20 Language Processing Capacity

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1 Introduction

In this chapter I will focus on the development of L2 processing capacity. In section 2, an overview will be provided of different approaches to SLA that entail a processing perspective. The bulk of the chapter is devoted to one specific approach, processability theory (PT), because it affords an explicit account of L2 processing capacity. Within this framework, I will show that research on L2 processing skills contributes to an explanation of linguistic development by defining which linguistic forms are processable at different points in development. I will further show that the concept of "processability" makes testable predictions for developmental routes across typologically different languages, that it applies to L2 as well as to L1 acquisition, and that it delineates the scope of interlanguage variation as well as L1 transfer.

2 Processing Approaches to SLA

The notion of limited processing capacity is a standard assumption in work on human cognition. For instance, short-term memory is thought to be limited in capacity and duration (e.g., Baddely, 1990). The assumption that the processing capacity of L2 learners is limited forms the basis of several approaches to SLA. The limited-capacity view of L2 processing constitutes a basic assumption in work on L2 input processing (e.g., Krashen, 1982; VanPatten, 1996), in research on L2 skill acquisition (e.g., McLaughlin, 1987), in work on operating principles (e.g., Andersen, 1984), in the "competition model" (e.g., Bates and MacWhinney, 1981), and in Clahsen's (1984) L2 processing strategies, as well as in my own work on processability.

In this section I will briefly review the above approaches in an attempt to assess how explicitly the L2 processor is specified, because in my view only an explication of L2 processing procedures permits one to integrate a theoretical model of L2 processing with a module of L2 knowledge, and only procedural explicitness allows the processing module to be falsified. One needs to bear in mind, however, that the above approaches were not solely designed to model L2 processing. Instead they also touch upon issues dealt with in other chapters of this volume, such as automatization, memory, and attention. Nevertheless, it should be noted that this chapter will focus as far as possible on the architecture of the language processor and its impact on second language development. Other issues will therefore be mentioned only in passing.

2.1 *Input processing*

One early approach to SLA that incorporates, amongst other things, a processing perspective is Krashen's (1985) monitor model. This work received a great amount of attention in the 1980s and has been subjected to extensive critiques (e.g., Gregg, 1984; Long, 1985; McLaughlin, 1978, 1987).

In his Input Hypothesis, Krashen claims that: "humans acquire language in only one way – by understanding messages, or by receiving 'comprehensible input' . . . We move from *i*, our current level, to *i+1*, the next level along the natural order, by understanding input containing *i+1*" (Krashen, 1985, p. 2). As this quotation illustrates, the Input Hypothesis is aimed at explaining two things, namely (i) the inferential mechanisms that drive the acquisition process, and (ii) the assumed universal order of acquisition. It has been pointed out in the above-mentioned critiques that the Input Hypothesis cannot be operationalized for any of its components. As a result, it cannot be tested empirically. How are *i* and *i+1* defined? What is the exact process by which the learner incorporates *i+1* into his or her interlanguage system? And what is the relationship between linguistic input and the representation of L2 knowledge? In other words, Krashen's model evades the issue of specifying the architecture of the L2 processor and the inferential mechanisms involved. As research of the past two decades has shown, these turned out to be monumental tasks.

VanPatten's (1996) work is an example of later mainstream research on input processing. VanPatten follows the main idea of the Input Hypothesis and stipulates two sets of input-processing strategies in an attempt to spell out aspects of the architecture of the L2 processor. The first set consists of five cognitive strategies that are supposed to regulate which aspects of the linguistic input are attended to and processed first (VanPatten, 1996, p. 14f). The second set consists of three Bever-style (Bever, 1970) strategies for the assignment of grammatical and semantic roles to nouns (VanPatten, 1996, p. 32). VanPatten follows Corder (1967) in distinguishing between "input" and "intake" and stipulates attention as the necessary condition for input to be transformed into intake. In his model the first set of strategies is intended to operationalize "attention," and the second, aspects of "sentence processing." However, these processing strategies are limited to one narrow domain of language processing and are subject to the same conceptual limitations as Clahsen's (1984) strategies approach, which will be summarized at the end of this section.

Carroll (1999, 2000) reviews the literature on L2 input processing and concludes that the standard assumption, based on Corder's (1967) input–intake distinction, according to which "perception is regulated only by attention, which in turn is regulated by intention" (Carroll, 1999, p. 343), is not supported by any explicit theory of attention. Her own view on the matter contrasts sharply with the attention-filter assumption. Carroll seeks to demonstrate that signal detection is regulated by human knowledge systems independently of intention and concludes that: "[i]nput is . . . determined by our grammars" (Carroll, 1999, p. 343). Carroll (1999, 2000) proposes the Autonomous Induction Theory, which is an explicit theoretical framework for the induction of linguistic representation from linguistic input. In this induction process, Carroll distinguishes between the input to speech processing and the input to language-learning mechanisms. This position is compatible with a modular view of processing and a UG-position on cognition, and is thus juxtaposed to the functionalist orientation of the standard view on the attention filter in processing. Irrespective of one's theoretical inclination, this work highlights the enormity of the task of specifying the inferential mechanisms that explain how input becomes intake. In other words, Carroll's work focuses on the inferential mechanisms and is not designed as a contribution to specifying the architecture of the L2 processor.

This brief summary of trends in theory on L2 input processing also illustrates that work in this area involves a large number of factors in addition to language-processing capacity, which is the focus of this chapter.

2.2 *Procedural skills*

Reference to language-processing capacity is also made in research on the acquisition of L2 procedural skills. From their cognitive perspective, McLaughlin and his associates (McLaughlin, 1987; McLaughlin, Rossman, and McLeod, 1983) assume that "[t]o learn a second language is to learn a *skill*" (McLaughlin, 1987, p. 133) and that L2 learning "requires the automatization of component sub-skills" (McLaughlin, 1987, p. 133). Similarly, other authors have also expressed the view that language acquisition entails the acquisition of procedural skills (e.g., Hulstijn, 1990; Levelt, 1978; Schmidt, 1992). In line with his cognitive perspective, McLaughlin views humans as limited-capacity processors for controlled processes. He assumes that L2 processing skills become more efficient through automatization, which allows them to be processed automatically and thus without the limitation of controlled processes. He concludes that "[t]he notion of a capacity-free (automatic) process provides an explanation for improvement in performance" (McLaughlin, 1987, p. 136).

McLaughlin's work is not directly concerned with language-processing procedures. Instead it focuses on two key notions: *automaticity* and *restructuring*. Automaticity makes recourse to the dichotomy of *controlled* and *automatic processing* (Posner and Snyder, 1975; Schneider and Shiffrin, 1977; Shiffrin and Schneider, 1977). Restructuring refers to the replacement of existing procedures by more efficient ones. McLaughlin believes that "once the procedures at any phase become automatized . . . learners step up to a 'metaprocedural' level, which generates representational change and restructuring" (McLaughlin, 1987, p. 138). In other words, McLaughlin's approach is aimed at the skills that underlie L2 processing, as well as at the acquisition of these skills. And automatization is seen as the process by which the overall L2 processing capacity can be increased. As far as the explicitness of his approach and of cognitive theory generally is concerned, McLaughlin makes the following cautious statement: "Cognitive theory does not represent a highly articulated theoretical position. There have been relatively few attempts to spell out with any degree of precision what the predictions of such a theory would be for second language learning" (McLaughlin, 1987, p. 150).

2.3 *Operating principles*

Andersen (1984, 1988) based his approach to SLA on a different set of assumptions. Following the basic design of Slobin's (1973, 1985) approach to L1 acquisition, he proposed a set of "operating principles" for SLA which concern two aspects of the acquisition process: the processing of language and the discovery of its formal and functional properties. In other words, Andersen's approach goes beyond language processing and incorporates learning mechanisms. An example is the "one-to-one principle," which states that "[a]n interlanguage system should be constructed in such a way that an intended underlying meaning is expressed with one clear invariant surface form" (Andersen, 1984, p. 79).

Andersen's and Slobin's approaches have been criticized for being difficult to test, because the operating principles are not clearly separated from each other (e.g., Larsen-Freeman, 1975); instead, they compete with one another. This leads to typical post-factual explanations. If an IL phenomenon cannot be attributed to principle A, then it can be attributed to a competing principle B. Bowerman (1985) points out that operating principles are not falsifiable, because evidence against existing principles can be countered by the introduction of ever new principles. The reason why operating principles are not testable is because they do not contain procedural information to implement the micro-structure of language processing. For instance, to make Slobin's (1973) operating principle "Be semantically expressive" productive for the speaker, one needs to specify the exact procedures required to generate the surface structures which best express the semantic structures intended by the speaker. In sum, operating principles lack linguistic or procedural explicitness.

2.4 *The competition model*

The competition model (Bates and MacWhinney, 1981, 1982, 1987) is a further approach to language acquisition that assumes limited processing resources in L2 learners. It is a functionalist approach that is based on the assumption that linguistic behavior is constrained, among other things, by general cognition (and not by a language-specific cognitive module) and communicative needs. Following the functionalist tradition, Bates and MacWhinney assume that "the surface conventions of natural languages are created, governed, constrained, acquired, and used in the service of communicative functions" (Bates and MacWhinney, 1981, p. 192).

As the above quotation indicates, the competition model is claimed to be applicable to child language, language processing in general, and second language acquisition. According to this model, it is the task of the language learner to discover the specific relationship between the linguistic forms of a given language and their communicative functions. The linguistic forms used to mark grammatical and semantic roles differ from language to language. For instance, agreement marking, word order, and animacy play a different role in the marking of subject-hood and agency in different languages. Linguistic forms are seen as "cues" for semantic interpretation in on-line comprehension and production, and different cues may compete, as in the above case of the marking of subject-hood. Hence, the name: competition model.

In the competition model, the process of learning linguistic forms is driven by the frequency and complexity of form–function relationships in the input. In this context, the majority of L2 learning problems is modeled in connectionist terms. MacWhinney (1987) exemplifies this with the pre-verbal positioning of a linguistic form as a (processing) cue for the semantic actor-role. He states that the strength of this cue "can be viewed as the weight on the connection between the preverbal positioning node (an input node) and the actor role (an output node). If the preverbal positioning node is activated, it then sends activation to the actor node in proportion to the weight on the connection" (MacWhinney, 1987, p. 320).

The competition model has formed the conceptual basis of experiments on bilingual sentence processing (e.g., Gass, 1987; Harrington, 1987; Kilborn and Ito, 1989; McDonald and Heilenman, 1991; Sasaki, 1991). In these studies, bilingual speakers of different languages have to identify the function of different "cues" in L1 and L2. Input material is designed to reflect the co-ordination and competition of cues. For instance, Harrington (1987) studies the (competing) effect of word order, animacy, and stress on the comprehension of Japanese and English sentences by native speakers and non-native speakers of the two languages who are all speakers of both languages. Obviously, the three cues have different weights in the two target languages concerned. The results show that L2 learners transfer their L1 processing strategies (i.e., weighting of cues) when interpreting L2 sentences. This overall result is predicted by the competition model, since within this framework, processing cues are not initially separated by languages and their weighting can therefore be predicted to be transferred. However, the above studies also produced a host of effects that are not predicted by the model or that cannot even be captured by it. Aside from the limitations of the connectionist framework (cf. Pinker and Prince, 1987), which MacWhinney (1987) recognizes, the competition model can presently offer only fragments of the architecture of the language processor.

2.5 Processing strategies

The use of processing strategies in Clahsen's (1984) approach yielded a considerable number of testable hypotheses. It therefore warrants a somewhat more explicit summary and critique. Clahsen's (1984) "strategies" approach was designed to explain the stages in the acquisition of German L2 word order found in the ZISA study (Clahsen, Meisel, and Pienemann, 1983):

x	Canonical order	SVO
x + 1	Adverb preposing (ADV)	adv SVO
x + 2	Verb separation (SEP)	X SVOV
x + 3	Inversion (INV)	X VSY
x + 4	Verb final (V-END)	comp SOV

Clahsen (1984) assumed a set of speech-processing strategies which constrain the otherwise overly powerful grammar of the learner. These strategies are stated below:

i *Canonical Order Strategy (COS)*: "In underlying sequences [x1 + x2 . . . Xn] Cx [ ] Cx + 1 [ ] Cx + m, in which each of the subconstituents contributes information to the internal structure of the constituent Cx, no subconstituent is moved out of Cx, and no material from the subsequent constituents Cx + 1, Cx + 2, Cx + n is moved into Cx."

ii *Initialization-Finalization Strategy (IFS)*: "In underlying sequences, [X Y Z]s permutations are blocked which move X between Y and Z or Z between X and Y."

iii *Subordinate Clause Strategy (SCS)*: "In subordinate clauses permutations are avoided." (Clahsen, 1984, pp. 219–42)

This work was originally carried out in the late 1970s (Clahsen, 1979). Clahsen based these strategies on research into speech processing and language acquisition. COS was based on Bever's (1970) experiments on comprehension. IFS was based on findings from memory research, and SCS on the finding that subordinate clauses are processed in a different mode than main clauses. Table 20.1 shows schematically how the above strategies account for the observed order of acquisition.

In principle, the above strategies are understood as heuristic principles which allow the learner to short cut the comprehension-production process. For instance, the COS, which is based on Bever's (1970) postulation of an NVN strategy, permits direct mapping of semantic structure onto syntactic forms. In the psycholinguistic discussion of the 1970s, Bever-style strategies were conceptualized as "performance short cuts" of the derivational process. This view

Table 20.1 Processing stages and acquisition order

Stage	*Rule*	*Strategies*		
x	Canonical order		+COS	+SCS
x + 1	Adverb preposing	+IFS	+COS	+SCS
x + 2	Verb separation	+IFS	−COS	+SCS
x + 3	Inversion	–IFS	−COS	+SCS
x + 4	Verb final	–IFS	−COS	–SCS

reconciled two seemingly opposed sets of facts, namely (i) the validity of the transformational theory of the time as a property theory, and (ii) its lack of psychological plausibility. Clahsen (1984) related these strategies to the concept of *psychological complexity*. Following research into sentence comprehension, he assumed that the psychological complexity of a structure is dependent on the degree of *reordering and rearrangement* of linguistic material involved in the process of mapping underlying semantics onto surface forms. From this perspective, he viewed the acquisition process as a process of *constraint shedding*.[1]

Given that Clahsen's approach was based on psycholinguistic concepts which were developed in the 1970s, it is not surprising that his perspective is at odds with more recent research. Quite naturally, scholars pointed out the shortcomings of this approach, with the following criticisms being made:

- The status of grammar in language acquisition remains unclear (e.g., Towell and Hawkins, 1994). Generally speaking, interlanguage grammars are underdetermined by the strategies available to the learner at any given stage of acquisition. Put another way, the learner does not have sufficient information to go on for the construction of interlanguage speech on the basis of strategies alone. Strategies can only operate as complements to a grammar, not as grammar substitutes.
- Processing strategies are based on comprehension-related phenomena and formulated through the interpretation of empirical findings on comprehension, although it is clear that comprehension and production are not mirror images of one another (White, 1989, 1991). The NVN strategy (Bever, 1970), in particular, accounts for observational facts in speech comprehension.
- Strategies are stated in such a way that they are constraints on movement transformations as conceptualized in TG. This has a rather important side effect: the strategies approach is set up to prevent the movement of "materialized" sub-constituents across the boundaries of major constituents. This view automatically limits the strategies approach to the domain of word order.
- A final problem with the strategies approach is its relation to learnability and extendibility (e.g., Pinker, 1984). I pointed out above that the strategies

> in Clahsen's framework are not sufficient prerequisites for the learnability of the structures in question. At the same time, they serve to predict the order of complexity once the structures are described with recourse to an additional paradigm, namely, aspects of a grammatical formalism. Only in this latter sense is the processing approach predictive.

In the final analysis, the strategies approach proves to lack the degree of procedural explicitness required to integrate it into a theory of SLA, even though the approach does produce falsifiable hypotheses and withstood a fair number of empirical tests.

To sum up, the processing-oriented approaches reviewed above (with the exception of Clahsen's) are not focused solely on L2 processing and its effect on L2 development. Instead, L2 processing is studied as one of several interacting factors that contribute to L2 acquisition. In other words, those approaches are aimed at explaining more than developmental trajectories. For instance, most of them also include the inferential process as an explanandum. And more than one explanatory component is used to account for the explananda. The wide scope of these approaches comes at the cost of explicitness. Since I view procedural explicitness as a necessary prerequisite for the operationalizibility of an approach to L2 processing capacity, the remainder of this chapter will focus on a modular processing approach to SLA that aims at procedural explicitness, namely processability theory (Pienemann, 1998a).

3 Processability Theory

3.1 Step 1: A hierarchy of processing procedures

The logic underlying processability theory (PT) is the following: at any stage of development, the learner can produce and comprehend only those L2 linguistic forms which the current state of the language processor can manage. It is, therefore, crucial to understand the architecture of the language processor and the way in which it handles a second language. This enables one to predict the course of development of L2 linguistic forms in language production and comprehension across languages.

The architecture of the language processor (e.g., Levelt's, 1989, model) accounts for language processing in real time and within human psychological constraints, such as word access and human memory. The incorporation of the language processor into the study of second language acquisition, therefore, brings to bear a set of human psychological constraints that are crucial for the processing of languages. PT (Pienemann, 1998a), which is based on Levelt's (1989) skill-based approach to language production and Bresnan's (1982) lexical-functional grammar, was designed to overcome the limitations of the strategies approach by which it was originally inspired:

- *The role of grammar*: Rather than assuming a set of strategies which operate on grammar, processes which create complexity are identified and implemented into a theory of grammar that is closely related to a psychologically plausible performance grammar.
- *Restriction to movement*: This limitation of the strategies approach was due to the choice of grammatical theory, namely transformational grammar. In PT, processing factors are integrated into lexical-functional grammar, a grammatical theory which is based on the systematic utilization of a psychologically plausible operation: feature unification. This process has implications for syntax and morphology.
- *Comprehension and production*: Processing strategies were conceptualized as short cuts within a full derivational process of TG. The features of language processing utilized in PT are far more general in nature. They are related to the linearity of speech production and the exchange of grammatical information.

PT is based on a universal hierarchy of processing procedures, which is derived from the general architecture of the language processor. This hierarchy is related to the requirements of the specific procedural skills needed for the TL. In this way, predictions can be made for language development which can be tested empirically.

The view of language production followed in PT is largely that described by Levelt (1989), which overlaps to some extent with the computational model of Kempen and Hoenkamp (1987), which in turn emulates much of Merrill Garrett's work (e.g., Garrett, 1976, 1980, 1982), on which the corresponding section of Levelt's model is based. The basic premises of that view are the following.

i Processing components, such as procedures to build NPs, are relatively autonomous specialists which operate largely automatically. Levelt (1989) describes such grammatical procedures as "stupid," because their capacity is strictly limited to the very narrow but highly efficient handling of extremely specific processing tasks (e.g., NP-procedures, VP-procedures, etc.). The automaticity of these procedures implies that their execution is not normally subject to conscious control.

ii Processing is incremental. This means that surface lexicogrammatical form is gradually constructed while conceptualization is still on-going. A key implication of incremental language processing is the need for grammatical memory. For the next processor to be able to work on still-incomplete output of the current processor and for all of this to result in coherent surface forms, some of the incomplete intermediate output has to be held in memory.

iii The output of the processor is linear, even though it may not be mapped onto the underlying meaning in a linear way. This is known as the "linearization problem" (Levelt, 1981), which applies to the mapping of conceptual structure onto linguistic form, as well as to the generation of morphosyntactic structures. One example is subject–verb agreement, as illustrated in the sentence "*She gives him a book.*" The affixation of the agreement marker to the verb depends, amongst other things, on the storage of information about the grammatical subject (namely number and person), which is created before the verb is retrieved from the lexicon.

iv Grammatical processing has access to a grammatical memory store. The need for a grammatical memory store derives from the linearization problem and the automatic and incremental nature of language generation. Levelt (1989) assumes that grammatical information is held temporarily in a grammatical memory store which is highly task-specific and in which specialized grammatical processors can deposit information of a specific nature (e.g., the value of diacritic features). In Kempen and Hoenkamp's (1987) Incremental Procedural Grammar, the locus of the grammatical buffer is the specialized procedures which process NPs, VPs, etc. Pienemann (1998a) presents evidence from on-line experiments and aphasia research in support of these assumptions (e.g., Cooper and Zurif, 1983; Engelkamp, 1974; Paradis, 1994; Zurif, Swinney, Prater, and Love, 1994).

The process of incremental language generation as envisaged by Levelt (1989) and Kempen and Hoenkamp (1987) is exemplified in figure 20.1, which illustrates some of the key processes involved in the generation of the example sentence "*A child gives a cat to the mother*." The concepts underlying this sentence are produced in the Conceptualizer.

The conceptual material produced first activates the lemma CHILD in the lexicon. The lemma contains the category information N, which calls the categorial procedure NP. This procedure can build the phrasal category in which N is head, that is, NP. The categorial procedure inspects the conceptual material of the current iteration (the material currently being processed) for possible complements and specifiers and provides values for diacritic features. Given certain conceptual specifications, the lemma "A" is activated and the NP-procedure attaches the branch Det to NP. During this process the diacritic parameters of Det and N are checked against each other. This implies that the grammatical information "singular" is extracted from each of the two lemmas at the time of their activation and is then stored in NP until the head of the phrase is produced. This process of exchange of grammatical information is a key feature of language production. Below, we will see that in LFG it can be modeled by feature unification.

The production process has now proceeded to the point where the structure of a phrase has been created and the associated lemmata are activated. What is still needed to make this the beginning of a continuous and fluent utterance is the establishment of a relation between the phrase and the rest of the intended message. This is accomplished by assigning a grammatical function to the newly created phrase. The outcome of all of this is depicted by a tree structure in figure 20.1. And while this structure was produced and the associated lemmata were activated, the next conceptual fragment would have been processed in parallel and the output of the Formulator would have been delivered

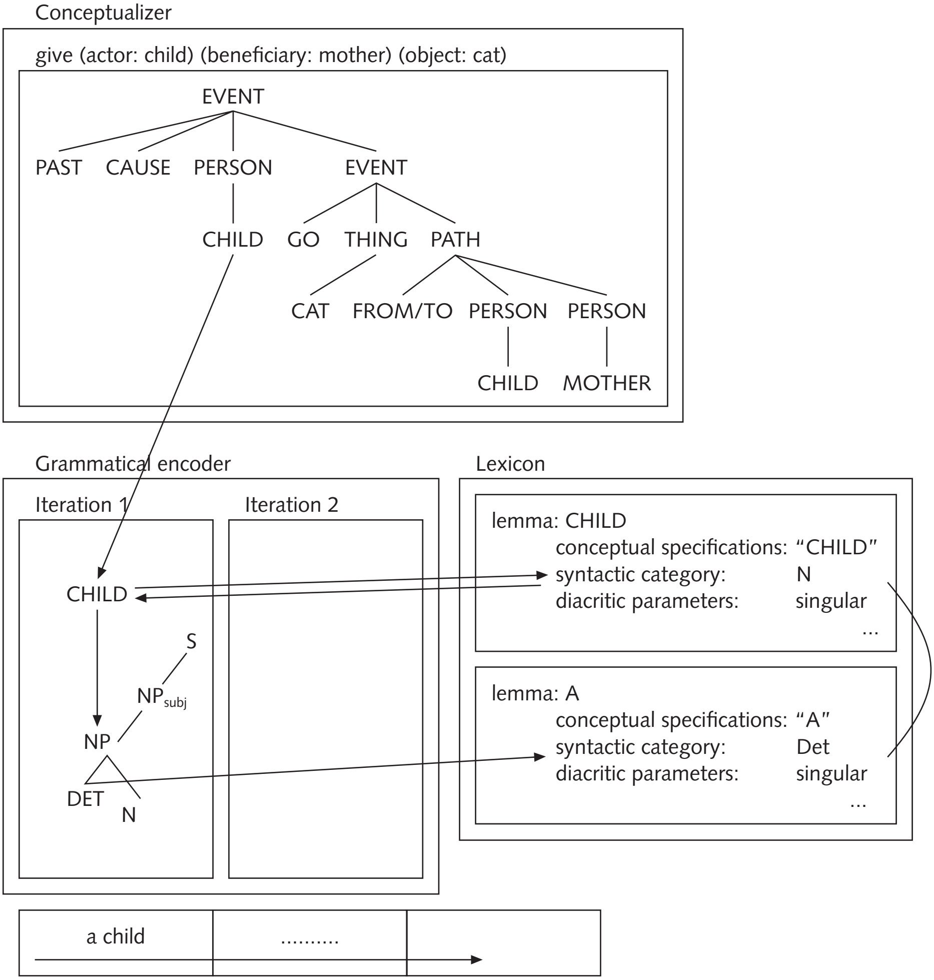

Figure 20.1 Incremental language generation

to the Articulator. This means that new conceptualization occurs while the conceptual structure of the previous iteration is being produced. The whole process then moves on from iteration to iteration.

In the process of incremental language generation the following processing procedures and routines are activated in the sequence indicated:

i lemma access;
ii the category procedure;
iii the phrasal procedure;
iv the S-procedure;
v the subordinate clause procedure, if applicable.

Pienemann (1998a) hypothesizes that this set of key grammatical encoding procedures is arranged according to the items' sequence of activation in the language generation process, and this sequence follows an implicational pattern in which each procedure is a necessary prerequisite for the following procedures. The basic thesis of PT is that in the acquisition of language-processing procedures, the assembly of the component parts will follow the above-mentioned implicational sequence. The key to predicting processable grammars is which pieces of grammatical information can be exchanged between which constituents, given the availability of the different procedures and their storage capacity.

It is important to note that the above processing procedures are operational only in mature users of a language, not in language learners. While even beginning second language learners can make recourse to the same *general* cognitive resources as mature native language users, they have to create language-specific processing routines. In this context, it is important to ensure that Levelt's model (and Kempen and Hoenkamp's specific section of it) can, in principle, account for language processing in bilinguals, since second language acquisition will lead to a bilingual language processor.

De Bot (1992) adapted Levelt's model to language production in bilinguals. On the basis of work by Paradis (1987), he shows that information about the specific language to be used is present in each part of the pre-verbal message, and this subsequently informs the selection of language-specific lexical items and of language-specific routines in the Formulator. The key assumption of De Bot's work for L2 processing is that in all cases where the L2 is not closely related to the L1, different (language-specific) procedures have to be assumed. Therefore, most of the above processing procedures have to be acquired by the L2 learner. The differences in the lexical prerequisites for language processing are obvious in diacritic features, such as "tense," "number," "gender," and "case," which vary between languages.

What happens when an element is missing in this implicational hierarchy? Pienemann (1998a) hypothesizes that the hierarchy will be cut off in the learner grammar at the point of the missing processing procedure, and the rest of the hierarchy will be replaced by a direct mapping of conceptual structures onto surface form, as long as there are lemmata that match the conceptually instigated searches of the lexicon. In other words, it is hypothesized that processing procedures and the capacity for the exchange of grammatical information will be acquired in their implicational sequence, as depicted in table 20.2.

If the hierarchy in table 20.2 is to be universally applicable to language acquisition, it needs to be interpretable in relation to grammatical structures of individual languages. This is achieved by interpreting the processability hierarchy through a theory of grammar which is typologically and psychologically plausible. The theory of grammar used for this purpose in PT is LFG. The reason for that choice is that every level of the hierarchy of processing procedures can be captured through feature unification in LFG, which also shares three key features with Kempen and Hoenkamp's procedural account of language generation, namely (i) the assumption that grammars are lexically driven, (ii)

Table 20.2 Hypothetical hierarchy of processing procedures

Procedure	*t1*	*t2*	*t3*	*t4*	*t5*
S′ (embedded S)	–	–	–	–	+
S	–	Simplified	Simplified	Inter-phrasal information	Inter-phrasal information
Phrasal	–	–	Phrasal information	Phrasal information	Phrasal information
Category	–	Lexical morphemes	Lexical morphemes	Lexical morphemes	Lexical morphemes
Word/lemma	+	+	+	+	+

the functional annotations of phrases (e.g., "subject of"), and (iii) reliance on lexical feature unification as a key process in sentence generation. In other words, an LFG description of the structure to be learned affords an analysis of the psycholinguistic process of grammatical information exchange, and the latter is the key component of the processability hierarchy.

3.1.1 A brief sketch of LFG

Before I demonstrate how the processability hierarchy is implemented into an LFG-based description of a target language (and the developing interlanguage), I will give a brief outline of lexical-functional grammar. LFG is a unification grammar, the most prominent characteristic of which is the unification of features. Put simply, the process of feature unification ensures that the different parts that constitute a sentence do actually fit together.

LFG consists of three parts: (i) a constituent structure (c-structure) component that generates "surface structure" constituents and c-structure relationships; (ii) a lexicon, whose entries contain syntactic and other information relevant to the generation of sentences; and (iii) a functional component which compiles for every sentence all the grammatical information needed to interpret the sentence semantically.

All c-structures are generated directly by phrase structure rules without any intervening transformations. Hence the mapping of predicate–argument structures onto surface forms is achieved without any intervening levels of representation. Grammatical functions assume the role of grammatical primitives, and major constituents are annotated for their grammatical function. The c-structure of the sentence "Peter owns a dog," for instance is shown in figure 20.2, which can be generated by the annotated phrase structure rules shown in figure 20.3. A simplified account of the lexical entries relating to figure 20.2 is given in table 20.3.

As is obvious from these simplified examples, lexical entries specify a number of syntactic and other properties of lexical items by assigning values to features (e.g., NUM = SG). In most cases, such equations *define* the value of

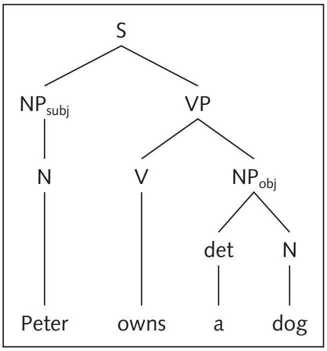

Figure 20.2 Example of a constituent structure

S	⟶	$NP_{subj}VP$
NP	⟶	(det) N
VP	⟶	V (NP_{obj})

Figure 20.3 C-structure rules

Table 20.3 Lexical entries

Peter:	N,	PRED	=	"Peter"
owns:	V,	PRED	=	"own" (SUBJ, OBJ)
		TENSE	=	present
		SUBJ PERSON	=	3
		SUBJ NUM	=	SG
a:	DET,	SPEC	=	"a"
		NUM	=	SG
dog:	N,	PRED	=	"dog"
		NUM	=	SG

features. In some cases they may also "demand" certain values elsewhere in the functional description of a sentence. One example for such a constraining equation would be:

$WH =_c +$

This equation stipulates that the phrase to which it is attached must be a *wh*-word.

The functional structure or "f-structure" of a sentence is a list of those pieces of grammatical information needed to semantically interpret the sentence. It

Table 20.4 Functional structure

PRED	"own" (SUBJ, OBJ)	
TENSE	present	
SUBJ	PRED	"Peter"
OBJ	SPEC	"a"
	NUM	SG
	PRED	"dog"

is generated by the interaction between c-structure and the lexicon. The f-structure of the sentence in figure 20.2 is given in table 20.4.

The predicate entry [PRED "own" (SUBJ, OBJ)] is taken from the lexical entry of the verb. Listing the stem of the verb in quotation marks ("own") is simply a shorthand convention for a semantic representation of the word. The slots to the right of the verb, which are filled by SUBJ and OBJ in table 20.4, list the arguments of the predicate: first the *owner*, then the *item owned*. The PRED entry of the f-structure, therefore, makes it possible to relate the different constituents to the "players" described by the sentence (actor, patient, etc.). This forms the link between the syntactic form and its underlying predicate–argument relations.

3.2 *Step 2: Implementing a processing hierarchy into LFG*

The implementation of the processability hierarchy into an LFG-based description of a given language affords us a prediction of the stages in which the language can develop in L2 learners. The main point of the implementation is to demonstrate the flow of grammatical information in the production of linguistic structures. I will demonstrate this with the example of three English morphological rules.

In LFG, the morphological component operates on the basis of a functional description of the sentence. The following sentence may illustrate this:

A man owns many dogs.

Note that lexical entries contain schemas which are relevant here. These are listed in table 20.5.

The well-formedness of sentences is guaranteed, amongst other things, by ensuring that functional descriptions of the sentence and lexical entries match; for example, the phrase "a man" is functionally well-formed because, amongst other things, the value for NUM is "SG" in the subsidiary function NUM = SG under SUBJ, as well as in the lexical entry for "man." In the same way, "many dogs" is well-formed because of a match of the feature "NUM."

The actual structure of the morphological component is not crucial to the present line of argument. The central point here is that morphological processes

Table 20.5 Lexical entries for 'A man owns many dogs'

a:	DET,	SPEC	=	"A"
		NUM	=	SG
man:	N,	PRED	=	"MAN"
		NUM	=	SG
		PERS	=	3
owns:	V,	PRED	=	"OWN" (SUBJ) (OBJ)
		SUBJ NUM	=	SG
		SUBJ PERS	=	3
		TENSE	=	PRESENT
many:	DET,	SPEC	=	"MANY"
		NUM	=	PL
dogs:	N,	PRED	=	"DOG"
		NUM	=	PL

are informed by feature unification. One can now see that the unification of the NUM value in noun phrases is an operation which is restricted entirely to the NP. In PT this type of affixation is called *phrasal* because it occurs inside phrase boundaries (cf. Pienemann, 1998a). An example of a *lexical* morpheme is regular English tense marking (V+ "-ed"), the information for which can be read off the lexical entry of the verb, as can be seen in figure 20.1 above.

Subject–verb agreement, in contrast, involves the matching of features in two distinct constituents, namely NP_{subj} and VP. The insertion of the -s affix for subject-verb agreement marking requires the following syntactic information:

S-V affix	TENSE	=	present
	SUBJ NUMBER	=	sg
	SUBJ PERSON	=	3

While the value of the first two equations is read off the functional description of sentences as illustrated above, the values for NUMBER and PERSON must be identical in the f-structure of SUBJ and the lexical entry of V. Hence, this information has to be matched across constituent boundaries from inside both constituents. One may informally describe this process as follows:

[A man]$_{NP_{subj}}$			[{holds} . . .]$_{VP}$ (Present, imperfective)		
PERSON	=	3	PERSON	=	3
NUM	=	sg	NUM	=	sg

From a processing point of view, the two morphological processes, plural agreement in NP_{subj} and SV-agreement, have a different status. While the first occurs exclusively inside one major constituent, the second requires that

Table 20.6 Processing procedures applied to English

Processing procedure	*L2 process*	*Morphology*	*Syntax*
5 Subordinate clause procedure	Main and subordinate clause		Cancel INV
4 S-procedure	Interphrasal information	*SV agreement* (= 3sg-s)	Do2nd, INVERSION
3 Phrasal procedure	Phrasal information	*NP agreement*	ADV, Do-Front, Topi Neg+V
2 Category procedure	Lexical morpheme	*plural*, *past -ed*, possessive pronoun	Canonical order
1 Word/lemma	"Words"	Invariant forms	Single constituent

grammatical information be exchanged across constituent boundaries. This type of morphological process is referred to as *interphrasal affixation*.

We are now in a position to locate three English morphological phenomena within the hierarchy of processability. These structures have been highlighted in table 20.6. The table also lists a range of further structures and their position within the hierarchy. However, due to limited space, a full exposition of ESL development within PT will not be possible here.

The predicted ESL sequence is supported by Johnston's (1985) cross-sectional study of 16 Polish and Vietnamese learners of English, which includes 12 of the grammatical rules contained in the ESL table. Johnston's data result in an implicational table with 100 percent scalability. Additional evidence is provided by a cross-sectional study of 13 child ESL learners (Pienemann and Mackey, 1993), which includes 14 of the structures from the ESL table and also results in an implicational table with 100 percent scalability. The ESL scale also contains several items that relate to interrogatives. The developmental sequence of interrogatives implicit in the ESL scale is fully supported by a longitudinal study by Cazden, Cancino, Rosansky, and Schumann (1975) of six Spanish ESL learners (cf. also Ravem, 1974) and by a longitudinal study of child ESL by Felix (1982).

4 Cross-Linguistic Predictions for Development

If the processing factors employed in the approach described above are to be generic for human languages (as L2s), then they have to apply cross-linguistically. In addition, an empirical test of factors determining the acquisition process will have a higher degree of validity if it is performed not in terms of general trends (e.g., "more of X co-occurs with more of Y"), but specifically at the level of identifiable linguistic forms ("prerequisite A can process structures X, Y, and Z, but not structures U or V"). This ensures that the theory to be tested is conceptually refined to the point where such specific predictions can be made.

PT has been tested against an array of data at this precise level of detail, with English, Swedish, German, and Japanese as target languages. The first step in such a test is to relate a set of target-language linguistic structures to the general hierarchy of processability and, more specifically, to the exchange of grammatical information involved in producing those structures. The outcome of the process is a language-specific prediction for the sequence in which these structures will be acquired. In a second step, the hypothesized sequence is compared with empirical data from the acquisition of the given language. It may be useful to illustrate these two steps with examples from Japanese, the language of the group of four tested with the greatest typological distance from German and English, and for which PT was originally conceptualized. For reasons of space, I will restrict this exercise to the identification of phrasal and lexical morphemes in Japanese.

Japanese is a morphologically rich, agglutinative language. According to Shibatani (1990, p. 306f), verbal affixes usually occur in the following order:

Vstem – causative – passive – aspect – desiderative – negation – tense.

This is exemplified by several morphological forms of *kak-u* ('write') in (1) to (4):[2]

(1) kak-areru (passive)
stem-(passive)

(2) kak-aseru (causative)
stem-(causative)

(3) kak-aser-areru (causative-passive)
stem-(causative)-(passive)

(4) kak-aser-are-tai (causative-passive-desiderative)
stem-(causative)-(passive)-(desiderative)

In other words, one morpheme usually expresses one function. However, because of a large set of morphological classes and morphophonological variation (compare examples (3) and (4) for the form of the passive morpheme), complex form–function relationships create learning problems of a different kind.

Most or all of the verbal morphemes listed above (expressing causative, passive, aspect, desiderative, negation, and tense) can be derived directly from conceptual structure. In other words, the only processing requirement for the insertion of these morphemes is that the formal lexical class "verb" is so marked in the lexicon. These morphemes are therefore lexical. However, information distribution is crucial in the verbal system when more than one verb occurs. In this case, Japanese is no different from European languages, in that only one of the verbs can be finite. One can see this in examples (5) and (6), where the penultimate verb is marked with the -te morpheme, which is a marker of non-finiteness and seriality: *shi-te mi-ta* [do-(serial) try (-past)] in (5) and *tabe-te iru* [eat (serial) (progressive)] in (6). The verb marked '*-te*' appears in penultimate position and cannot be marked for any of the features causative, passive, aspect, desiderative, negation, or tense. To achieve this, the two verbs have to exchange the information INF = + in the encoding process. The entry for the verb 'shi-te' in (5) contains, amongst other things, the following information:

shi-te: V, PRED = 'shi-te (SUBJ) (OBJ)'
INF = +

The entry for the verb 'mi-tä' contains the following information:

mi-tä: V, PRED = 'mitä, V-COMP (SUBJ)'
V-COMP INF $=_c$ +

Because the information INF = + has to be exchanged between the two verbs, -te is a phrasal morpheme:

(5) *Tomoko ga* *Kimiko ni* *denwa* *o* *shi-te*
(name) (subj-part.) (name) (indir.obj part.) telephone (obj-part.) do-(serial)
mi-ta
try (-past)
"Tomoko tried to give Kimiko a ring."

(6) *Tomoko ga* *gohan o* *tabe-te* *iru.*
(name) (subj-part.) rice (obj part.) eat (serial) (progressive)
"Tomoko is eating rice."

In this very brief discussion, two types of morphemes have been identified in Japanese according to the exchange of grammatical information required for their production. This is summarized in table 20.7.

This predicted sequence was confirmed in two empirical studies (Huter, 1998; Kawaguchi, 1996), the key findings of which are shown in tables 20.8 and 20.9.

Given that English, German, and Swedish are all Germanic languages, it is much easier to transfer the analysis of morphosyntax within the processability framework from one of these languages to the others. For instance, all three

Table 20.7 Japanese as L2

Processing procedure	*L2 process*	*Morphology*
3 Phrasal procedure	Phrasal information	V-te V
2 Category procedure	Lexical morpheme	V_{aff}
1 Word/lemma	"Words"	Invariant forms

Table 20.8 Kawaguchi's (1996) study

Affix	*Meg*	*Kat*	*Sim*	*Iri*	*Sam*	*Nat*	*Hel*
No affix	/	/	/	/	/	/	/
Lexical affix	+	+	+	+	+	+	+
Phrasal affix	–	–	–	+	+	+	+

Table 20.9 Huter's (1998) study

Affix	*M1*	*K1*	*K2*	*K3*	*M2*	*M3*	*M4*	*K4*	*K5*	*J1*	*J2*	*J3*	*J4*	*J5*
No affix	/	/	/	/	/	/	/	/	/	/	/	/	/	/
Lexical affix	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Phrasal affix	–	–	–	–	–	–	–	–	–	–	–	–	+	+

languages display some form of subject–verb inversion. INVERSION is indeed positioned at the same level of processability for each of these languages, and the exchange of grammatical information involved in the production of inversion structures is in fact very similar to the above account for the English language. Also, all three languages differentiate syntactically between main and subordinate clauses. One way in which this manifests itself is that INVERSION is blocked in subordinate clauses. Again, this syntactic feature is positioned at the same level of processability across the three languages.

A number of examples of English lexical, phrasal, and interphrasal morphemes was given above. Tables 20.10 and 20.11 list further examples for Swedish and German. In each case, the identification of the level of processing depends on the type of exchange of grammatical information. It is worth noting that despite some structural similarities between German, Swedish, and English syntax, most morphological regularities do not overlap. Pienemann (1998a) analyzed the exchange of grammatical information involved in each of the morphological and syntactic structures of English, German, and Swedish shown in tables 20.6, 20.10, and 20.11 and identified the corresponding level of processability in this way.

Table 20.10 German as L2

Processing procedures	*L2 process*	*Syntax*	*Morphology*
6 Subordinate clause procedure	Main and subordinate clause	V-End	
5 S-procedure	Interphrasal information	INV	SV-agreement
4 VP-procedure	Phrasal information VP	SEP	
3 Phrasal procedure	Phrasal information NP	ADV	Plural agreement
2 None	Lexical morphemes	Canonical order	Past-te, etc.
1 Word/lemma	"Words"	Single constituent	Invariant forms

Table 20.11 Swedish as L2

Processing procedures	*L2 structure*	*Morphology*	*Syntax*	*Negation*
5 Subordinate clause procedure	Main and subordinate clause		Cancel INV	neg V_f
4 S-procedure	Interphrasal information	Predicate agreement	INV	X V_f NP_s neg
3 Phrasal procedure	Phrasal information	NP agr VPagr	ADV WH fronting	V_f neg
2 Category procedure	Lexical morpheme	pl, def	Canonical order	(Aux) V neg (Aux) neg V neg V
1 Word/lemma	"Words"	Invariant forms	Single const.	neg+X

The empirical support for each of these hierarchies is very strong. A series of longitudinal and cross-sectional studies by Boss (1996), Clahsen (1980), Clahsen et al. (1983), Jansen (1991), Meisel et al. (1981), and Pienemann (1980, 1981, 1987) all demonstrate that German L2 morphosyntactic forms emerge in the sequence predicted by PT.

Vainikka and Young-Scholten (1994) analyzed cross-sectional data from the acquisition of German by 11 Turkish and 6 Korean adults. Their study also supports the processability hierarchy. However, an evaluation of this study in relation to the processability hierarchy will be easier to contextualize after an analysis of German L1 acquisition within this framework. I will therefore return to this study at the end of section 6.

The case of Swedish as a second language was examined in detail by Pienemann and Håkansson (1999), who surveyed 14 major studies of Swedish as L2 to test the predicted processability hierarchy for Swedish morphology, syntax, and negation. These studies are based on over 1000 informants. Some of the studies are longitudinal, others are cross-sectional. This survey did not reveal one single piece of counter-evidence to the predicted hierarchy.

5 Variation and Processing Constraints

Perhaps the strongest doubts about the universality of grammatical development have been expressed by scholars who study L2 variation, and by language testers. For instance, Bachman (1988) voices the following concern about acquisition-based profiling procedures: ". . . to what extent is the procedure sensitive to individual variations that may result from different elicitation contexts, and to what extent will this affect the determination of the developmental stage?" (p. 204). Similarly, Douglas (1986) is concerned about ". . . the problem of characterizing a learner's competence when it would appear that 'competence' varies with task" (p. 158).

There is indeed ample evidence that the shape of an interlanguage varies within one and the same learner on one and the same day depending on which linguistic task the learner performs in which context (e.g., Crookes, 1989; Crookes and Gass, 1993; Selinker and Douglas, 1985; Tarone, 1983). For instance, Tarone (1989) observed that the frequency of producing /r/ may vary between 50 percent and almost 100 percent where the latter occurs in the reading of word lists and the first in "free speech." However, the issue at stake is not whether interlanguage performance is constant across tasks, but whether the developmental stage is constant across tasks. Obviously, if the stage can change from situation to situation, the concept of universal routes of development becomes vacuous.

The question of the stability of stages is one that can be answered empirically. Pienemann (1998a) put forward the "steadiness hypothesis," which predicts that the basic nature of the grammatical system of an IL does not change in different communicative tasks, as long as these are based on the same skill type in language production (such as "free conversation"). Pienemann (1998a) tested the steadiness hypothesis in a sample containing six ESL learners, each of whom carried out six different communicative tasks. The IL profiles of all learners were found to be *perfectly consistent* across all tasks in the area of syntax according to the emergence criterion. For the area of morphology, a total of three out of 324 possible cases of "underproduction," and not a single case of "overproduction," were found. This amounts to a 99.1 percent fit of the data in this area. In other words, these data constitute strong support for the steadiness hypothesis.

Pienemann (1998a) further demonstrated that fluctuations in correctness levels across tasks do not reflect different levels of acquisition and that they are instead brought about by the specific lexical needs of individual tasks and the status of morphological marking in different entries to the learner's lexicon. In all these analyses, it is essential to compare learner behavior with measures that are well defined, theoretically motivated, and applied consistently across different corpora. For all measurements of learner behavior, Pienemann (1998a) provided quantified distributional analyses for each individual speaker. He further used the emergence criterion because of its suitability as a measure of the in-principle acquisition of processing skills. In addition, implicational scaling was used to determine developmental stages.

It should be added that within PT, interlanguage variation is not merely defined as fluctuations in correctness levels. Instead it is defined a priori by the learner's current level of processing. In other words, it is defined as a specific range of structural options that are available to the learner. This range of structural options results from the fact that the learner's limited processing resources constrain the way in which he or she can avoid structures which have not yet been acquired. An example is the acquisition of English inversion. As noted above, this rule is acquired at stage 4 in the ESL hierarchy. The rule describes the observational fact that auxiliaries are placed in second position in English *wh*-questions, as in the following example:

(7) Where is he going?

Variability occurs in *wh*-questions before this rule is acquired. At the prior stage, some learners leave out one or more constituents:

(8) Where he going?

(9) Where is going?

Other learners produce *wh*-questions using canonical word order:

(10) Where he is going?

The range of possible solutions to the formation of *wh*-questions simply derives from the state of the learner's grammar before stage 4. The ESL processability hierarchy specifies the following for stage 4:

$$S'' \rightarrow \underset{\left\{\begin{array}{l}\text{wh} =_c +\\ \text{adv} =_c \text{“seldom, rarely . . .”}\\ \text{SENT MOOD = INV}\end{array}\right\}}{(XP)} \qquad S'$$

$$S' \rightarrow (V) \qquad S$$
$$\left\{ \begin{array}{l} \text{aux} =_c + \\ \text{ROOT} =_c + \\ \text{SENT MOOD} =_c \text{INV} \end{array} \right\}$$

In other words, the information "SENT MOOD = INV" has to be exchanged between XP and V to achieve the desired position of the auxiliary in second position. However, before stage 4, the interlanguage processor cannot carry out this operation because the S-node is not available yet as the information store for this process (cf. Pienemann, 1998a, pp. 175f, 239f). Quite logically, the learner has only a limited number of options for resolving this problem: (i) leaving out one of the constituents involved in the exchange of grammatical information, which ensures that the impossible information exchange becomes obsolete; or (ii) applying a canonical sentence schema to the sentence ($S \rightarrow wh\ NP_{subj}\ V\ X$), which makes the crucial exchange of information obsolete; or (iii) avoiding the context for this structure (i.e., no *wh*-questions), which again avoids the impossible operation. However, these are all the options that are available. There is no alternative way to exchange the crucial grammatical information and thus to produce inversion (except in rote-memorized chunks). In other words, the full range of solutions to the developmental problem is dictated by the current state of the learner's production grammar.

This brief summary of the treatment of variation within the processability approach highlights a key feature of that approach, namely the fact that it provides a coherent formal framework for the treatment of the dynamics of second language development. On the one hand, it makes testable predictions about stages of development across languages by defining those classes of grammars that are processable at each stage. On the other hand, processability leaves a certain amount of leeway, which allows the learner to develop a range of solutions to developmental problems. However, this range is strictly constrained.

Mentioning testable predictions triggers the question as to how PT can be falsified. The simple answer is: "when it makes incorrect predictions." To be more specific, predictions on processability involve implicational hierarchies, such as A before B before C. If such a prediction is made and it can be demonstrated in a corpus with sufficient data on A, B, and C that C is acquired before, say B, then the prediction is falsified.

6 L1–L2 Differences and the Processability Hierarchy

I will show in this section that the same dynamics as are present in IL variation also apply to the comparison of L1 and L2 development.

There is overwhelming evidence for fundamental differences between L1 and L2 acquisition in ultimate attainment (cf. Long, 1990). Remarkable differences between L1 and L2 acquisition also exist in the developmental schedule. Clahsen (1982, 1990, 1992) found a developmental pattern in the acquisition of German as a first language that is shown below. This pattern differs markedly from the one observed in the acquisition of German as a second language:

L1 sequence:	*L2 sequence:*
(1) Variable word order	(1) SVO
(2) SOV	(2) ADV
(3) V-2nd and SV-agreement marking	(3) SEP
(4) Subordinate clauses (without any errors in the positioning of the verb)	(4) INVERSION, SV-agreement sometimes
	(5) V-Final in subordinate clauses (with errors in the positioning of the verb)

The differences between L1 and L2 go beyond that of the developmental path. Clahsen observed that as soon as the child uses complementizers, the position of verbal elements in subordinate clauses is completely in line with the structure of the adult language. He also found that in German child language development, SV-agreement is acquired at exactly the same point in time as V–2nd position. This is not the case in the acquisition of German as L2.

Despite these differences in the course of development, it can be shown that the L1 schedule is constrained by the processability hierarchy. Similarly to SVO structures in L2 acquisition, the initial word order hypothesis in L1 acquisition (i.e., SOV) can be accounted for simply by a c-structure rule along the lines of (R-a). Since grammatical functions can be read off c-structure and no exchange of grammatical information is required, SOV order is positioned at the lowest level in the processability hierarchy.

This simple analysis of initial word order in L1 acquisition also highlights an important difference between Clahsen's strategies and the processability approach. As Vainikka and Young-Scholten (1994) and Towell and Hawkins (1994) point out, Clahsen's strategies would predict that the initial hypothesis in L2 acquisition is formed on the perceptual array "actor, action, acted-upon," thus producing universal SVO patterns for all L2s. No such assumption is made in PT. The only stipulation that exists at this level is that no grammatical information be exchanged within the sentence. This constrains the language processor to produce only structures that can be processed without such information exchange. SVO and SOV both satisfy this condition.

The Verb-2nd phenomenon found in the L1 sequence can be produced by (R-b) and (R-c) in a way similar to German and English INVERSION. For the V-2nd position to be produced, the grammatical information SENT MOOD has to be exchanged between two constituents (XP and V). This places V-2nd at the same level in the processability hierarchy as INVERSION and SV-agreement. In other words, SOV and V-2nd do indeed fall within the constraints of the processability hierarchy and their sequence of acquisition is predicted correctly.

Note that the rule SEP is absent from the L1 sequence. To explain why this is the case, one has to consider the effect of the rules R–a-c: on the basis of an SOV c-structure, these three rules have the same effect as the combined application of SEP and INVERSION on the basis of an SVO c-structure. Since in R-a, the verb is in final position, and R-b jointly with R-c permit the finite verb to appear in second position, the "split verb" position is also permitted.

The sentence-final position of the verb in subordinate clauses is predicted to occur at level 6 of the processability hierarchy. The final stage of the L1 sequence is therefore also in line with PT:

$$\text{(R-a)}\quad S \rightarrow NP_{subj}\ VP$$
$$VP \rightarrow (NP_{obj1})(NP_{obj2})\ V\ (V)$$

$$\text{(R-b)}\quad \bar{S} \rightarrow \underset{\left\{\begin{array}{l} wh =_c + \\ adv =_c + \\ N =_c + \\ \text{SENT MOOD} = \text{INV} \end{array}\right\}}{(XP)}\quad S$$

$$\text{(R-c)}\quad \bar{S} \rightarrow \underset{\left\{\begin{array}{l} \text{ROOT} =_c + \\ \text{SENT MOOD} =_c \text{INV} \end{array}\right\}}{(V)}\quad S$$

Table 20.12 provides an overview of this comparison of grammatical development in the acquisition of German as a second and as a first language; it shows at a glance that both developmental paths fall within the confines of the processability hierarchy. In other words, there are no differences in the temporal order in which processing procedures are activated. All grammars are processable at the time they develop, and each grammar builds upon the processing procedures acquired at the previous stages in a cumulative fashion. However, the L1 learner achieves this in two key "moves," SOV and V-2nd (with SV agreement), while the L2 learner takes five "moves," most of which introduce ungrammatical structures that have to be modified in later moves.

Two questions remain after this comparison. (i) Why are there different routes of development? And (ii) Where do the initial structural hypotheses come from? Both questions are outside the intended scope of the processability approach, which focuses on the explanation of sequences and variation in development. Pienemann (1998a) developed an additional explanatory module that interacts with PT, and according to which the route of development is caused largely by the initial hypothesis. The structural properties contained in the initial hypothesis propagate throughout development by a dynamic process known as "generative entrenchment" that is mathematically well described.

The above summary of my position concerning processing similarities in the L1 and the L2 has been described in more detail in a "keynote article"

Table 20.12 Development in German L1 and L2 from a processability perspective

Stage	*Exchange of information*	*Resources*	*German L2*	*German L1*
6	Within subordinate clause	+/− ROOT	V-End	V-End (no errors)
5	Interphrasal	WO rules S-Procedure	INV +/−agr	V-2nd +agr
4	Phrasal	WO rules VP-Procedure	PART	–
3	None	Lexical categories Saliency	ADV	–
2	None	Lexical categories	SVO	SOV Variable word order
1	None	Lexical entres	Words	Words

(Pienemann, 1998b) which was published together with eight partly critical peer commentaries. For instance, De Bot (1998) queries the relationship between the Formulator and LFG, Bialystok (1998) wonders how LFG can capture language processing, and Schachter (1998) discusses the neurophysiological plausibility of the proposed processing similarity between L1 and L2.

It is now time to return briefly to the study by Vainikka and Young-Scholten (1994), which adds an interesting twist to the comparison of developmental schedules. As mentioned above, the researchers studied 11 Turkish and 6 Korean adult learners of German. It is important to bear in mind that both source languages follow an SOV pattern. These authors claim to have found that "the development of phrase structure in . . . [their L2 corpus, MP] follows a pattern noted in first language acquisition" (Vainikka and Young-Scholten, 1994, p. 295). Specifically, their learners are reported to produce SOV structures before verb-second. In other words, these authors claim that the Turkish and Korean learners of German start out with a different initial hypothesis on word order from that of Italian and Spanish learners of German, and that the hypothesis of the first group of L2 learners is identical to that of L1 learners.

From the above observations, Vainikka and Young-Scholten (1994) infer that L2 learners will transfer certain basic constituent structure features, but not the basic prerequisites for morphological processes, such as SV-agreement marking. As the above L1–L2 comparison demonstrated, such a variable initial hypothesis would be within the confines of the hypothesis space defined by

PT. However, Vainikka and Young-Scholten's hypothesis is merely a generalization of their observations and does not withstand the test of cross-linguistic validity, since it is inconsistent with the observation that English learners of Japanese do not transfer the basic SVO pattern to Japanese (cf. Huter, 1998; Kawaguchi, p.c.).

7 Developmental Constraints on L1 Transfer

A further key aspect of PT is its capacity to spell out developmental constraints on L1 transfer. The assumption that L1 transfer may be developmentally constrained is not new. For instance, Wode (1976, 1978) demonstrated that for the acquisition of ESL negation and interrogatives, certain L1 forms appear in the interlanguage only after learners gradually develop the structural prerequisites for them in the L2. Similar observations were made by Zobl (1980) and Kellerman (1983).

PT provides a formal framework within which such developmental constraints on L2 transfer can be formally delineated. The logic behind this is quite straightforward. If L1 structures were able to be transferred "in bulk," as assumed in the "full transfer" hypothesis by Schwartz and Sprouse (1996), one would have to assume that the learner can generally utilize L1 procedures for the L2. In Pienemann (1998a), I demonstrated that this assumption is implausible, given the lexically driven nature of human language processors.

Using L1 procedures for the L2 would lead to internal problems in the processor because all of the processing procedures described above need to be orchestrated in a language-specific way. If any of them is missing or incompatible with the rest, the Formulator is inoperable. If, for instance, the lexical category information is missing, category and phrasal procedures cannot be called. If diacritic features are missing or have no values or values which are incompatible with those listed in agreeing phrases, or if they are incompatible with the Functorization rules, then the processor will be inoperable. This does not mean that the learner will never attempt to form diacritic features and Functorization rules that reflect L1 regularities. However, a "bulk transfer" of the L1 Formulator would lead to very unwieldy hypotheses (Pienemann, 1998a, pp. 80ff).

The case of constraints on the transfer of morphological and lexical regularities is obvious. As the above LFG treatment of subject–verb inversion shows, similar constraints also apply to word order. The key point of the argument is that the positioning of verbs is controlled by the unification of a lexical feature that is specific to the verb. In other words, word-order phenomena may also depend on the correct annotation of lexical entries. Therefore, word order is as much dependent on the delicate mechanics of the developing language processor as morphological and lexical patterns. This is demonstrated particularly strongly in a study by Håkansson, Pienemann, and Sayehli (2002), which shows that Swedish learners of German do not transfer the verb-second pattern from the L1 to the L2, even though this pattern is part of both languages. Instead, the informants produce a structure (XSVO) which is ungrammatical in both languages. The authors argue with reference to PT that this is the case because the L2 processor cannot initially handle verb-second due to a lack of the necessary L2 processing procedures (see box 20.1).

8 Linguistic Knowledge, Language Use, and Performance Grammars

In the discussion of processing approaches to SLA, the relationship between competence and performance has been critically examined. As I showed in the early part of this chapter, most of the key criticisms of processing strategies such as Clahsen's (1984) have been addressed in later work on L2 processing. One key point of interest in current discussion of language processing and SLA is the relationship between the processor and linguistic knowledge. White (1991) equates research on acquisition with research on linguistic knowledge only, and she relegates everything else to the domain of language use. Kaplan and Bresnan (1982) have a different view. In the context of language acquisition, they put research on language processing on an equal footing with research on linguistic knowledge, as the following quotation illustrates: "[Children] acquire knowledge and skills that enable them to produce and comprehend an infinite number of novel utterances . . . The major goal of psycholinguistic research is to devise an explanatory account of the mental operations that underlie these linguistic abilities" (Kaplan and Bresnan, 1982, p. 177).

PT is positioned in this tradition. It therefore does not fit White's dichotomy. As Kaplan and Bresnan (1982) point out, the various components of a theory of language acquisition can be studied separately as long as they ultimately fit together in a coherent model. And it is for reasons of overall coherence that LFG was chosen as the grammatical framework for PT, because it provides a basis for relating linguistic knowledge to the processor. However, the issue of this relationship is not the focus of PT. In other words, PT is constructed in a modular fashion, and the study of the relationship between the processor and grammatical knowledge is one that can be pursued within the processability framework, since the language processor is seen as the computational routines that operate on, but are separate from, linguistic knowledge (cf. Kaplan and Bresnan, 1982).

Such an integrative line of research could prove highly productive. For instance, White (1991) is concerned that production data may not reveal a learner's linguistic knowledge because the learner may fail to produce certain structures for reasons to be found in the production routines rather than in his or her linguistic knowledge. In fact, White's concern highlights the fact that the interface between the processor and linguistic knowledge is of particular relevance to those SLA researchers who focus on the study of linguistic knowledge. As Chomsky (1978, p. 10) pointed out, we do not know a priori which aspects of

Box 20.1 Håkansson et al. (2002)

Research question: One of the key issues in SLA research has been the question of L1 transfer. Håkansson et al. (2002) provide strong empirical evidence to demonstrate that L1 transfer is developmentally moderated as predicted by PT.

The study focuses on the acquisition of German by Swedish school children. The L1 and the L2 share the following word order regularities in affirmative main clauses: SVO; adverb fronting (ADV); and subject–verb inversion (INV) after ADV.

Results: The results of this study are summarized in table 20.13, which treats all learner samples as parts of a cross-sectional study. Therefore, table 20.13 represents an implicational analysis of the data which demonstrates that the learners follow the sequence (i) SVO, (ii) ADV, and (iii) INV. In other words, ADV and INV are not transferred from the L1 at the initial state even though these rules are contained in the L1 and the L2. This implies that for a period of time the learners produce the constituent order:

* adverb+ S + V + O,

which is ungrammatical in the L1 as well as in the L2.

Conclusion: Håkansson et al. (2002) argue on the basis of Processability Theory (Pienemann, 1998a) that the L2 system can utilize L1 production mechanisms only when the L2 system has developed the necessary prerequisites to process L1 forms, and that, therefore, the procedures required for INV in the L1 cannot be utilized before the full S-procedure has developed in the L2.

Table 20.13 Implicational scale based on all learners in the study by Håkansson et al. (2002)

Name	*SVO*	*ADV*	*INV*
Gelika (year 1)	+	–	–
Emily (year 1)	+	–	–
Robin (year 1)	+	–	–
Kennet (year 1)	+	–	–
Mats (year 2)	+	–	–
Camilla (year 2)	+	–	–
Johann (year 1)	+	+	–
Cecilia (year 1)	+	+	–
Eduard (year 1)	+	+	–
Anna (year 1)	+	+	–
Sandra (year 1)	+	+	–
Erika (year 1)	+	+	–
Mateus (year 2)	+	+	–
Karolin (year 2)	+	+	–
Ceci (year 2)	+	+	–
Peter (year 2)	+	+	–
Johan (year 2)	+	+	+
Zandra (year 2)	+	+	+
Zofie (year 2)	+	+	+
Caro (year 2)	+	+	+

linguistic data are attributable to grammatical competence and which to innumerable other factors. Language acquisition studies that focus on linguistic competence, therefore, ought to place special emphasis on the interface between the processor and grammatical knowledge, since the latter is accessible only through the first, especially in SLA, where it cannot be taken for granted that individual utterances are representative of the structure of the underlying linguistic system. Utilizing an explicit production grammar and a compatible theory of linguistic representation would allow one to explore this issue in detail. Such a study could potentially shed light on the relationship between production routines and linguistic representation. Naturally, it assumes that the researcher accepts that the study of both the language processor and linguistic knowledge is a valid contribution to a theory of second language acquisition.

NOTES

1 It may be worthwhile at this point to clarify that the strategies approach to SLA is a separate proposition from the Multidimensional Model of SLA (cf. Meisel, Clahsen, and Pienemann, 1981). These two approaches tend to be conflated in reference works, for instance in Ellis (1994). The first approach is designed to explain sequences of acquisition, while the latter is a framework for the description of dynamic acquisition processes.

2 I want to thank Satomi Kawaguchi for allowing me to use these examples. They are taken from her M.A. thesis on simplified registers in Japanese (Kawaguchi, 1996).

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