Processability Approaches to Second Language Development and Second Language Learning
TO MY MENTOR AND FRIEND,

MANFRED PIENEMANN
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ABOUT THIS BOOK

A fundamental issue in second language acquisition research and in applied linguistics is the question of how learners acquire a second language (Doughty and Long 2003). Today it is general knowledge that any second language learning follows certain, theoretically established and empirically supported developmental sequences. Based on a universal psycholinguistic matrix, namely the hierarchy of language processability (Pienemann 1998 and 2005) one can diagnose current states of (individual) learners’ second language development. Knowing about the path of second language development provides important insights into what learners are ready to acquire in the foreign/second language at a given point in time. This can support second language learning both in natural and instructional settings (Keßler 2007, Pienemann and Keßler 2007). Pienemann’s Processability Theory (PT) provides a well researched and empirically substantiated framework to explain the developmental sequences in second language learning across languages.

There have been plenty of studies in second language acquisition research using PT as their theoretical framework. Many findings have been published either as monographs or as chapters in edited volumes or journals. However, there have not yet been any compilations dedicated exclusively to recent studies within the PT framework extending the theory and its application in pedagogical contexts.

This book is a follow-up volume to Mansouri (2007) on Second Language Acquisition Research. Theory Construction and Testing. Mansouri (2007:5) sketches out that SLA research is “a recognised independent field of academic inquiry that is concerned with cognitive, psychological, social and pragmatic aspects of second language development. Therefore, SLA research tends to be highly theoretical and experimental and as such lends itself to the rigour of scientific research.”

In this book the more general theoretical approach to SLA covered in Mansouri (2007) is utilized, and the book focuses exclusively on Processability Theory (Pienemann 1998 and 2005) both for theory development as well as for an application to second language learning in

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1 For further information and a list of PT references, please visit the PT website: http://www.processability.net/cms/index.php (17/08/07).
classroom settings. It compiles a number of recent studies within the PT framework that deal with current theoretical issues across languages to extend PT’s cross-linguistic validity. An even more recent development within the PT framework is its application to second language learning in classroom settings. This strength of the theory is covered in several chapters in this book.

The structure of this book


Part I: Introduction

The first part of this book is an introduction into key aspects of second language development and second language learning from a PT perspective: Pienemann gives a state of the art introduction to PT and widens the scope on recent developments towards a further extension of his theory. He points out that PT-based research currently works on the inclusion of written data and the application of his theory to automatic profiling. The successful integration of a parser into the PT framework offers a broad range of new approaches to SLA research and L2 assessment.

Being modelled in a broader theory of grammar, LFG (Bresnan 2001), there is a need to understand basic concepts of LFG. Fabri’s chapter offers a current and non-technical introduction to LFG and provides numerous examples from various languages. His chapter lays the foundation to understanding the more theoretical chapters of part two of this book.

Keßler summarizes some current issues in SLA research and theory construction. Taking VanPatten and Williams (2007) as his point of departure he demonstrates how the explanatory power of PT accounts for many of the key aspects covered by current SLA theories.

Part II: Current Theoretical Issues within the PT Framework

The second part of the book examines new theoretical issues within the PT framework: Kawaguchi investigates how languages across
typology encode grammatical relations using different types of syntactic or morphological expressions. This approach is important both for consolidating PT’s crosslinguistic validity as well the extension of the theory.

Zhang presents the findings of her study which tests two theoretical positions on language transfer: the Full Transfer/Full Access Model (FT/FA) (Schwartz and Sprouse 1996), and the Developmentally Moderated Transfer Hypothesis (DMTH) (Pienemann, Di Biase Kawaguchi and Håkansson 2005). Her findings show that the FT/FA was unable to make consistent predictions about L1 transfer: what had been predicted to transfer on structural grounds was not borne out empirically. Thus, her study provides further empirical evidence in favour of the DMTH, a well-researched processability approach to second language development and second language learning. Zhang’s study is of particular in the context of the recent controversial debate on transfer as featured for example in the journal “Second Language Acquisition Research”.

A new extension of the PT framework is introduced by Rahkonen and Håkansson. Their study reports on the inclusion of written language production into the PT framework. Their controversial findings towards the PT hierarchy in written language production open a new field of discussion and research. It is still an open question as to whether a theory that has formally been designed to explain second language development in spoken language can be validly transferred into a theory also catering for written language data. Rahkonen and Håkansson’s chapter offers a new approach to written second language development and invites further research in this field.

Part III: Applying PT to the Second Language Classroom

The third part applies major findings of PT to the second language classroom: Keßler and Keatinge apply PT to diagnose second language development in the EFL/ESL classroom. They show how Rapid Profile, a computer software developed by Manfred Pienemann and his collaborators and empirically tested by Keßler (2007) can be applied in the classroom to gain quick and valid profiles of second language learners’ interlanguage development. These profiles tell language teachers and curriculum designers what the learners are ready to acquire at a given point in their process of second language learning.

Di Biase presents a classroom-based study of development of Italian as a second language in primary school children. It demonstrates the beneficial effects of an extended - PT based developmentally moderated –
focus on form on the rate of L2 development in the second language classroom. Combining the diagnostic power of Rapid Profile as shown in Keßler and Keatinge’s chapter with the developmentally moderated focus on form approach to classroom based second language acquisition clearly demonstrates how Processability approaches to second language learning turn out to be the key element for both instruction and feedback.

Lenzing’s analysis of two textbooks for English at primary school level introduces another processability approach to the second language classroom. She shows that crucial insights into how learners acquire a language have not been considered in the design of curricula and textbooks for early ELT. Her study provides a valid basis for promoting more realistic learning goals in second language textbooks.

**Part IV: Work in Progress within the PT Framework**

The fourth part of this book is dedicated to two promising studies which are part of doctoral research. These two longitudinal studies contribute to the strength of the PT framework: Yamaguchi applies PT to the early syntactic development in child L2 acquisition. By formalising her findings in LFG along the extended version of PT (cf. Pienemann, Di Biase and Kawaguchi 2005) her study contributes to testing the Topic Hypothesis first introduced by Pienemann, Di Biase and Kawaguchi (2005). Further research will provide more L2 data to make a valid test of this hypothesis.

Al Shatters study on the development of verbal structures in L2 Arabic provides further and more detailed data on the development of L2 Arabic. Thus, his study contributes to the cross-linguistic validity of PT.

**Bibliography**


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Jörg-U. Keßler
PART I

INTRODUCTION
A BRIEF INTRODUCTION TO PROCESSABILITY THEORY

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Processability Theory (Pienemann 1998) is a theory of second language development. The logic underlying Processability Theory (PT) (Pienemann, 1998; 2005) 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 handle. 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.

1. The focus and the scope of Processability Theory

The architecture of the language processor 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 in the study of second language acquisition therefore brings to bear a set of human psychological constraints that are crucial for the processing of languages. The view on 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 emulates much of Merrill Garrett's work (e.g. Garrett, 1976, 1980, 1982) and on which the corresponding section of Levelt's model is based. The basic premises of that view are the following:

- Processing components operate largely automatically and are generally not consciously controlled;
- Processing is incremental;
The output of the processor is linear, while it may not be mapped onto the underlying meaning in a linear way;

Grammatical processing has access to a temporary memory store that can hold grammatical information. (cf. Pienemann, 1998 for detail)

The core of PT is formed by a universal processability hierarchy that is based on Levelt’s (1989) approach to language production. PT is formally modelled using Lexical Functional Grammar (Bresnan 2001). PT is a universal framework that has the capacity to predict developmental trajectories for any second language. The notion ‘developmental trajectory’ implies a developmental dimension known as ‘staged development’ as well as a variational dimension accounting for individual differences between developmental trajectories as illustrated in Figure 1.

Figure 1 shows two different developmental trajectories, T1 and T2, which are based on the same set of developmental stages (indicated by the dotted horizontal lines). The two developmental trajectories differ with respect to the interlanguage varieties that are developed at each stage (indicated by vertical lines). As can be seen in Figure 1, there are many possible developmental trajectories based on the same stages of development.

![Figure 1: Two different developmental trajectories](image)

In this paradigm, each stage represents a set of grammatical rules that share certain processing routines, and each interlanguage variety represents a specific variant of the grammatical rules. For instance, in ESL question formation the following developmental sequence has been found (e.g. Pienemann 1998):
<table>
<thead>
<tr>
<th>Stage</th>
<th>Structure</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>SVO question</td>
<td>He live here?</td>
</tr>
<tr>
<td>Stage 2</td>
<td>WH+SVO</td>
<td>Where he is?</td>
</tr>
<tr>
<td>Stage 3</td>
<td>Copula inversion</td>
<td>Where is he?</td>
</tr>
<tr>
<td>Stage 4</td>
<td>Aux-second</td>
<td>Where has he been?</td>
</tr>
</tbody>
</table>

Learners attempting to produce ‘Aux-second’ at stage 3 (i.e. before they are ready for this structure) have been found to produce the following interlanguage variants:

- A Where he been?
- B Where has been?
- C Where he has been?
- D He has been where?

Variants A to D have in common that they get around placing the auxiliary in second position after an initial WH-word. In other words, they constitute different solutions to the same learning problem. In Figure 1 each of the different solutions is represented by a vertical line. It is important to bear in mind that for each structural learning process there is a limited set of variable solutions. In the course of L2 development, the learner accumulates grammatical rules and their variants, allowing her or him to develop an individual developmental trajectory while adhering to the overall developmental schedule. In this way, PT defines a two-dimensional space for the formation of processable hypotheses. Both dimensions of this space (i.e. ‘Hypothesis Space’) are constrained by the processability hierarchy which can be applied to any L2 using Lexical Functional Grammar, a theory of language to be described later in this chapter.

The original version of PT (Pienemann 1998) focused solely on what is known as the ‘developmental problem’ (that is, ‘why do learners follow universal stages of acquisition?’). The extended version of PT (Pienemann, DiBiase and Kawaguchi 2005) also starts to address the so-called ‘logical problem’ (that is, ‘what is the origin of linguistic knowledge?’ For instance, how do learners know that there are such things as nouns and verbs?). The developmental and the logical problem are the key issues of any theory of language acquisition, and PT addresses these issues in a modular fashion. One module deals with the developmental problem, a separate, but connected module deals with the logical problem. Both modules are based on Lexical-Functional Grammar (LFG) because
LFG\(^1\) is designed to account for linguistic knowledge in a way that is compatible with the architecture of the language processor, and both these components are needed for PT to address the developmental and the logical problem. The developmental problem is addressed by describing the constraints the language processor places on development, and the logical problem is addressed using specific components of LFG that are summarized below.

The commitment of LFG to the interface between linguistic knowledge and language processing is illustrated very clearly in the following quotation:

"[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, 177)

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. In the PT framework the language processor is seen as the computational routines that operate on, but are separate from linguistic knowledge (cf. Kaplan and Bresnan 1982).

The key idea behind PT is that language acquisition is constrained by language processing. There have been other approaches to language acquisition that subscribed to this idea. One of them was the Strategies Approach that was developed by Clahsen (1984) to explain the development of German L2 word order. It is based on a set of processing strategies which are assumed to be shed as interlanguage development progresses. Meisel (1983) produced his own version of the Strategies Approach that is more closely related to Slobin’s (1973) and Anderson’s (1984) acquisition strategies. These variants of the Strategies Approach were limited to explaining German L2 word order development, and they were not related to a theory of language.

PT has the same objective as the Strategies Approach (to account for trajectories of L2 development). However, it pursues this objective using an entirely different theoretical ‘machinery’, using an explicit theory of language (LFG) that is compatible with an overall model of language production. In this way PT is applicable to a wide array of grammatical phenomena in any language. A detailed account of the history of PT is available in Pienemann (2005c).

\(^1\) For an introduction to LFG see Fabri, this volume.
The basic claim of the original version of PT is that language development is constrained by processability. This affects first and second language development (albeit in different ways). It also affects interlanguage variation and L1 transfer. The extended version of PT adds to this the claim that the initial form of grammar in SLA is determined by the default relationship between what is known as ‘argument structure’, that is, the ideas expressed in a sentence, and the way they are expressed by grammatical forms.

2. The key constructs in PT

2.1 The processability hierarchy

In Pienemann (1998) the processability hierarchy is based on the notion of transfer of grammatical information within and between the phrases of a sentence. For instance, in the sentence ‘Little Peter goes home’ the grammatical information ‘third person singular’ is present in the phrase ‘Little Peter’ and in ‘goes’. This is commonly referred to as ‘subject-verb agreement’. In LFG and in Levelt’s model of language generation it is assumed that the language processor checks if the two parts of the sentence, ‘Little Peter’ and ‘goes’, contain the same grammatical information. To be able to carry out this checking operation, the procedures that build phrases in language generation need to have developed in the second language processing system. In our example learners need to have developed a procedure for building noun phrases such as ‘Little Peter’ and verb phrases such as ‘goes home’. They also need to have developed a procedure for putting these two phrases together to form a sentence. In Levelt’s (1989) model of language generation it is assumed that the grammatical information ‘third person singular’ needs to be stored in the procedures that build the phrases in which this information is used and that the two lots of information are compared within the procedure that puts the two phrases together to form a sentence. The learner of a language needs to develop procedures that can handle the job of storing and comparing grammatical information. This way, speakers can learn to decide which sentences are grammatically acceptable and which one aren’t. For instance, in the sentence ‘*Little Peter go home’ the phrase ‘little Peter’ is marked for ‘third person singular’, but the verb isn’t. This would be detected by a competent speaker when the noun phrase and the verb phrase are assembled to form a sentence. However, if the learner...
has not yet developed a fully functioning sentence procedure the mismatch will not be detected.

The same principle applies to grammatical information contained within phrases. For instance, in the noun phrase ‘two kids’ the grammatical information ‘plural’ is contained in the numeral ‘two’ and in the noun ‘kids’. In language generation these two bits of information are compared when the noun phrase is assembled by the noun phrase-procedure. In the case of ‘two’ and ‘kids’ the two bits of grammatical information do match.

We can now see that in both examples grammatical information has to be matched between parts of the sentence. In Lexical Functional Grammar this process is called ‘feature unification’. In non-technical language we might describe this process as information matching. LFG uses formal means to account for such processes. The fact that LFG has this capacity is one of the key reasons why PT uses LFG to model these psycholinguistic processes.

The two examples we used also serve to illustrate the processability hierarchy. It is easy to see that in the ‘Little Peter’-example grammatical information has to be matched between a noun phrase and the verb phrase and that this occurs when the two pieces are assembled to form a sentence. In contrast, in the second example the information matching occurs in the noun phrase procedure – before the sentence is assembled. In other words, there is a time sequence involved in the matching of grammatical information which forms the basis of the original processability hierarchy. Noun phrases are assembled before verb phrases which are assembled before the sentence. In addition, individual words belong to categories such as ‘noun’ and ‘verb’, and category procedures are the memory stores that hold grammatical information such as ‘singular’ or ‘past’. Therefore category procedures appear before noun phrase procedures.

The following is an overview of the original processability hierarchy, following Pienemann (1998):

1. no procedure
2. category procedure
3. noun phrase procedure
4. verb phrase procedure
5. sentence procedure
6. subordinate clause procedure.

The basic hypothesis underlying PT is that learners develop their grammatical inventory following this hierarchy for two reasons: (1)
because the hierarchy is implicationally ordered, i.e. every procedure is a necessary prerequisite for the next procedure and (2) because the hierarchy mirrors the time-course in language generation. Therefore the learner has no choice other than to develop along this hierarchy. Phrases cannot be assembled without words being assigned to categories such as ‘noun’ and ‘verb’, and sentences cannot be assembled without the phrases they contain and so forth. The fact that learners have no choice in the path they take in the development of processing procedures follows from the time-course of language generation and the design of processing procedures. This is how the architecture of language generation constrains language development.

As mentioned above, the original version of the processability hierarchy focuses on information transfer within phrase structure. In the extended version of PT (Pienemann, DiBiase and Kawaguchi 2005) the processability hierarchy is extended to include further aspects of language generation, in particular the relationship between what is known as ‘conceptual structure’ and grammatical structure. Argument structure refers to the basic ideas conveyed in a sentence, i.e. who does what to whom. In other words, the extended version of PT also includes the relationship between what is intended to be said and the way this is expressed using grammatical forms. This extension is also modeled using Lexical-Functional Grammar. Details will be summarized later on.

Figure 2 illustrates the basic points of the processability hierarchy. Three examples of phrase structures are listed in the left-hand column. The second column specifies the type of information transfer possible at each stage. ESL morphological structures are given in the next column to exemplify the types of structures possible at each stage, and the information transfer involved in the generation of these structures is illustrated in the column on the right-hand side.
2.2 Hypothesis Space

The processability hierarchy has been described as the sequence in which the fundamental design of the language processor develops in L2 acquisition, and it has been added that the learner is constrained to follow this sequence. At the same time, the processing procedures developed at every stage of the hierarchy do allow for some degree of leeway for the shape of the L2 grammar. Hypothesis Space is created by the interplay between the processability hierarchy and the leeway it generates at every level.

The constraining effect of the processability hierarchy is illustrated in Figure 2. As can be seen in Figure 2, at the stage ‘phrase’ grammatical information can be exchanged only within phrases, not beyond the phrasal boundary. Therefore grammatical structures requiring information exchange beyond the phrase boundary, such as subject verb-agreement cannot be processed at this stage. To recoup, learners have no choice other than to follow the processability hierarchy in their development of the L2 grammatical inventory because of the internal architecture of the language processor. At any given point in the hierarchy any grammatical operation requiring processing procedures that are beyond the current point of development are out of reach for the learners. In other words, processing procedures constrain the range of possible production grammars for every level.
At the same time, these constraints leave sufficient leeway for learners to find different solutions to structural learning problems. I illustrated this above with the example of the position of auxiliaries in English WH-questions. This position requires processing procedures at the sentence level in the hierarchy. L2 learners can nevertheless produce WH-questions. When they attempt to do this, learners have four structural options that avoid the placement of the auxiliary in second position. The options available are all processable using the resources available at the previous stage, and the number of options is limited because of the limited resources that are available. The fact that learners need to circumnavigate a structural problem (here Aux-second) is caused by the constraints inherent in the hierarchy. In this way, possible developmental trajectories are constrained by the processability hierarchy.

2.3 Developmental dynamics

Developmental trajectories within Hypothesis Space have their own dynamics that are a key component of language development. These dynamics are particularly well visible in a comparison of first and second language development as shown in Table 1 which lists two sets of processing procedures and the differential developmental trajectories found in the acquisition of German as a first and as a second language (cf. Pienemann 1998b).

To appreciate the developmental dynamics shown in Table 1, the reader needs to bear in mind the following descriptive facts about German word order.

- Affirmative main clauses follow an SVO pattern (as in English) except for sentences with a non-subject in initial position (e.g. ‘Gestern ging er weg’. / ‘Yesterday went he away’).
- In sentences containing more than one verb the non-finite verb appears in final position (e.g. ‘Er hat ihn gesehen’ / ‘He has him seen’).
- In main clauses the inflected verb is always in second position.
- In embedded clauses the verb is in final position.
A Brief Introduction to Processability Theory

### Table 1: Developmental dynamics

As can be seen in Table 1, L1 and L2 learners follow different developmental trajectories that both reach the same target containing all word order regularities listed above, and both trajectories are placed within the constraints defined by Hypothesis Space. Nevertheless, the two developmental trajectories are fundamentally different, mainly because they start with a different initial hypothesis, and the structure entailed in the initial hypothesis propagates through the entire developmental process (cf. Pienemann 1998b). L1 learners preserve the initial SOV order and modify it to fit the target language, whereas L2 learners preserve the SVO order and make adjustments on this basis that also leads to a close match of the target pattern. I will show below that these dynamics can be modeled using a formal approach to developmental dynamics called ‘Generative Entrenchment’ (Wimsatt 1986).

<table>
<thead>
<tr>
<th>Processing procedures</th>
<th>Constituent structure mapping</th>
<th>L2 German</th>
<th>L1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>German</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>subordinate clause procedure</td>
<td>comp SOV</td>
<td>comp SOV</td>
<td></td>
</tr>
<tr>
<td>use of S-procedure for storage across constituents in S</td>
<td>topicalisation of core arguments</td>
<td>X Vf S O Vi</td>
<td>X Vf S O Vi</td>
</tr>
<tr>
<td>use of VP-procedure for storage across constituents in VP</td>
<td></td>
<td>X S Vf O Vi</td>
<td>---</td>
</tr>
<tr>
<td>use of saliency principle to relax canonical order constraint</td>
<td>XP-adjunction</td>
<td>X S V O</td>
<td>---</td>
</tr>
<tr>
<td>category procedure</td>
<td>unmarked alignment</td>
<td>S V O</td>
<td>S OV</td>
</tr>
<tr>
<td></td>
<td>(both result in canonical order)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3. The key processes posited in PT

3.1 Transfer of grammatical information and feature unification

As mentioned above, the original version of PT focused on phrase structure (which is called ‘constituent structure’ in LFG) and the transfer of grammatical information within it. This information transfer process is modelled using feature unification. The modelling of feature unification is based on the following notions and assumptions. Every entry in the learner’s mental lexicon needs to be annotated for the specific features of the target language. For instance, the entry ‘Peter’ needs to be assigned to the lexical class ‘noun’. It needs to be annotated as a proper noun, and the feature ‘NUMBER’ needs to have the value ‘singular’. The lexical entry ‘sees’ needs to be assigned to the lexical class ‘verb’, and the features NUMBER, PERSON, TENSE and ASPECT need to have the following values:

\[
\begin{align*}
\text{NUMBER} & = \text{singular} \\
\text{PERSON} & = 3 \\
\text{TENSE} & = \text{present} \\
\text{ASPECT} & = \text{non-continuous}
\end{align*}
\]

To achieve subject verb-agreement in the sentence ‘Peter sees a dog’ the value of the features NUMBER and PERSON have to be matched. In LFG this is called ‘feature unification’. Figure 2 illustrates the unification of the features NUMBER and PERSON between the noun phrase ‘Peter’ and the verb ‘sees’. These features and their values ‘3rd’ and ‘singular’ reside in the lexical entries of the noun ‘Peter’ and the verb ‘sees’. This grammatical information is passed on to the noun phrase procedure (NP) and verb phrase procedure (VP) respectively. From there the two lots of information are passed on to the sentence procedure (S) where they are matched (or ‘unified’).

In the design of PT, the point of unification is related to the hierarchy of processability that reflects the time course of real time processing. The hierarchy that results from a comparison of the points of feature...
unification can be illustrated on the basis of Figure 2 which shows that the example structures illustrated in Figure 2 can be ordered as follows:

1. No exchange of grammatical information (= no unification of features),
2. Exchange of grammatical information within the phrase,
3. Exchange of grammatical information within the sentence.

Once one applies this hierarchy to ESL morphology, the following developmental trajectory can be predicted:

1. past –ed which will appear before
2. plural –s which in turn will appear before
3. third person –s.

In order to appreciate the universal nature of PT it is crucial to consider that the hierarchy illustrated in Figure 2 is not language-specific and that, in principle, it applies to the transfer of grammatical information in any language. In contrast, the examples that were given for ESL morphology utilise this hierarchy and apply it to one specific target language. The application of the full processability hierarchy to the syntax and morphology of specific languages will, of course, involve more detail of the LFG formalism.

### 3.2 Lexically driven grammar

A lexically driven grammar stores grammatical information in the lexicon. For instance, the lexical entry for ‘walked’ is marked for past tense and it lists the core argument of the verb as ‘agent’. This lexical information is required in the assembly of the sentence. The lexically driven nature of sentence generation is an integral part of Levelt’s approach and is backed up by extensive empirical evidence. LFG also encodes syntactic properties primarily in the lexicon (cf. Schwarze 2002, 148-9). This makes LFG particularly suitable for the study of dynamic linguistic systems such as developing learner grammars, because LFG affords a formal account of the linguistic dynamics present in developing learner grammars.

The lexically driven nature of sentence generation is supported by a wide range of psycholinguistic empirical evidence including research on slips of the tongue and on-line experiments (cf. Levelt 1989) and was demonstrated again recently in experimental work on sentence production by Pickering, Branigan, and McLean (2002) which shows that "constituent
structure is formulated in one stage" and thus supports the architecture of LFG.

Pienemann (1998) showed that for every level of the PT hierarchy, processing procedures can be captured through feature unification in LFG which in turn shares key characteristics with Kempen and Hoenkamp’s (1987) procedural account of language generation.

### 3.3 Generative entrenchment

The basic mechanism behind generative entrenchment is the principle that developmentally early decisions bias the further development of the interlanguage system. This percolation of structural properties in developmental processes is known in biology and philosophy and has been termed *generative entrenchment* by Wimsatt (1986, 1991).

The concept of generative entrenchment is exemplified, for instance, by the embryonic development of animals where sections of the fertilized egg take on more and more specialized structures. The segmentation of the body plan occurs very early in these processes for all animals. These structural features are maintained throughout the developmental process, and they do not have to be decided on every time a refinement of parts of the structure is made. One can say that these features are "developmentally entrenched".

We also know that incorrect information on the positioning of segments can have serious consequences for the ultimate shape of the organism. This sometimes unfortunate phenomenon illustrates the concept of the depth of generative entrenchment. The earlier a decision is made in structural development, the more far-reaching the consequences for the ultimate stage in structural development. However, once a decision has been made and a new structure has been added, it is very costly, if not impossible, for the developmental process to move to a different developmental path. In effect, changing the developmental path would mean that all developmental steps up to the node that gives access to the alternative path would have to be cancelled. As a result, a great deal of structural information would be lost in such a move. Many physical processes of development are indeed irreversible, as the example of developmentally malformed organisms shows.

The key explanatory point that can be derived from the concept of generative entrenchment for language acquisition is that a massive computational saving can be made if structural decisions do not have to be revised in the developmental process every time a structural change occurs.
To illustrate this point, let’s assume that a developmental process consists of ten stages and that potentially there are 10 different options for each stage. Wimsatt calculated that in order for the learners to get to the end of the developmental process they need 1,000,000,000 different trials if all structural decisions have to be revised for each stage and each option. However, if they can retain the solution found for every stage a mere 100 trials is needed.

In this model initial structural features propagate in the developing system and thus determine the ultimate structure without being invoked again and again. The basic ‘body plan’ stays the same. In other words, a computational saving is made by laying structures down and keeping them. The alternative would be a developing system in which all processes of structural refinement have to be orchestrated globally for every developmental step, and this would require far more computational resources than the preservation of structures once they have developed.

### 3.4 Lexical mapping and the Unmarked Alignment Hypothesis

Lexical Mapping Theory is a component of Lexical-Functional Grammar (cf. Bresnan 2001). LFG has three independent and parallel levels of representation as shown in Figure 4: argument structure, functional structure and constituent structure. Argument structure describes who does what to whom in a sentence. It is based on a universal hierarchy of argument roles that includes roles such as ‘agent’ or ‘patient’. The core argument roles for each verb are listed in the lexical entry of the verb. For instance, the argument roles of the English verb ‘see’ are ‘experiencer’ and ‘theme’. The following notation is used for this:

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see <experiencer, theme>.
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In other words, the act of seeing requires someone who experiences the seeing and something that is seen.

As mentioned above, ‘constituent structure’ is basically another name for ‘phrase structure’ and describes the structure of the parts of sentences. This component consists of universal units (such as ‘verb’, ‘noun phrase’ etc.), but these are arranged in a way that is specific for every language. For instance, in some languages adjectives precede the noun, in other languages they follow the noun. Functional structure also consists of universal units (such as ‘SUBJECT’ or ‘OBJECT’) which are related to constituent structure in a language-specific way. Functional structure serves to connect argument structure and constituent structure.