natural languages. First, crystal-clear definitions of most categories in languages cannot be given. Most linguistic categories are fuzzy concepts that can best be defined in terms of prototypes and graded membership. For any given natural language, linguists can give typical examples of members of categories such as vowel, syllable, morpheme, noun, verb, and of members of category

pairs such as countable-uncountable, animate-inanimate, present-past etc. but borderline cases exist for each category or category-pair distinction. Second, very few regularities in natural languages can be captured by means of rules that apply always, regardless of semantic and pragmatic context. Most regularities can better be conceived of as arrangements of linguistic units that generally and typically occur but for which exceptions do exist. In summary, in an UB view, languages cannot adequately be described in terms of hard, context-free, exception-less rules that operate on clearly defined categories. Instead, languages can better be described in terms of typicality: regularities in the arrangement of members of soft categories that typically, i.e. most often occur (e.g. MacWhinney, 1989; Smolensky, 1999). The fundamental role of typicality reflects the observation that some elements and some arrangements of elements occur more often in language use than others and that, thus, the statistical properties of language elements and their arrangements in utterances constitute the essence of languages as systems of form-meaning mappings. The fact that, more often than not, one utterance can have various meanings and that one meaning can be expressed (more or less successfully) with more than one arrangement of forms, underscores the communicative need for languages to be flexible systems. A theory that aims to account for the phenomena of L1and L2 acquisition listed above needs to take the probabilistic nature of natural languages into account.

Some categories or regularities in natural languages, however, can be expressed in clear terms. While this is the case for some regularities implicitly acquired by all L1 learners, it applies typically to aspects of language that have been codified as standardized vehicles in culturally, intellectually and socio-economically developed societies, for the purpose of complex forms of communication. For most languages in the industrialized world, writing systems and orthographies have been developed and prescriptive rules of proper, socially appropriate language use have been formulated. This is what Hulstijn (2011, 2015) calls 'higher' or 'extended' language. At least some of those rules are formulated as clear rules that operate on clearly defined categories. In literate societies, journalists, lawyers, civil servants and members of many other social groups, frequently involved in more complex forms of communication, receive instruction about rules of grammar, orthography and socially accepted forms of language use (e.g. "Say and write *a* and *an* when the first sound of the following word is a consonant or vowel, respectively"). Thus, some types of language use, especially the use of (mainly written) language in complex forms of communication, follow rules that can be and are explicitly formulated.

2. How much of a language is learned incidentally and unconsciously by children?
Let us loosely define implicit learning as a learning process in which the learner is unaware of the statistical properties and the degree of regularity in the linguistic stimuli to which (s)he is exposed. As Williams (2009) argues, implicit learning is the typical learning mode in settings of incidental (non-intentional) learning. For establishing

the power or limitations of implicit learning, it is important to find out which elements of language are acquired implicitly (and incidentally). This part of L1 acquisition pertains, roughly, to the first five years of life, in societies with obligatory elementary-school education where children begin learning to read and write at around age five. The breadth and depth of language knowledge that children acquire before they go to school, is primarily determined by the language proficiency of the adult native speakers in their immediate environment. The quality and range of parents' language input is largely determined by their level of education. In generative linguistics, it is generally simply taken for granted that all children acquire all essential elements of the grammar of their L1. For instance, Meisel (2011, p. 241) asserts that "(s)uccess, uniformity and fast acquisition rates have thus been identified as defining characteristics of grammatical development in the first language." The empirical question, however, is to what extent this success is true for all (typically developing) children and to what extent all of this knowledge is acquired implicitly (Bates, Dale, & Thal, 1995; Lieven, 2006). Furthermore, it is a matter of subjective appreciation to call acquisition with an annual input of around 2,5 million utterances, taking four to five years to produce utterances that resemble those of adults, 'fast' (Hart & Risley, 1995, referred to by O'Grady, 2012, p. 120).

Recently, I examined the contents of four main textbooks that are used in the large majority of elementary schools in the Netherlands for Dutch L1 instruction, beginning at the level that is internationally commonly referred to as grade one (age six). The Dutch language belongs to the Germanic language group, with English and German and several other languages spoken in North-Western Europe. What is trained in grade one, i.e. what is apparently not acquired by all children implicitly before they enter grade one, pertains to the following: tell which nouns take the definite article *de* (common gender) or *het* (neutral gender) (knowledge of gender), put singular noun forms into the plural (knowledge of plural endings in various classes of nouns), make past tense forms (knowledge of past tense devices in various classes of so called strong and weak verbs), choose the right form of adjectives in attributive positions (knowledge of adjective-noun agreement), form questions (knowledge of word order) and turn questions into assertions (knowledge of word order). Note that the instructions for these excercises do not contain metalinguistic terms (except for 'plural' and 'past/present'). The excercises train morpho-phonological and syntactic knowledge, not metalinguistic awareness. The fact that these morpho-phonological and syntactic devices, featuring in daily speech, are trained in school, may suggest that L1 acquisition is not so 'successful' for all children as generative linguists claim.

3. How much of a first language is learned implicitly?
As various studies conducted by Dąbrowska suggested (Dąbrowska, 1997, 2012; Dąbrowska & Street, 2006), many language features that generative linguistics assumes to be part of the competence of all native speakers, may in fact not be acquired by all

native speakers (see also Mulder & Hulstijn 2011). In other words, it may well be that a substantial part of the knowledge that college-level native speakers possess of their L1 has been explicitly acquired at school and is 'declarative', meaning that one is able to explicitly acknowledge that one knows things about one's L1 (although declarative knowledge may be imperfect and although the sophistication with which it can be formulated may be highly defective). This type of L1 knowledge cannot be acquired before children have reached the stage of cognitive development that includes what is called a "theory of mind" (e.g. the understanding that words like "I" and "you" refer to different individuals, depending who is speaking) and probably the stage of concrete operations as defined by Piaget. Much empirical work has to be done to establish what truth and what fiction is with respect to L1 knowledge shared by all children at pre-school age, and at successive school ages, in relation to the contents of the language curriculum taught at school. Only with such data can it be established, for a range of typologically different languages, which properties of natural languages can and are in fact implicitly acquired in L1 acquisition. Computer simulations of statistical learning should be able to simulate the unsupervised learning of at least these properties.

4. How to conceptualize implicit language knowledge?

Perhaps with the exception of historical linguistics, sociolinguistics and clinical linguistics, the discipline of general linguistics has been dominated, since Chomsky (1965), by generative linguistics, which can be placed in the philosophical tradition of rationalism. The following three theses, central in the generative school, are relevant to the implicit/explicit issue (Newmeyer, 1998: 17–18): (1) the autonomy of syntax as a non-semantic, purely formal system that makes no reference to the functional use of language, (2) the autonomy of knowledge of language (competence), independent of the use of language (performance), and (3) the autonomy of grammar as a system independent from other forms of human cognition. None of these claims have survived in the UB school, which adopts a radically different perspective on the conceptualization of linguistic knowledge, representing the philosophical tradition of empiricism. The basic idea is that language knowledge is usage based and not (necessarily) distinct from other types of cognition. The UB ambition is to account for both knowledge and use of knowledge with a device (grammar, network, model, system), not fundamentally different from devices for other (non-linguistic) forms of cognition.

An important issue, investigated in a host of studies of artificial grammar learning, is whether implicit knowledge of regularities in the language is represented in the form of abstract rules (as was originally proposed by Reber, 1967), or in the form of stored co-occurrences of stimulus elements, also known as chunks (e.g. Dulany, Carlson & Dewey, 1984; Dienes, Broadbent, & Berry, 1991; Perruchet & Pacteau, 1990). The research community now appears to agree that chunks, similarity, familiarity, and statistics form the substance of implicit acquisition (see Pothos, 2007, for an overview).

What is not entirely clear from the literature (at least to me) is whether a single system can account for the fact that what L1 and L2 users are able to express (productive language use) lags considerably behind their ability to understand the speech of others (receptive language use). Apparently, a network that is implicitly capable of understanding speech is, in its formal architecture, not necessarily implicitly capable of generating procedures for speech production. These procedures need to be built, separately, it appears, albeit that this is accomplished more easily and more quickly when implicit receptive knowledge is already firmly established (MacWhinney, 2008, 2011).

A theory of language, whether a generativist, functionalist or emergentist theory, may, of course, choose to limit itself to giving the simplest account of the systematicity in form-meaning mappings in all natural languages and it may limit itself to explaining language universals (commonalities and differences between languages). Eventually, however, their explanatory power will increase when their commensurability can be shown with phenomena of language acquisition (developmental paths) and representation of language cognition in the brain.

5. How is language stored and processed in the brain?

In cognitive neuroscience, Ullman (2001, 2004, 2005) proposed a two-system declarative-procedural model with respect to language, subserved by different brain systems. The declarative system, which is mainly concerned with the storage and use of facts and events, including lexical knowledge, grammatical knowledge stored as multi-word chunks, and explicit language rules, is associated with activation in medial temporal lobe regions, including the hippocampus. The procedural system, which supports the learning and execution of motor and cognitive skills, including the morpho-syntactic regularities of language, is associated with a network of specific frontal, basal-ganglia, parietal and cerebellar structures. A dichotomy between declarative and procedural memory systems with their distinct neurophysiological correlates was earlier suggested by other scholars (e.g. Cohen & Squire 1980; McClelland, McNaughton, & O'Reilly,1995; Paradis, 1994, 2004, 2009; Reber, Allen, & Reber, 1999; Squire & Knowlton, 2000). However, given the fact that the brain is one of the most complex structures in biology, and given the fact that natural languages are extremely complex form-meaning systems, it is likely that the claim that linguistic cognition can be rendered by a two-system model with straightforward links to the biology of the brain (its physiology and chemical processes) has to be replaced by more complex models in the not too distant future. For example, the basal ganglia and the cerebellum, brain structures involved in the learning of motor skills, have been claimed to play distinct and independent roles in this type of learning (Hikosaka, Nakamura, Sakai, & Nakahara, 2002). This may suggest that procedural learning in language may also have to be broken down into different types. As Bassett and Gazzaniga (2011: 208) predict: "the next

few years will likely see a revolution in the study of mind-brain interface as tools from mathematics and complex systems, which have as yet only brushed the surface, take hold of the field of neuroscience."

6. Is consciousness dichotomous?

If learning, in terms of mental mechanism(s), is little more than the establishment of an association or link between two or more pieces of information that somehow appear to be similar, then a dichotomy of conscious (explicit) and unconscious or sub-conscious (implicit) learning might suffice to account for human (language) learning. However, imagine that research would show (i) that the type of consciousness would vary with the object of learning (as has been suggested by Dienes and Perner (1999) and Dienes (2012)), or (ii) that the number of learning episodes (the number of exposures to the relevant stimuli necessary for the establishment of an association in long-term memory) (instantaneous versus gradual/prolonged learning) would vary with the object of learning, or (iii) that the frequency or distribution of learning episodes of time would vary with the object of learning. There might then be empirical grounds to replace the conscious- unconscious dichotomy by a conscious-unconscious continuum, as has been suggested by, among others, Cleeremans (2008, 2011) and Reder, Park, and Kieffaber (2009).

The pitfalls of a two-system theory

Science is reductionist in nature, in that scholars abstract away from the phenomena they seek to understand. In other words, the paradox of science is that – in order to understand the world (the observed phenomena) – it must do injustice to the world, by constructing theories consisting of highly abstract constructs. The more we allow ourselves to distance ourselves from the real phenomena, from the "messy data" as it were, the more plausible a two-system theory, distinguishing between implicit and explicit cognition, becomes in explaining L1 and L2 acquisition. This may be a two-system theory such as Monitor Theory (Krashen, 1981), distinguishing between (ill defined) notions of unconscious and conscious knowledge, or dual-mechanism theories of a more circumscribed nature, such as the implicit/explicit theory of Paradis (1994, 2004), the declarative/procedural-knowledge theory of Anderson and Lebiere (1998), the two-level CLARION model of Sun (1997, 1999), or the neuro-cognitive two-system model of Ullman (2004, 2005), depending on the linguistic, psychological or neurolinguistic focus of the researchers proposing these theories (see also Williams, 2009, 326–327).

If we are willing to abstract further away from the data, even a one-system theory becomes plausible, taking explicit knowledge as a re-described form of implicit knowledge (Karmiloff-Smith, 1992; see also Bialystok, 1986). Over the last fifteen

years, various scholars in cognitive science have argued against two-system views, developing computational networks aiming at explaining phenomena of learning and memory with a single system and/or a single learning mechanisms (e.g. Cleeremans, 2008, 2011; Reder, Park, & Kieffaber, 2009; Perruchet, 2008; Perruchet & Vinter, 1998; Shanks, 2005; Shanks & Berry, 2012) Alternatively, Sun, Slusarz, and Terry (2005) have proposed a model in which knowledge can be acquired in three ways: bottom up (first implicit then explicit), top down (first explicit then implicit), or simultaneously (implicit and explicit mutually affecting each other). But if we consider, as was done in previous sections of this paper, (1) the fact that natural languages are extremely complex systems of form-function mappings (the WHAT of learning), (2) the fact that the brain is an extremely large and complex collection of areas that affect each other to various degrees during online information processing (the WHERE and HOW of learning), and (3) the possibility that consciousness should perhaps be conceived as a continuum rather than a conscious-unconscious dichotomy (the HOW of learning), then we should not rule out the possibility that a theory explaining L1 and L2 acquisition (as well as the acquisition of many other cognitive skills) might have to postulate more than two systems.

More than fifteen years ago, Baddeley (1997: 151–152, 301, and 357) warned against the dangers of a dichotomy, which may have biased our thinking. Baddeley argues "that a dichotomy is probably an oversimplification" (p. 151). He suspects that "there is one part of the long-term memory system that is indeed responsible for our capacity to acquire new information and to relate it to ourselves and our environment (…), a process which is impaired in the amnesic syndrome" (p. 151). Baddeley refers to this part of memory with the label 'episodic memory'. Other types of learning and knowledge, "that do not need this autobiographical or episodic component for their acquisition" (p. 152) are so varied that they cannot be captured in a unitary system of implicit learning. Baddeley suspects "that the processes underlying short-term priming in word identification, for example, will prove to be quite different from those involved in classical conditioning, which in turn will be quite different from those involved in acquiring a new motor skill. In short, I believe we need an analysis and taxonomy of procedural learning rather than broad explanations based on an assumed dichotomy" (p. 152). The pitfall of a general two-system theory is that, because of its coarse grain, it gives the impression that it can explain all relevant phenomena and that we become blind to potentially conflicting evidence.

The interface issue in L2 acquisition

Krashen (1981) claimed that learned L2 knowledge cannot alter acquired L2 knowledge. This view has become known as the non-interface position. Proponents of the non-interface position, meaning that explicit knowledge cannot be transformed into

implicit knowledge through practice, include Paradis (1994, 2004, 2009) and Hulstijn (2002). These researchers argued, from a neurocognitive perspective, that information stored in one brain region (medial temporal lobe, in particular the hippocampus) cannot literary, physically 'transform' itself into information stored in other brain regions (frontal areas of the cortex). What is quite conceivable, however, is that through extensive practice with instances representing a certain grammatical regularity, guided by a declarative, conscious knowledge of that regularity, an implicit representation of it (perhaps in the form of production procedures as proposed by O'Grady, 2005, 2012) gradually emerges elsewhere in the brain. "Thus, explicit L2 learning need not take place in the absence of implicit L2 learning. Learners who have chosen to try to master an L2 with the help of grammar rules, and are thus engaged in processing primary linguistic information (during listening, reading, speaking and writing activities) cannot prevent a process of implicit learning taking place simultaneously" (Hulstijn, 2002, p. 208). (For recent empirical evidence of intentional learning producing both explicit and implicit knowledge, see Hamrick & Rebuschat, 2012.) In other words, a non-interface position in the neurophysiological sense is by no means at variance with the practice-makes-perfect maxim.

The strong interface position (DeKeyser, 1995, 1997) holds that the presence of declarative, explicit knowledge "is conducive, or plays a causal role" in the development of "procedural, automatized, or implicit knowledge" (DeKeyser, 2009, 126). This position leaves open the possibility that declarative knowledge co-exists with procedural knowledge. The weak interface position (Ellis, 1993) differs from the strong interface position in the following way: while the strong interface position posits a causal relationship between declarative and procedural knowledge, the weak interface position claims that the role of declarative knowledge is only helpful in the process of implicit learning.

The SLA literature of the last twenty years is rich on theoretical and empirical papers in the interface debate. The findings of empirical research show subtle interactions between (1) factors concerning operationalizing explicit learning, (2) linguistic factors (type of target structures; contrast between L1 and L2), (3) treatment-task factors (e.g. length of treatment or amount of exposure), (4) participant attributes, and (5) posttest-task factors (Ellis et al. 2009). Despite differences in theoretical stances in the interface debate, most of the participants appear to agree on the point that L2 learners can only reach the stage of fluent and effortless L2 speech (with respect to morphosyntax) through continued practice (language use) in varied communicative settings. In my view, it is *continued* practice in speaking that is ultimately causally responsible for proceduralized, automatic and largely unconscious cognition in L2 speech production, which may or may not co-exist with declarative knowledge, as was pointed out already by Macnamara (1973) and Anderson (1980) (see the quotes in Hulstijn, 1990, p. 35).

Explaining some fundamental issues in L1 and L2 acquisition and use

In this section, I return to the six questions listed in an earlier section. In trying to answer them, I adopt a UB approach to language and a two-system approach to language cognition. I am fully aware of the fact that the explanations given here are highly metaphorical and do not meet the requirements of testability – a point to which I return in the final section of this chapter. Part of what I argue in this section is speculation; for references and empirical evidence (to the extent available) see Hulstijn (2015).

1. *Early L1 acquisition.* Early L1 acquisition appears to be a matter of implicit, statistical learning, through which knowledge becomes initially represented in a distributed form, inaccessible to consciousness. After ample language exposure, abstract fuzzy categories emerge in the system (network) and abstract probabilistic production procedures that operate on these categories (typicality) will gradually be formed. At later stages of cognitive development, some of this implicit knowledge (the part that can be meaningfully interpreted) may also take the form of declarative, explicit knowledge, and become available to consciousness (Bialystok, 1986; Cleeremans, 2008, 2011; Karmiloff-Smith, 1992; Sun, 1997; Sun et al. 2005). Some implicit knowledge, especially in the domain of the perception and production (articulation) of speech sounds, remains implicit, as is the case with much of the cognition of motor skills (Reed, McLeod, & Dienes, 2010).

2. *Subsequent L1 acquisition.* With cognitive development at the stages of concrete and formal operations, and with language as a school subject (including literacy skills), school children gradually begin to combine explicit with implicit learning. Not all children are good at explicit learning nor do all children take part in literacy related activities in out-of-school contexts to the same extent. Many spelling rules and conventions of 'higher' or 'extended' language are explicitly taught and explicitly learned in school and later in life, depending on people's cognitive abilities and careers.

3. *Output variability in L2-learners.* Variability occurs at stages when a given form or rule of pedagogical grammar has not yet been completely incorporated (proceduralized) in implicit knowledge. The stage of output variability for a particular form or rule may last many years, even several decades. Only when the communicative situation allows L2 users to pay attention to grammatical correctness of what they are trying to say and when L2 users are sufficiently motivated to pay attention to grammatical correctness, are they likely to produce the correct form, provided that they have declarative knowledge of what the correct form is. (This is what Krashen (1981) called Monitor use, with a capital M.)

4. *Informal versus instructed L2 learning.* This issue cannot be solved with a general statement because it refers to various phenomena. I propose that prolonged practice in speaking, in combination with sustained motivation to speak the L2 correctly, accounts for the eventual attainment of native-like performance. For many forms and rules of 'higher' or 'extended' language (Hulstijn, 2011, 2015), explicit knowledge is indispensable, for L2 users as well as for L1 users. However, many regularities are hard to commit to memory in a declarative form (e.g. grammar rules *with* their list of exceptions, to be found in pedagogic grammars; for examples, see Hulstijn & De Graaff, 1994) and in such cases there is simply no explicit knowledge to rely on. Attaining fluent, native-like productive control in an L2 is ultimately a matter of building and strengthening production procedures, reflecting the fuzziness and probabilistic nature of native language use, independent of declarative knowledge of the rules of pedagogic grammar.

5. *L1 transfer in L2 acquisition.* If it is true that one can only have very limited explicit knowledge of how to pronounce certain speech sounds, explicit knowledge is of limited help for control of articulation. In contrast, it is feasible to obtain a considerable amount of declarative knowledge in the domains of lexis, morphosyntax and pragmatics (i.e. knowledge that some forms are correct while others are not) and using that knowledge to correct oneself. This difference in attainability of explicit knowledge may explain why L1 transfer in the domain of pronunciation appears to be more persistent and more difficult to overcome than L1 transfer in the domains of lexis, morphosyntax and pragmatics.

6. *Differential effects of explicit instruction and learning.* For pronunciation, I refer to the answer to question 5. In the domain of lexis and grammar, when elements or rules belong to the 'higher' or 'extended' language of literacy, explicit knowledge, including some metalinguistic knowledge, is required and if acquiring that knowledge requires some intelligence on the part of the learner (the L2 learner as well as the native speaker), then success or failure may be primarily caused by individual differences in intelligence. If explicit instruction fails even when learners do possess adequate declarative knowledge, 'failure' is due to lack of continued practice so that implicit production procedures cannot be formed.

In post-puberty L2 learning or in L2 learning after elementary school (Muñoz & Singleton, 2011), many types of L2 learners can be discerned. In the present context of implicit and explicit learning, the following two types are relevant:

1. *L2 learners at lower educational levels.* Many L2 learners are entirely illiterate, or illiterate in the writing system of the L2, and/or have received little or no schooling, but they are motivated to learn the L2 in the aural/oral modalities. Some of

them may find themselves in an environment of level-appropriate and prolonged exposure and feedback (usually at least several years). This may be the case, for example, when they live with a native speaker of the L2. Under such circumstances they might well acquire a vocabulary of several thousands of content words and the ability to produce fairly correct L2 speech to communicate effectively in daily situations commensurate to their low or modest level of education. Grammatical knowledge, to the extent acquired, will largely be of an implicit form.

2. *L2 learners at higher educational levels*. Many L2 learners have become literate in the writing system of their L1 during elementary education. L2 learning will most likely take place in the setting of secondary or tertiary education or in the setting of an extra-curricular language course (instructed L2 learning), with or without additional time to practice the L2 (e.g. in conversation lessons with a native speaker or during a study-abroad period). The level of L2 proficiency that L2 learners of this type can attain will depend, first, on their motivation and the opportunities of investing much time and effort in L2 learning and, second, on their educational, professional and leisure-time profile (Hulstijn, 2011, 2015). Only L2 learners of this type may benefit from explicit knowledge of the rules of pedagogical grammar in attaining, over time and with much practice, the stage of implicit, proceduralized cognition of L2 grammar.

The big question, in the current context of implicit and explicit L2 acquisition, is to what extent it is possible for L2 learners of the second type to acquire an L2 at a proficiency level higher than A2 of the Common European Framework (Council of Europe, 2001) for speaking and writing, without learning at least some explicit metalinguistic knowledge. Perhaps it might be possible to attain a B1 (or higher) level without any metalinguistic learning, but for implicit learning to accomplish that enterprise would probably require extremely long periods of input and practice. In contrast, some metalinguistic information is likely to help learners to reach their goals much quicker and much more efficiently (DeKeyser, 2003). If, at school, L2 learners have learned some metalinguistic knowledge with respect to their L1, it would be quite unnatural and inefficient if they would or could not use that knowledge while learning an L2, to the extent relevant for L2. To the extent that 'extended' or 'higher' language use is governed by explicit rules of 'proper language use', proficiency in this higher type of language use cannot be acquired without declarative knowledge of its conventions. The role of explicit knowledge is causal for attaining proficiency in this 'higher' language register. In many cases, this explicit knowledge is likely to continue to co-exist with implicit knowledge, as was pointed out already by Macnamara (1973) and Anderson (1980) (see the quotes in Hulstijn, 1990, p. 35) and repeated by Hulstijn (2002).

Conclusions

If we accept, like Krashen (1981) apparently did, a high degree of granularity – i.e. a rather large distance between theory and data – then a two-system theory remains very appealing, especially for explanations of L1 and L2 acquisition, including instructed L2 learning.

This theory distinguishes between the following two learning mechanisms (HOW), in combination with the object of learning (WHAT): (i) unconscious/implicit statistical learning of co-occurrences of elements in the utterances that L1 and L2 learners hear, and (ii) conscious/explicit learning of individual forms (e.g. words), categories and rules.

Work in cognitive and neurocognitive science of the last thirty years has produced some support for Krashen's broad (and unfortunately poorly defined) distinction between acquired (implicit) and learned (explicit) knowledge. However, the pitfall of two-system theories is that, because of their use of general, verbal dichotomies (e.g. conscious, unconscious), two-system theories tend to fit all data and become blind to potentially conflicting evidence. In the years to come, evidence from continued work on (1) computer simulations of language learning, (2) experimental artificial-grammar learning studies with human subjects, and (3) neurocognitive research (model-based fMRI, diffusion-weighted imaging, ERP, PET) is likely to produce data at finer levels of granularity, painting a picture much more differentiated than a two-system theory does. This should not be surprising, given the complexity of natural languages (WHAT), the complexity of the brain (HOW and WHERE), and the intricacies of the centuries-old consciousness debate (HOW). As Shukla, Gervain, Mehler and Nespor (2012, p. 171) argued: "Recently, a synthesis started to emerge asking not whether language acquisition is governed by our genetic endowment or general learning mechanisms, but rather what aspects of language acquisition are governed by which mechanism."

Research agenda. One of the points made in this chapter is that we need to know more about early and late L1 acquisition and L1 knowledge acquired by all versus some L1 learners. Much empirical work has to be done to establish what truth and fiction is with respect to L1 knowledge shared by all children at pre-school age, and at successive school ages, in relation to the contents of the language curriculum taught at school. Only with such data can it be established, for a range of typologically different languages, which properties of natural languages can and are in fact implicitly acquired in L1 acquisition. Computer simulations of statistical learning should be able to simulate the unsupervised learning of at least these properties.

Furthermore, I pointed out that we need to know whether a single system can account for the fact that what L1 and L2 users are able to express (productive language

use) lags considerably behind their ability to understand the speech of others (receptive language use). Apparently, a network that is implicitly capable of understanding speech is, in its formal architecture, not necessarily implicitly capable of generating procedures for speech production. These procedures need to be built, separately, it appears, albeit that this is accomplished more easily and more quickly when implicit receptive knowledge is already firmly established.

Finally, a running theme through this chapter was concerned with individual differences among both L1 and L2 learners (and bilinguals). The language knowledge and skills that people acquire are moderated, to a considerable extent, by socio-economic factors (affecting linguistic input for language learning) and socio-psychological factors (such as people's age, intelligence, self-perceived identity, motivation, and their educational, professional and leisure-time profiles). The implication for empirical research on implicit and explicit L1 and L2 learning (including bilingualism) is that not only university students should be involved as participants but that participants should be selected reflecting the full range of differences found in the populations of L1 and L2 users of a given language.

Closing remarks. Although it is true that the tension between global, more general types of explanations and local, more detailed explanations are part and parcel of scientific inquiry, I experience it as particularly frustrating that, after many years of scholarly work, still no adequate, detailed answers- at the level of learning mechanisms and neural representations - exist for two crucial questions: (1) How does symbolic cognition (consisting of categories and rules) emerge from subsymbolic representations of input? and (2) How exactly are production procedures formed; how are they connected to or even dependent on receptive procedures?

In addition, in the real world of L2 learning and teaching, there is another matter that bothers me. Having poor to advanced control of a few foreign languages (but no near-native speaking proficiency in any of them), having been an L2 instructor for many years, and having conducted empirical research on automatization in L2 acquisition, I find it frustrating that it takes such a long time to learn a language (both L1 and in particular an L2) and that attaining fluency in L1 and L2 speaking skills lags so much behind learning to understand a language. There is not much that explicit learning can do in speeding up implicit learning. Surprisingly, in the SLA literature, the fact that L2 acquistion takes so much time has attracted much less attention than the question of under which circumstances L2 learners might benefit from explicit knowledge of grammar. Of course, the methodological problem for researchers is that it may take longitudinal studies spanning a long period of time to support or reject claims of implicit learning. In the real world of L2 learning and teaching, the only thing I can advise myself and others is: practice, practice, and practice speaking the language in a variety of communicative situations.

Acknowledgements

References

Anderson, J.R. (1980). *Cognitive psychology and its implications*. San Francisco, CA: Freeman.

Anderson, J.R., & Lebiere, C. (1998). *The atomic components of thought*. Mahwah, NJ: Lawrence Erlbaum Associates.

Baddeley, A. (1997). *Human memory: Theory and practice*. Revised edition. Hove, UK: Psychology Press.

Bassett, D.S., & Gazzaniga, M.S. (2011). Understanding complexity in the human brain. *Trends in Cognitive Sciences*, *15*, 200–208. DOI: 10.1016/j.tics.2011.03.006

Bates, E., Dale, P.S., & Thal, D. (1995). Individual differences and their applications for theories of language development. In P. Fletcher & B. MacWhinney (Eds.), *The handbook of child language* (pp. 96–151). Oxford: Blackwell.

Berman, R.A. (2007). Developing linguistic knowledge and language use across adolescence. In E. Hoff & M. Shatz (Eds.), *Blackwell handbook of language development* (pp. 347–367). Malden, MA: Blackwell. DOI: 10.1002/9780470757833.ch17

Bialystok, E. (1986). Factors in the growth of linguistic awareness. *Child Development*, *57*, 498–510. DOI: 10.2307/1130604

Cleeremans, A. (2008). Consciousness: The radical plasticity thesis. In R. Banerjee & B.K. Chakrabarti (Eds), Models of brain and mind-physical, computational and psychological approaches. *Progress in Brain Research*, *168*, 19–33. DOI: 10.1016/S0079-6123(07)68003-0

Cleeremans, A. (2011). The radical plasticity thesis: How the brain learns to be conscious *Frontiers in Psychology, 2*, 1–12. DOI: 10.3389/fpsyg.2011.00086

Cohen, N.J., & Squire, L.R. (1980). Preserved learning and retention of pattern-analyzing skill in amnesia: Dissociation of knowing how and knowing that. *Science*, *210*(4466), 207–210. DOI: 10.1126/science.7414331

Corder, S.P. (1967). The significance of learners' errors. *International Review of Applied Linguistics*, *5*, 161–169. DOI: 10.1515/iral.1967.5.1-4.161

Dąbrowska, E. 1997. The LAD goes to school: A cautionary tale for nativists. *Linguistics, 35*, 735–766. DOI: 10.1515/ling.1997.35.4.735

Dąbrowska, E. (2012). Different speakers, different grammars: Individual differences in native language attainment. *Linguistic Approaches to Bilingualism, 2,* 219–253.
DOI: 10.1075/lab.2.3.01dab

Dąbrowska, E., & Street, J. (2006). Individual differences in language attainment: Comprehension of passive sentences by native and non-native English speakers. *Language Sciences, 28*, 604–615. DOI: 10.1016/j.langsci.2005.11.014

DeKeyser, R.M. (1995). Learning second language grammar rules: An experiment with a miniature linguistic system. *Studies in Second Language Acquisition*, *17*, 379–410.
DOI: 10.1017/S027226310001425X

DeKeyser, R.M. (1997). Beyond explicit rule learning: Automatizing second language morphosyntax. *Studies in Second Language Acquisition*, *19*, 195–221. DOI: 10.1017/S0272263197002040

DeKeyser, R. (2003). Implicit and explicit learning. In C.J. Doughty & M.H. Long (Eds.), *The handbook of second language learning* (pp. 313–348). Oxford: Blackwell.

DeKeyser, R.M. (2009). Cognitive-psychological processes in second language learning. In M.H.Long & C.J.Doughty (Eds.), *The handbook of language teaching* (pp. 119–138). Oxford: Blackwell. DOI: 10.1002/9781444315783.ch8

Dienes, Z. (2012). Conscious versus unconscious learning of structure. In P. Rebuschat & J.N. Williams (Eds.), *Statistical learning and language acquisition* (pp. 337–364). Berlin: Mouton de Gruyter.

Dienes, Z., Broadbent, D., & Berry, D. (1991). Implicit and explicit knowledge bases in artificial grammar learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *17*, 875–887. DOI: 10.1037/0278-7393.17.5.875

Dienes, Z., & Perner, J. (1999). A theory of implicit and explicit knowledge. *Behavioral and Brain Sciences*, *22*, 735–808. DOI: 10.1017/S0140525X99002186

Dulany, D.E., Carlson, R.A., & Dewey, G.I. (1984). A case of syntactical learning and judgment. How conscious and how abstract? *Journal of Experimental Psychology: General*, *113*, 541–555. DOI: 10.1037/0096-3445.113.4.541

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

Ellis, R. (1993). The structural syllabus and second language acquisition.*TESOL Quarterly*, *27*, 91–113. DOI: 10.2307/3586953

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

Ellis, R., Loewen, S., Elder, C., Erlam, R., Philp, J., & Reinders, H. (2009). *Implicit and explicit knowledge in second language learning, testing and teaching*. Bristol: Multilingual Matters.

Gregg, K. (1984). Krashen's Monitor and Occam's Razor. *Applied Linguistics*, *5*, 79–100. DOI: 10.1093/applin/5.2.79

Hamrick, P., & Rebuschat, P. (2012). How implicit is statistical learning? In P. Rebuschat & J.N. Williams (Eds.), *Statistical learning and language acquisition* (pp. 365–382). Berlin: Mouton de Gruyter.

Hart, B., & Risley, T. (1995). *Meaningful differences in the everyday experience of young American children*. Baltimore, MD: Brooks.

Hikosaka, O., Nakamura, K., Sakai, K., & Nakahara, H. (2002). Central mechanisms of motor skill learning. *Current Opinion in Neurobiology*, *12*, 217–222. DOI: 10.1016/S0959-4388(02)00307-0

Hulstijn, J.H. (1990). A comparison between the information-processing and the analysis/control approaches to language learning. *Applied Linguistics, 11*, 30–45. DOI: 10.1093/applin/11.1.30

Hulstijn, J.H.. (2002). Towards a unified account of the representation, processing and acquisition of second language knowledge. *Second Language Research*, *18*, 193–223. DOI: 10.1191/0267658302sr207oa

Hulstijn, J.H. (2011). Language proficiency in native and nonnative speakers: An agenda for research and suggestions for second-language assessment. *Language Assessment Quarterly, 8*, 229–249. DOI: 10.1080/15434303.2011.565844

Hulstijn, J.H. (2013). Is the second language acquisition discipline disintegrating? *Language Teaching, 46*, 511–517. DOI: 10.1017/S0261444811000620

Hulstijn, J.H. (2015). *Language proficiency in native and non-native speakers: Theory and research*. Amsterdam: John Benjamins.

Hulstijn, J.H. & De Graaff, R. (1994). Under what conditions does explicit knowledge of a second language facilitate the acquisition of implicit knowledge? A research proposal. *AILA Review*, *11*, 97-112.

Hulstijn, J.H., & Hulstijn, W. (1984). Grammatical errors as a function of processing constraints and explicit knowledge. *Language Learning*, *34*, 23-43.

Karmiloff-Smith, A. (1992). *Beyond modularity: A developmental perspective on cognitive science*. Cambridge, MA: The MIT Press.

Krashen, S. (1978). Individual variation in the use of the monitor. In W. Ritchie (Ed.), *Second language acquisition research* (pp. 175–183). New York, NY: Academic Press.

Krashen, S. (1981). *Second language acquisition and second language learning*. Oxford: Pergamon.

Krashen, S. (1982). *Principles and practice in second language acquisition*. Oxford: Pergamon.

Krashen, S. (1985). *The input hypothesis: Issues and implications*. London: Longman.

Krashen, S. (1991). The input hypothesis: An update. *Georgetown University Round Table on Languages and Linguistics*, 1991, 409–431.

Lieven, E. (2006). Variation in first language acquisition. In K. Brown (Ed.), *Encyclopedia of language and linguistics* (2nd ed,, Vol. B) (pp. 350–354). Amsterdam: Elsevier. DOI: 10.1016/B0-08-044854-2/01496-6

Lieven, E. (2009). Developing constructions. *Cognitive Linguistics*, *20*, 191–199.

Macnamara, J. (1973). The cognitive strategies of language learning. In J.W.Oller & J.C. Richards (Eds.), *Focus on the learner* (pp 57–63). Rowley, MA: Newbury House.

MacWhinney, B. (1989). Competition and connectionism. In B. MacWhinney & E. Bates (Eds.), *The crosslinguistic study of sentence processing* (pp. 422–457). Cambridge: Cambridge University Press.

MacWhinney, B. (2008). A unified model. In P. Robinson & N.C. Ellis (Eds.), *Handbook of cognitive linguistics and second language acquisition* (pp. 341–371). New York, NY: Routledge.

MacWhinney, B. (2011). The logic of the unified model. In S. Gass & A. Mackey (Eds.), *Handbook of second language acquisition*. New York, NY: Routledge.

McClelland, J.L., McNaughton, B.L., & O'Reilly, R.C. (1995). Why there are complementary learning systems in the hippocampus and neocortex: Insights from the successes and failures of connectionist models of learning and memory. *Psychological Review*, *102*, 419–457. DOI: 10.1037/0033-295X.102.3.419

McLaughlin, B. (1978). The Monitor Model: some methodological considerations. *Language Learning*, *28*, 309–332. DOI: 10.1111/j.1467-1770.1978.tb00137.x

Meisel, J.M. (2011). *First and second language acquisition: Parallels and differences*. Cambridge: Cambridge University Press. DOI: 10.1017/CBO9780511862694

Mulder, K., & Hulstijn, J.H. (2011). Linguistic skills of adult native speakers, as a function of age and level of education. *Applied Linguistics*, *32*, 475–494. DOI: 10.1093/applin/amr016

Misyak, J.B., Goldstein, M.H., & Christiansen, M.H. (2012). Statistical-sequential learning in development. In P. Rebuschat & J.N. Williams (Eds.), *Statistical learning and language acquisition* (pp. 13–54). Berlin: Mouton de Gruyter.

Muñoz, C., & Singleton, D. (2011). A critical review of age-related research on L2 ultimate attainment. *Language Teaching*, *44*, 1–35. DOI: 10.1017/S0261444810000327

Newmeyer, F.J. (1998). *Language form and language function*. Cambridge, MA: The MIT Press.

O'Grady, W. (2005). *Syntactic carpentry: An emergentist approach to syntax*. Mahwah, NJ: Lawrence Erlbaum Associates.

O'Grady, W. (2012). Language acquisition without an acquisition device. *Language Teaching*, *45*, 116–130. DOI: 10.1017/S026144481000056X

Paradis, M. (1994). Neurolinguistic aspects of implicit and explicit memory: Implications for bilingualism and SLA. In N. Ellis (Ed.), *Implicit and explicit learning of languages* (pp. 393–419). London: Academic Press.

Paradis, M. (2004). *A neurolinguistic theory of bilingualism*. Amsterdam: John Benjamins. DOI: 10.1075/sibil.18

Paradis, M. (2009). *Declarative and procedural determinants of second languages*. Amsterdam: John Benjamins. DOI: 10.1075/sibil.40

Perruchet, P. (2008). Implicit learning. In H.L. Roediger, III (Ed.), *Cognitive psychology of memory* (*Vol. 2*): *of Learning and memory: A comprehensive reference,* 4 vols., J. Byrne (Ed.) (pp. 597–621). Oxford: Elsevier. DOI: 10.1016/B978-012370509-9.00149-2

Perruchet, P., & Pacteau, C. (1990). Synthetic grammar learning: Implicit rule abstraction or explicit fragmentary knowledge. *Journal of Experimental Psychology: General*, *119*, 264–275. DOI: 10.1037/0096-3445.119.3.264

Perruchet, P., & Vinter, A. (1998). PARSER: A model for word segmentation. *Journal of Memory & Language, 39*, 246–263. DOI: 10.1006/jmla.1998.2576

Poldrack, R.A. (2010). Mapping mental function to brain structure: How can cognitive neuroimaging succeed? *Perspectives in Psychological Science, 5*, 753–761. DOI: 10.1177/1745691610388777

Pothos, E.M. (2007). Theories of artificial grammar learning. *Psychological Bulletin, 133*, 227–244. DOI: 10.1037/0033-2909.133.2.227

Reber, A.S. (1967). Implicit learning of artificial grammar. *Journal of Verbal Learning and Verbal Behaviour*, *6*, 855–863. DOI: 10.1016/S0022-5371(67)80149-X

Reber, A.S., Allen,R., & Reber, P.J. (1999). Implicit versus explicit learning. In R.J. Sternberg (Ed.), *The nature of cognition* (pp. 475–513). Cambridge, MA: The MIT Press.

Rebuschat, P., & Williams, J.N. (Eds.). (2012). *Statistical learning and language acquisition*. Berlin: Mouton de Gruyter.

Reder, L.M., Park, H., & Kieffaber, P.D. (2009). Memory systems do not divide on consciousness: Reinterpreting memory in terms of activation and binding. *Psychological Bulletin, 135*, 23–49. DOI: 10.1037/a0013974

Reed, N., McLeod, P., & Dienes, Z. (2010). Implicit knowledge and motor skill: What people who know how to catch don't know. *Consciousness and Cognition*, *19*, 63–76. DOI: 10.1016/j.concog.2009.07.006

Selinker, L. (1972). Interlanguage. *International Review of Applied Linguistics*, *10*, 209–231.

Shanks, D.R. (2005). Implicit learning. In K. Lamberts & R. Goldstone (Eds.), *Handbook of cognition* (pp. 202–220). London: Sage.

Sharwood Smith, M. (1981). Consciousness-raising and the second language learner. *Applied Linguistics*, *2*, 159–169. DOI: 10.1093/applin/2.2.159

Shukla, M., Gervain, J., Mehler, J., & Nespor, M. (2012). Linguistic constraints on statistical learning in early language acquisition. In P. Rebuschat & J.N. Williams (Eds.), *Statistical learning and language acquisition* (pp. 171–202). Berlin: Mouton de Gruyter.

Smolensky, P. (1999). Grammar-based connectionist approaches to language. *Cognitive Science, 23*, 589–613. DOI: 10.1207/s15516709cog2304_9

Squire, L.R., & Knowlton, B.J. (2000). The medial temporal lobe, the hippocampus, and the memory systems of the brain. In M.S. Gazzaniga (Ed.), *The new cognitive neurosciences* (pp. 765–779). Cambridge, MA: The MIT Press.

Sun, R. (1997). Learning, action, and consciousness: A hybrid approach towards modelling consciousness. *Neural networks*, *10*, 1317–1331. DOI: 10.1016/S0893-6080(97)00050-6

Sun R. (1999). Accounting for the computational basis of consciousness: A connectionist approach. *Consciousness and Cognition*, 8, 529–565. DOI: 10.1006/ccog.1999.0405

Sun, R., Slusarz, P., & Terry, C. (2005). The interaction of the explicit and the implicit in skill learning: A dual-process approach. *Psychological Review*, *112*, 159–192. DOI: 10.1037/0033-295X.112.1.159

Ullman, M.T. (2001). The neural basis of lexicon and grammar in first and second language: The declarative/procedural model. *Bilingualism:Language and Cognition, 4*, 105–22. DOI: 10.1017/S1366728901000220

Ullman, M.T. (2004). Contributions of memory circuits to language: The declarative/procedural model. *Cognition*, *92*, 231–270. DOI: 10.1016/j.cognition.2003.10.008

Ullman, M.T. (2005). A cognitive neuroscience perspective on second language acquisition: The declarative/procedural model. In C. Sanz (Ed.), *Mind and context in adult second language acquisition: Methods, theory and practice* (pp. 141–178). Washington, DC: Georgetown University Press.

Tomasello, M. (2008). *The origins of communication*. Cambridge, MA: The MIT Press.

Towell, R., & Hawkins, R. (1994). *Approaches to second language acquisition*. Clevedon: Multilingual Matters.

VanPatten, B., & Williams, J. (Eds.). (2007). *Theories in second language acquisition: An introduction*. Mahwah, NJ: Lawrence Erlbaum Associates.

Williams, J.N. (2009). Implicit learning. In W.C. Ritchie & T.K. Bhatia (Eds.), *The new handbook of second language acquisition* (pp. 319–353). Bingley: Emerald.