Chapter 2
Theoretical and Empirical Accounts of the "Modular Mind"

Abstract Research on bilingualism has focused on the areas of grammar that require greater effort to reach native-like attainment. It questioned whether simultaneous or sequential bilingual acquirers can achieve linguistic knowledge and language processing strategies to a similar extent as monolingual speakers who are exposed to efficient and continuous linguistic input and, if not, which areas of grammar are more demanding in this regard. Various bilingual groups have been tested in an attempt to identify the areas of grammar that are prone to:

- CLI effects, language dominance and quality and quantity of input in simultaneous and sequential bilingual acquisition (Hulk and Müller 2000; Müller and Hulk 2001; Argyri and Sorace 2007; Paradis and Navarro 2003; Hacohen and Schaeffer 2007),
- Language attrition effects (Gürel 2004; Tsimpli et al. 2004)
- Difficulties for near-native level attainment in L2 learners (Sorace and Filiaci 2006; Sorace 1999)

The common denominator in the outcome of these studies is bilinguals' non-native-like behavior in structures that require the integration of grammatical knowledge into contextual settings, i.e., at semantics-syntax and pragmatics-syntax interfaces. Before presenting these bilingual studies in the following chapter, this chapter first provides various theoretical assumptions on the modular mind and the interface phenomenon and then presents earlier research on the interface phenomenon in child and agrammatic speech as well as the theoretical accounts that resulted from these investigations. This chapter presents the theoretical assumptions on the function and the internal organization of the mind in Sect. 2.1, and informs on Fodorian modularity thesis, Chomskian ideas on the Language Acquisition Device, and Jackendoff's parallel architecture module. In Sect. 2.2 it presents previous research on child and agrammatic speech which investigated linguistic interfaces.

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2.1 Historical Background of the Modular Mind

2.1.1 The Modular Mind: Many Modules Linked by Interface Mechanisms

The mind is assumed to comprise a variety of distinct and simultaneously acting psychological mechanisms. The outcome of the interaction of these psychological mechanisms results in observable behavior (Fodor 1983, p. 1). This assumption necessitates the examination of two things in particular: first the characteristics of each of these distinct mechanisms; second the ways in which they interact with each other. Fodor (1983) depicted the functional organization of the mind in his manuscript entitled “Modularity of Mind.” Although this title points only to the mechanisms that are “modular,” Fodor (1983) proposed a mixed module consisting of both modular and non-modular mechanisms as this section describes.

2.1.1.1 Internal Organization of the Cognitive System

Memory, imagination, attention, sensibility, and perception interact with each other during any cognitive process. Performing a task may demand a particular combination of these faculties; the same psychological mechanism can identify the wildflowers in the environment and work on balancing a checkbook (Fodor 1983, p. 14). Thus the same set of mechanisms may fulfill various tasks (Fodor 1983, p. 11). An alternative view would assume psychological mechanisms to have particular functions whereby each mechanism fulfills only one specific task (Fodor 1983, p. 20). According to this second view, the computational system should consist of separate subsystems for each task. Fodor assumed that cognitive tasks require functioning of both types of mechanisms and proposed a cognitive system that consists of the mechanisms that serve many functions as well as the mechanisms that serve specific functions.

Fodor’s cognitive system has three mechanisms: transducers, input systems, and a central system. Each of these mechanisms constitutes a separate level in a hierarchical relation. Figure 2.1 illustrates these levels.

The first level hosts the senses that get in touch with the outside world. This level is comprised of transducer systems. During object perception or speech production, the input information first becomes accessible to the transducers. Transducers collect environmental signals and, without manipulating their informational content, transform them into a form, which makes them accessible to the next level. The input information then flows into the “input systems” at the second level. The input systems perform basic recognition and description tasks, and inform the upper level about the world (Fodor 1983, p. 39).[1] More precisely, they encode mental

[1]These subsidiary systems are variously known as ‘input systems,’ ‘input analyzers,’ and ‘interface systems’ throughout Fodor’s manuscript (Fodor 1983, p. 41). The term ‘input systems’ is used throughout this book.

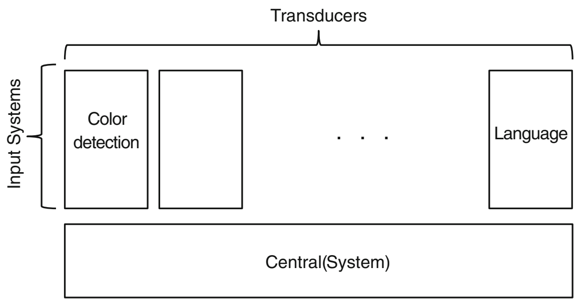


Fig. 2.1 Fodorian ternary mixed model of mind. Adapted from Cummins (1985, p. 101)

representations to provide domains for higher-level cognitive operations. Thus, the input systems mediate between the transducers and the central cognitive mechanisms[2] (Fodor 1983, p. 42). The central systems, on the other hand, perform complex operations on the representations they receive. These systems perform high-level cognitive tasks, such as belief fixation, at this third and highest level.

2.1.1.2 Characteristics of the Modular Systems

Although the modular systems have a number of common characteristics, they display these characteristics to various extents: as Fodor states, a cognitive mechanism can be modular "to some interesting extent" (Fodor 1983, p. 37). That is, modularity is a gradual notion and we may find some or all of the typical characteristics of modularity in a certain modular mechanism.

Fodor assumes the input systems, which mediate between transducers and the central mechanisms, to be modular and describes their characteristics in the following way. First of all, the modular systems are domain specific; each modular system has one specific function (Fodor 1983, p. 47). During object perception, for instance, separate and individual mechanisms process the shape, the color, and the size of an object. Second, the modular systems perform mandatory computations. Once the cognitive mechanism recognizes an object, it automatically perceives all of its properties, such as its shape, color, and size (Fodor 1983, p. 52). Another distinctive characteristic of the input systems is their being "informationally encapsulated," and this is the essence of modularity (Fodor 1983, p. 70). An informationally encapsulated mechanism can only contain the specific knowledge necessary for its specific function. Informational encapsulation locks the input systems and blocks the information flow across them. The input systems are sensitive only to specific types of information; they can access and operate on only this information. As they operate on very specific knowledge, the input systems perform

[2]Apart from these psychological mechanisms which function to fulfill a task, there might also be modular systems that do not subserve any of these functions; for instance, the systems involved in the motor integration of behaviors such as speech and locomotion (Fodor 1983, p. 42).

very rapidly (Fodor 1983, p. 69) and they produce shallow outputs (Fodor 1983, p. 87). Thus the input systems accomplish simple functions, which are insufficient to complete a cognitive task. Completion of a cognitive task requires access to and operation on all types of information from various domains, which can be done by the central systems.

2.1.1.3 Central Systems and Interfaces

Central systems perform higher-level cognitive tasks, such as fixing a belief or making a decision. The outputs of various input systems are simultaneously available to the central systems. This characteristic avoids central systems being domain specific (Fodor 1983, p. 101). Central systems integrate various outputs with knowledge that already exists in the mind; as Fodor states, the process they pursue is likely to “look simultaneously at the representations delivered by the various input systems and at the information currently in memory?” and “arrive at a best (available) hypothesis about how the world must be, given these various sorts of data” (1983, p. 102).

Overall, in this model, input analysis and higher-level cognitive processes accomplish—computations both at domain-specific and non-domain-specific levels (Fodor 1983, p. 126).

2.1.2 The Language Faculty

This section describes language representation in the language faculty (Chomsky 1995, p. 2). The language faculty shows the typical characteristics of the modular systems described above; it is domain-specific, i.e., functions only to perceive and produce language, informationally encapsulated, i.e., it is sensitive only to linguistic knowledge and it functions quickly and mandatorily. The language faculty operates in accordance with universal linguistic principles, which provide a set of options called linguistic parameters. The language-invariant universal principles are applied to specific languages by means of these linguistic parameters, which specify the values of a linguistic representation in any particular language (Chomsky 1995, p. 6, 25). The Minimalist Program (MP) assumes the initial state of the language faculty to be genetically determined. The initial state goes through a series of states during early childhood and finally reaches a stable steady state, which undergoes little subsequent change[3] (Chomsky 1995, p. 14). Thus, language acquisition is understood as the process of setting the parameters of the initial state (Chomsky 1995, p. 6). A specific language is acquired by specifying the values for linguistic representations in one of the permissible ways. The theory of the initial state is

[3]Apart from the lexicon.

called *Universal Grammar* (UG), and the theory of the attained state (for a particular language) is called *grammar* (Chomsky 1995, pp. 14, 167). UG specifies certain linguistic levels, which constitute symbolic systems referred to as "representational systems" (Chomsky 1995, p. 167).

As typical of modular systems, the language faculty also consists of sub-modules: cognitive systems and performance systems. Cognitive systems contain linguistic information, which the performance systems access and use (Chomsky 1995, p. 2). These systems are also modular. The following sub-sections describe the characteristics, the internal organization, and the interaction of the cognitive system and performance systems. This is followed by experimental evidence supporting these assumptions.

2.1.2.1 Internal Interfaces

The cognitive system comprises a lexicon and a computational system (Chomsky 1995, p. 6). The former provides items belonging to *substantive categories*, such as nouns, verbs, adjectives, and particles, and the latter selects a particular linguistic expression from the lexicon and generates an infinite range of symbolic objects with complex properties called structural descriptions (SDs) (Chomsky 1995, p. 7). SDs specify the full array of the phonetic, semantic, and syntactic character of the linguistic expression (Chomsky 1995, pp. 14, 20, 167). However, the computational system has indirect access to the lexicon; a representation system called the D-structure mediates between the two and specifies how the lexical properties should be expressed (Chomsky 1995, p. 20, 27). In other words, the lexical properties become accessible to the computational system by means of the processing at the D-structure (Chomsky 1995, p. 20). The D-structure thus constitutes an *internal interface* within the cognitive system, between the lexicon and the computational system (Chomsky 1995, p. 187).

2.1.2.2 External Interfaces

The two different levels of performance systems interpret the sound and meaning of linguistic expressions; the sound is interpreted at the level of Phonetic Form (PF) in the articulatory-perceptual (A-P) system, and the meaning is interpreted at the level of Logical Form (LF) in the conceptual-intentional (C-I) system (Chomsky 1995, p. 21). The PF and the LF specify the linguistic aspects of sound and meaning. In other words, the sound and meaning of the SDs (which are part of the cognitive system) are interpreted at two levels of performance systems (outside of the cognitive system) (Chomsky 1995, pp. 2, 168). Two external *interface levels*, mediate between SDs and the performance systems; the PF at the A-P interface, and the LF at the C-I interface (Chomsky 1995, pp. 2, 168).

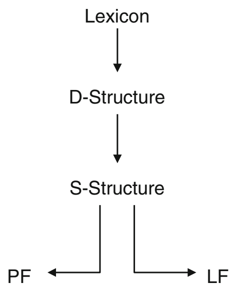


Fig. 2.2 Architecture of the language faculty in MP. Adapted from Chomsky (1995, p. 22)

UG principles require the A-P and C-I to meet three criteria, they have to (1) be universal, (2) be uniform, and (3) constitute an interface (Chomsky 1995, p. 21). For instance, the LF must capture a meaning that is universal; any thought that is expressible must be representable in any human language. The LF interpretation should be uniform; it captures all and only the properties of the system of language. LF representations must have an interpretation in terms of other systems of the mind involved with thought, referring, planning, and so on (Chomsky 1995, p. 21).

The D-structure—an internal interface—is in hierarchical relation to the performance systems PF and LF—external interfaces; S-Structure connects D-structure to the performance systems (Chomsky 1995, p. 22). The computational procedure maps the D-structure to the S-structure, and then "branches" to the PF and the LF (Chomsky 1995, pp. 23, 187). This is depicted in Fig. 2.2.

Overall, each SD has a representation at the internal interface of the computational system in the D-structure (δ), a derivative representation at the syntactic level in the S-structure (σ), and a representation at the external interfaces of the PF (π) and the LF (λ) (Chomsky 1995, p. 22).

As one level of representation is mapped onto another, the relationship between the levels of representations is inherently directional (Chomsky 1995, p. 22). The S-structure has a central role in this directionality because it is linked to the rest of the levels. This has been considered to be the only "solution" to relate the set of levels to each other (Chomsky 1995, p. 22). UG principles determine the way the S-structure level is linked to the other levels, and UG principles (binding theory, Case theory, the pro module, etc.) are applied at this level (Chomsky 1995, p. 187).

2.1.2.3 Interpretable Features

Importantly, LF interprets only certain features; only the interpretable features can enter LF. Interpretable and uninterpretable features are exemplified in the following. The sentence (1) is taken from Chomsky (1995, p. 277):

(1) "We build airplanes."

Grammatical features come in two types: the intrinsic features, which are mostly listed in the lexicon, and the optional features, which are added arbitrarily. The intrinsic and optional features of the words in (1) can be distinguished, as shown in (2a, b), taken from Chomsky (1995, p. 277):

(2) Intrinsic features:

a. Categorial features:

[1st person] in (we)

[3rd person] and [-human] (airplanes)

[assign accusative case] in (build)

[assign nominative case] in (T)

b. Optional features:

[plural] for the nouns

θ-features of *build*

The interpretability of features does not depend directly on their being categorical or optional (Chomsky 1995, p. 278). The interpretable features, in general, are characterized as the categorical features and the θ-features of nominals. However, the optional feature [±plural] of the nouns in (2b) is also interpretable, and can enter into LF (Chomsky 1995, p. 278).

2.1.2.4 Empirical Evidence on the Modularity of the Language Faculty

The above sections describe and discuss the theoretical assumptions on the modularity of mind and the modularity of language faculty. This section presents empirical evidence in support of these theoretical views based on Curtiss's (2013) review, whereby she classified the relevant studies into two types (Curtiss 2013, p. 68):

1. Those showing the characteristics of the language faculty as a modular mechanism, i.e., it is sensitive specifically to linguistic knowledge, it functions fast and mandatorily
2. Those showing that the language faculty consists of distinct domain-specific sub-modules

The studies that fall into the first type are electrophysiological investigations that used various techniques, such as recording event related potentials, optical scanning, or magnetoencephalography to examine the time windows of neural responses to linguistic and non-linguistic sound stimuli (Curtiss 2013, p. 71). A set of these studies (e.g., Phillips et al. 2000; Dehaene-Lambertz et al. 2002), for example, indicated a distinction on neural areas and cognitive correlates that are involved in processing linguistic and non-linguistic sounds. This evidence leads to the conclusion that each stimuli type (linguistic vs. nonlinguistic) is processed in distinct regions of the brain.

In line with these results, studies on individuals with selective deficits reported a double dissociation between linguistic processing and other cognitive processes. For instance, individuals with Asperger's syndrome or autism maintain normal grammars but have deficits in social interaction and communicative competence; individuals with Specific Language Impairment (SLI) have good non-verbal communication abilities alongside their impaired grammars; linguistic savants[4] have advanced linguistic abilities regardless of their cognitive deficits (e.g., Smith and Tsimpli 1995); and individuals with agrammatic aphasia have largely intact intelligence, along with difficulties in producing functional grammar structures (e.g., Bay 1964; Varley and Siega 2000).

The studies that fall into the second type further distinguish subsystems such as the lexicon, morphosyntax, and semantics within the grammar of speakers (Curtiss 2013, pp. 80, 86). For instance, aphasic speakers have selective impairments within:

- The lexicon, and more specifically in closed class elements (Bradley et al. 1980; Caramazza 1988; Jodzio et al. 2008)
- Morphology, which affects derivational and inflectional morphology differently (Thompson et al. 2002)
- Syntax (Grodzinsky 1986; Grodzinsky and Finkel 1998; Bastiaanse and van Zonneveld 1998; Bastiaanse and Thompson 2003; Buchert et al. 2008)

Similarly, individuals with SLI have selective deficits only in a single domain, such as phonology, syntax, lexicon, or pragmatics. Detailed analysis can detect discrete deficits on marking finiteness, tense, agreement, or a primary deficit in affixal morphology, verb movement, or hierarchical complexity (Friedmann and Novogrodsky 2008).

The functional magnetic resonance imaging studies also distinguish neural responses for syntactic and semantic processing (Newman et al. 2001), and lexical and syntactic processing (Indefrey et al. 2001).

All in all, both theoretical and empirical assumptions point to a modular language faculty.

[4]Linguistic savants are mentally deficient individuals with intact grammars and advanced linguistic abilities (Smith and Tsimpli 1995).

2.1.3 Parallel Architecture Model

Jackendoff (2002) provides a comprehensive description of the internal organization of the linguistic system, the sub-modules in this system, and their contents and characteristics based on and mostly in agreement with the views on modularity of cognitive mechanisms (Fodor 1983) and a domain-specific language faculty (Chomsky 1995). Jackendoff, further proposes a cognitive model that accounts for the real-time processes during language perception and production. The following two sections present the cognitive model proposed by Jackendoff. His views on the language faculty are presented in Sect. 2.1.3.1, and on the modularity of the cognitive systems in Sect. 2.1.3.2.

2.1.3.1 Language Representation and Processing in the Parallel Architecture

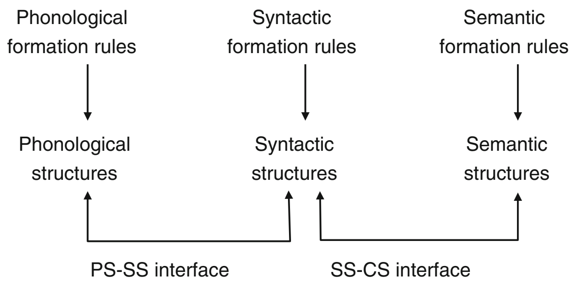
Jackendoff suggested that grammar has multiple, parallel sources of combinatoriality, where phonology, syntax, and semantics create their own characteristic structures (2002, p. 107). According to Jackendoff, "language comprises a number of independent combinatorial systems, which are aligned with each other by means of a collection of interface systems" (2002, p. 111). Syntax is one of these combinatorial systems, but it is certainly not the only one.

Figure 2.3 depicts the tripartite organization whereby syntactic structure serves as a "way station" between conceptual and phonological structures (Jackendoff 2002, p. 126). The intermediate position of syntax, between semantics and phonology, does not signal centrality (Jackendoff 2002, pp. 126, 198).

Jackendoff proposes the above architecture with multiple generative components —phonology, syntax, and semantics—which represent a set of independent structures, each having its own set of characteristics and combinatorial principles. These generative components are linked to each other by the interface components (Jackendoff 2002, p. 129).

Jackendoff pointed out the need for a serious account of meaning, without which a theory of language would be incomplete (2002, p. 270). Jackendoff considered semantics to be a distinct unit, and suggested that although all semantic content could

Fig. 2.3 Tripartite parallel architecture. Adapted from Jackendoff (2002, p. 125)



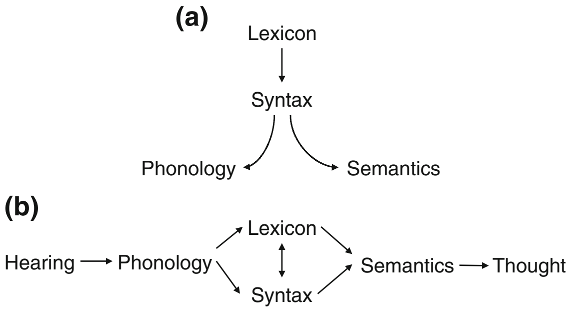


Fig. 2.4 Logical directionality in language perception and production (**b**) compared to the logical directionality of competence in Chomskian model (**a**) Adapted from Jackendoff (2002, p. 197)

be evacuated from syntactic structure, semantics is not *derived* from syntax but is correlated with it by means of an interface (Jackendoff 2002, p. 124). In the parallel architecture model, semantics is assumed to be the organization of thoughts that language can express (Jackendoff 2002, p. 123); language converts thoughts into syntax and phonology (Jackendoff 2002, p. 124). A cognitive organization called *conceptual structure* (CS) represents semantics in this model. Rather than solely being part of the language, CS is part of thought. CS interprets the linguistic utterances within context, and takes pragmatic considerations in the presence of “world knowledge.” Thus CS supports reasoning and planning and it operates on structures such as logical connectives, functions that take arguments, quantifiers that bind variables, and the relation of assertion to presupposition (Jackendoff 2002, p. 124).

In the parallel architecture model, the lexicon consists of words stored in the long-term memory, consisting of a small chunk of phonology, a small chunk of syntax, and a small chunk of semantics (Jackendoff 2002, p. 130). These chunks act in accordance with a small scale of the three-way interface rule; instead of entering into the syntactic derivation at some point, lexical items themselves correspond to syntactic constituents with phonological and conceptual structures (Jackendoff 2002, p. 131). Figure 2.4 illustrates the contradiction between the logical directionality of competence in Chomskian language model (presented in Sect. 2.1.2) (Fig. 2.4a) and that of language perception and production (Fig. 2.4b). The logical directionality of speech perception has to proceed from sounds to meanings, and speech production has to proceed from meaning to sounds (Jackendoff 2002, p. 197).

By virtue of being non-directional, the parallel architecture goes beyond providing a competence account, and unites linguistics with psycholinguistics; it is a theory of processing that accounts for how a language user creates structures for perceived and produced sentences in real time (Jackendoff 2002, pp. 196−197). Along these lines, the grammar should be understood as logically non-directional without having any inherent bias toward perception or production (Jackendoff 2002, p. 198). Parallel architecture allows a process to start at any component and pass along logical pathways to construct a larger coherent structure (Jackendoff 2002, p. 198). For instance, a process can start with phonology and construct

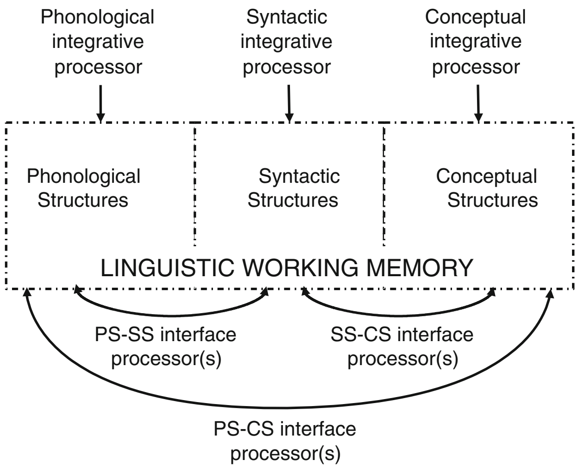


Fig. 2.5 Language processing and production in the parallel architecture model. Adapted from Jackendoff (2002, p. 199)

corresponding syntax and semantics via the interfaces. This model provides a route between sound and meaning, mediated by syntax and the lexicon, where the lexicon is part of the interface components (Jackendoff 2002, p. 200). This model is depicted in Fig. 2.5.

Beyond being a storage space for linguistic material, working memory is understood as a dynamic "workbench" or "blackboard" on which the processors operate in order to assemble linguistic structures. It has three divisions (departments or buffers) corresponding to the three levels of linguistic structure. In other words, it is composed of three functionally separate working memories, i.e., phonology, syntax, and semantics (Jackendoff 2002, p. 200).

Each linguistic structure has its own formation rules and processors. These processors are of three types (Jackendoff 2002, p. 198):

1. *Integrative processors* construct a structure at a given level by using the formation rules.
2. *Interface processors* link the different levels of structures.
3. *Inferential processors* operate on full or partial structures in a particular format in working memory, and link them to (or construct) new structures in the same format. The task of the third processor is similar to the rules of inference, which derive new conceptual structures from existing ones; it may, for instance, compare two phonological structures and check whether they rhyme.

2.1.3.2 Structural-Constrained Modularity with Interfaces

As typical of the modular systems described in Sect. 2.1.1, each module is strictly domain-specific in the parallel architecture. Therefore, the distinct integrative and inferential processors described above operate only on a certain structure level, whereas the interface processors are "bi-domain-specific" and they operate on two structure levels which they link to each other (Jackendoff 2002, p. 220). These generative modules are also informationally encapsulated; a module can only influence, interpret, and operate on its own input, and no other cognitive process, such as general inference or contextual understanding, can intervene in its operation (Jackendoff 2002, pp. 219, 220).

Importantly, Jackendoff realized the need to create stronger connections between the modules. If the modular capacity disconnects the linguistic modules from the rest of the mind and from each other, a linguistic module cannot support a goal such as belief fixation (i.e., to determine the truth value of an utterance), because a belief has to be worked out in terms of thought in general at the CS (Jackendoff 2002, pp. 221, 222). Thus, the linguistic modules need to access the information stored in the CS. The interface modules enable the access between the informationally encapsulated modules in Jackendoff's structure-constrained modularity (Jackendoff 2002, pp. 221, 222). Interface modules can read the materials on the memory (or blackboard) of more than one module; for instance, they can simultaneously access the input of CS and syntactic structures (Jackendoff 2002, p. 228).

2.2 Overview of Linguistic Interface Research: Evidence from Child and Agrammatic Speech

The theoretical assumptions presented above provided an insight into psycholinguistic research and inspired investigations on language processing on structures that require the functioning of various interface modules, such as the semantics-syntax interface, pragmatics-syntax interface, and so on, in an attempt to understand the grammar of normally developing monolingual children at various stages of acquisition, and the deficient or impaired areas in grammar of speakers with various disorders, such as SLI or acquired aphasia. This line of research has been followed by studies on bilingual language acquisition and maintenance, with particular regard to the non-native-like patterns, such as semantically or pragmatically inappropriate production or comprehension of linguistic structures.

Below, I review the research questions and discuss the findings of previous studies on linguistic interfaces, with specific focus on the semantics-syntax and pragmatics-syntax interfaces. First, in Sect. 2.2.1, I present various observations and empirical evidence on the problematic grammatical structures, such as those that are difficult to acquire in child language acquisition, deficient in SLI children or impaired in agrammatic speech. In particular, I lay out the very first accounts of the representation and processing of structures at linguistic interfaces. In Sect. 2.2.2 I focus on those studies that revealed a systematic pattern regarding the non-native-like behavior in children's speech. In Chapter 3 I present studies on linguistic interfaces in the context of bilingual language acquisition, attrition, and near-native L2 learners. Building on these, in Sect. 3.3 I describe how the Interface Hypothesis (IH) is formulated, discuss its implications, and present the criticisms directed at various aspects thereof. This review also points to apparent contradictions and gaps in the outcome of the previous studies, which subsequently lead to the research aims of this book (in Chap. 4).

2.2.1 Differentiating Narrow-Syntax and Interface-Syntax

2.2.1.1 C-Domain Vulnerability

Platzack investigated the syntactic interfaces within the MP framework. In MP, the clause universally consists of three phrases: the Verb Phrase (VP), the Inflectional Phrase (IP), and the Complementizer Phrase (CP) (Chomsky 1995). Platzack suggested that the system of thought accesses the linguistic system at three levels that correspond to the three phrase types. These levels have their own syntactic projections and hypothetically their own interface meaning, which is strongly related to the domain of the relevant level. These domains are:

- The VP: composed of different VP shells (Larson 1988; Chomsky 1995); concerned with the predicate-argument structure (theta-structure) of the clause
- The IP: composed of a Tense Phrase (TP) and an Agreement Phrase (AgrP) (Pollock 1989); concerned with the purely grammatical aspects of the clause
- The CP: composed of functional projections such as Fin(ite)P(hrase) and ForceP(hrase) (Rizzi 1997); concerned with the links between the propositional content of the clause and the discourse

Platzack assumes that the computational system first selects an element from the mental lexicon, and this element becomes accessible to each of these three levels to be assembled (2000, p. 21). More precisely, the lexical entities selected from the mental lexicon are first merged into a phrase structure (the V-domain), and the dual information from the functional projections of the lexicon and V-domain is then merged in order to expand the phrase structure into the I-domain. Lastly, at the highest interface level, the dual input from the I-domain and the lexicon is merged in order to expand the phrase structure into the C-domain (Platzack 2000, p. 24). These three domains, namely the V-domain, the I-domain, and the C-domain, represent different steps in the computational process and each has a corresponding interface: the ‘thematic form’ (TF), the ‘grammatical form’ (GF), the ‘discourse form’ (DF), and ‘phonetic form’ (PF) (Platzack 2000, p. 24), as depicted in Fig. 2.6.

In this model, information on the thematic roles and the modification of the event are exchanged at the TF interface, and information about grammatical meaning is exchanged at the GF interface (Platzack 2000, p. 38). The information exchanged at these two domains (TF and GF) are purely syntactic, whereas the information exchanged at the DF is concerned with the pragmatic properties and the sentence types used in a certain context (the speaker’s here and now) (Platzack 2000, pp. 25, 38). The DF operates on values at the C-domain, such as speech-act systems and

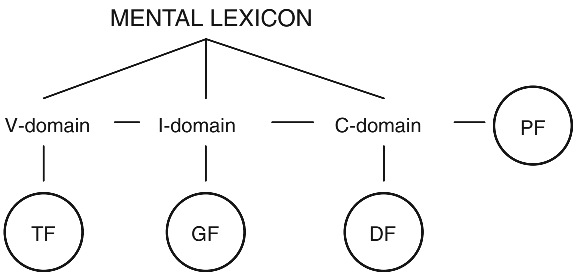


Fig. 2.6 Computational model and multiple interfaces. Adapted from Platzack (2000, p. 23)

information structure (i.e., focus and topic status of the arguments) among other discourse-related phenomena (Platzack 2000, p. 33).

Following Rizzi (1997), Platzack referred to the IP and the phrases lower than that as the I-domain. He considered the C-domain to have at least two parts, one outward-facing part, which is a sentence type projection which indicates whether the sentence is interrogative, imperative, or declarative, and an inward-facing part with a finite head, which licenses tense and mood in the IP. Tense provides the time frame, and finiteness integrates this time frame into the present moment of speech (Platzack 1999, p. 365). The C-domain links the information at the IP and the VP to the discourse and closes the I-domain (Platzack 1999, p. 365).

Platzack tested these assumptions on Swedish-speaking early L1 and L2 learners, children with SLI, and speakers with Broca's aphasia. He investigated production of four different C-domain structures: (1) obligatory finite verb, (2) verb second, (3) obligatory subject, and (4) wh-questions and two I-domain structures: (1) the non-finite verb preceding the direct object and (2) the verbal particle preceding the direct object.

The results[5] revealed that the speakers had difficulties only regarding the first set of structures; they produce non-target-like C-domain structures whereas they produce native-like I-domain structures (Platzack 1999, p. 367). Although the participants tested in this study belonged to many different age and pathology groups, their behavior was strikingly similar with respect to the syntactic phenomena under investigation. The selective nature of the speaker difficulties does not indicate a knowledge access problem, because these speakers sometimes also performed well at the C-domain, which proves that they can access C-domain representations. As there were also Broca's aphasics in the C-group, Platzack attributed the non-target-like production of the C-domain syntax to Broca's area (Platzack 1999,

[5]As native language production takes place quickly and accurately because of incremental processing (a processor can start working while another one is already working at the same time), frequent hesitations, anacoluthons, and occasional slips of the tongue were considered as byproducts of automatic and parallel processing of the subcomponents in the mind. Thus, 2 % of the errors were considered as target-like production, and the remainder non-target-like (Platzack 2001, p. 365).

p. 374). Platzack suggested that the speakers' difficulties stemmed from the demanding computational process of linking linguistic information to discourse at the C-domain.

Overall, Platzack showed that the speakers easily integrate various grammatical structures at the I-domain whereas they have difficulties performing a higher-level process that integrates the grammatical information into the discourse context at the C-domain.

2.2.1.2 Optional Versus Obligatory Structures

Jakubowicz and Nash (2001) expected difficulties in production of context dependent optional structures, in comparison to that of obligatory ones that are the same across all contexts. They hypothesized that the complexity of a structure depended on its being obligatory or optional, the latter being more complex. They took the tense system in French as a test case.

In French, time reference is marked by tense feature on the verb, as in Passé Simple. However, the past punctual events in spoken French are expressed by Passé Composé, which requires the use of a lexical verb in the infinite form—in other words as a participal—in combination with one of the finite auxiliaries *avoir/être* ("have/be").[6] Unlike Passé Simple, which is expressed by marking the tense on the verb, the tense feature is represented by a separate "word" or morpheme in Passé Composé (Jakubowicz and Nash 2001, p. 325). For this reason, the past tense in French is predicted to require a more complex syntactic computation and therefore leads to difficulties (Jakubowicz and Nash 2001, p. 336).

The results of a production test pointed to a split between the present and the past tense in French. Whereas the present tense was correctly produced and understood by both the normal and SLI children, the past tense was avoided, or misproduced and misunderstood, predominantly by the SLI children. Considering the assumptions regarding the variation in the complexity of these structures, Jakubowicz and Nash (2001) proposed the 'Computational Complexity Hypothesis,' according to which the level of computational complexity of the functional categories determines:

1. The order of acquisition of the functional features in normally developing children
2. The impairment patterns in the SLI children

Thus, the optional structures requiring further semantic modifications in the sentence are concluded to be more difficult to compute than the kernel functional categories (which obligatorily occur in every sentence) (Jakubowicz and Nash 2001, pp. 324, 337).

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[6]The choice between the auxiliaries depends partly on the valence of the lexical verb (Jakubowicz and Nash 2001, p. 325).

2.2.1.3 Narrow Versus Broad Syntax

As described above, an internal interface at the D-structure mediates between the lexicon and the computational system and provides the performance systems with linguistic representations. The performance systems then interpret the sound and meaning of these representations at the external interfaces, at PF and LF (Chomsky 1995). Avrutin distinguished the values on which the internal and external interface modules operate, and the types of processes they perform (Avrutin 2004, p. 95). Concerning the processes beyond the narrow syntax, he followed Jackendoff (Avrutin 2004, p. 113).

Although any operation that generates structures can be called ‘syntax,’ Avrutin suggested a distinction on types of values that syntactic processes operate on (Avrutin 2004, p. 96):

1. Narrow syntactic values that produce only grammatical strings, such as words, morphemes, or syntactic entities such as DP, VP, etc.
2. Non-syntactic values that link the output of the narrow syntax with the system of thought in the broader sense, i.e., properties that establish referential dependencies, encode old (given) or new information and determine discourse topics and introduce discourse presuppositions

In this view, the production and interpretation of structures constrained by discourse properties require advanced computational processes that are beyond the operations on the narrow syntax and are more demanding; these processes require the integration of grammatical properties into the discourse.[7] (Avrutin 2004, p. 96). Avrutin presented examples of such structures, the grammaticality of which can only be judged in relation to discourse-related concepts (Avrutin 2004, p. 97).

For instance, the extraction of a wh-phrase in English becomes more acceptable when it is linked to a presupposition that informs about the existence of some specific set of objects, as in (3), taken from Avrutin (2004, p. 97):

(3) **a.** *Mary asked what who read

b. Mary asked what which man read

The definite DPs with specific discourse functions can appear as associates for expletive ‘there,’ as in (4), taken from Avrutin (2004, p. 97):

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[7]The notion ‘discourse’ here is used in a technical sense to refer to a computational system that operates on the non-syntactic symbols and not on the narrow syntax symbols (Avrutin 2004, p. 96). Avrutin used the notions of discourse, conceptual-intentional interface, or the information structure interchangeably (Avrutin 2004, p. 96), because he viewed discourse as the place at which the output of the narrow syntactic processes are interpreted.

(4) **a.** **There were** *the* same people at both conferences

b. What's worth visiting here? **There is** *the* park, a restaurant, and the library

c. **There was** *the* wedding picture of a young black couple among his papers

In Russian, a sentence can be tenseless when it is preceded by a completed event with a specific temporal discourse point of reference, as in (5a). If not, the specific time reference should be made as in (5b), taken from Avrutin (2004, p. 98):

(5)	**a.**	*Korol'*	*rasskazal*	*anekdot.*	*Princessa*	*xoxotat'!*
		King	has-told	a joke.	Princess	to laugh!
	b.	*Korol'*	*rasskazyval*	*anekdot.*	**Princessa*	*xoxotatj'!*
		King	was-telling	a joke.	*Princess	to laugh!

The grammaticality of the above sentences is constrained by properties such as referentiality, topicality, specificity, and similar. These examples portray cases in which interpretation of properties that do not belong to narrow syntactic domain is crucial in language use (Avrutin 2004, p. 98).

Avrutin presents empirical evidence for the split between narrow syntax and syntax in the broader sense where the latter is more difficult to interpret and produce. For instance, both normally developing children and agrammatic speakers (Broca's aphasics) perform poorly when they have to identify a specific discourse referent in a picture that answers the question in (6a), whereas they perform above chance level when they answer a question such as (6b) that does not demand discourse level knowledge. The examples are taken from Avrutin (2004, p. 98):

(6) **a.** Which tiger did the lion chase?

b. Who did the lion chase?

Children tend to accept the sentence in (7) when presented with a picture depicting a boat with a red flag sailing past a house with a green flag. The example is taken from Avrutin (2004, p. 99):

(7) *Er vaart een boat voorbij. De flag is groen.*

There sails a boat by. The flag is green.

This pattern indicates that the children may rely on non-linguistic, deictic sources of information during language processing (Avrutin and Coopmans 2000).

Furthermore, children omit infinitives and determiners in early acquisition periods, as in (8), taken from Avrutin (2004, p. 110):

(8)	*Brug*	*maken*	[Dutch] (Niek, 2; 10)
	Bridge	to-make	

Similarly, Broca's aphasics also often omit the determiners and tense markers (De Roo 1999; Kolk 2001), as in (9), taken from Avrutin (2004, p. 110):

(9)	*'T*	*kindje*	*enetjes*	*wat*	*krijgen*	[Dutch] (patient G.S.)
	The	child	just	something	to-get	

In order to judge grammaticality such sentences accurately, the speakers need to integrate the syntactic representations into the discourse (Avrutin 2004, p. 99); tense introduces new events and determiners introduce new entities into the discourse (Avrutin 1999; Baauw et al. 2001).

In the above examples both children and agrammatic speakers omit discourse relevant structures and this is accounted by assumptions on language representation and processing respectively (Avrutin 2004, p. 110). According to the knowledge representation account, the children have difficulties producing and interpreting the values beyond narrow syntax because they have not acquired this knowledge yet; and the agrammatic aphasics lose exactly the same linguistic knowledge because of brain damage (Avrutin 2004, p. 110). According to the language processing account, on the other hand, children and the agrammatic speakers lack the necessary computational sources for operations on values beyond the narrow syntax because children have immature brains, and agrammatic speakers have brain damage. The fast, automatic conduction of syntactic operations on values beyond the narrow syntax, such as discourse presupposition, exert additional processing demands (Vincenzi 1991; Frazier and Clifton 2000). In particular, these speakers lack the sources that could perform such demanding processes. Children and agrammatic speakers cannot integrate grammatical and discourse-related knowledge because they cannot hold two representations (syntax related, bound variable anaphora on the one hand and discourse-related coreference on the other) in their working memories (Chien and Wexler 1990; Grodzinsky and Reinhart 1993).

However, it needs to be underlined here that the omissions illustrated above are, strictly speaking, not ungrammatical; indeed, they constitute an alternative within the limits of a natural language. If these speakers have limited processing sources and if syntactic processing competes with non-syntactic processing, it is within expectations for syntactic processing to win in most cases as it is the most economical source, even in normal adult grammar (Avrutin 2004, p. 111). This explains the individual variation among the speakers; the syntactic computation wins most of the time, but as the non-syntactic computation also participates in the competition it may also win in some of the cases. Thus, it is not surprising to find speakers who overuse overt structures instead of omitting them. Thus, it is also within expectations to observe children and agrammatic speakers who use overt determiners and tensed clauses (the narrow syntactic source wins), or determinerless NPs and non-finite utterances (the non-syntactic source wins) (Avrutin 2004, p. 111).

Overall, Avrutin distinguished narrow syntax from broad syntax[8]; the former operates on a single level, namely syntax, whereas the latter operates on two levels, syntax and discourse. Discourse level knowledge is beyond the syntax; it is linked to thought in general, i.e., semantics and pragmatics at CS (in the sense of Jackendoff). For the cognitive system to operate on discourse values, the working memory needs to hold both the grammatical and discourse level knowledge, which is more demanding then dealing with only a single knowledge domain.

2.2.2 Non-target-like Interface-Syntax in Children

Here I present studies that point to a systematic non-target-like use of structures relevant to syntactic interfaces in child speech. This pattern emerges as a result of a high sensitivity to pragmatic constraints; this sensitivity regulates children's production and interpretation of syntactic constituents in a linguistic context. Interestingly, although different to the grammar of adult speakers, the grammar of children exhibits a pattern within the range of language-specific pragmatic rules and language universals.

2.2.2.1 High Sensitivity to Pragmatic Properties in Children: Evidence from Language Production

Allen (2000) examined discourse constraints on the use of overt and null arguments (subjects and objects) in child speech. Children tend to omit arguments regardless of whether they speak a language that strictly prohibits argument omission (as in English and Danish), permits argument omission in topic-drop contexts (as in Dutch and German), or freely allows argument omission (as in Chinese, Japanese, Korean, and Turkish) (Allen 2000, p. 483). This might stem from an early (hyper) sensitivity to the pragmatic features of discourse (the dynamics of information flow in context) (Allen 2000, pp. 485, 486).

Allen predicted children to use arguments in line with the 'principle of informativeness' proposed by Greenfield and Smith (1976), according to which the

[8]The terms narrow syntax and interface syntax are used throughout the dissertation, instead of using terms such as interface structure or broad syntax, etc.

'informativeness' determines use of overt arguments. An overt argument is informative when its referent is uncertain, whereas it is uninformative when its argument has already occurred earlier in the discourse or it is presupposed. Informativeness of an argument correlates with its givenness and newness status; the arguments with an earlier mention are given (old), whereas the arguments unknown to the hearer are new (Bloom 1990; Valian 1991; Hirakawa 1993).

Allen tested children speaking Inuktitut,[9] which allows both subject and object omission. When these arguments are omitted, verbal affixes inform about person and number (2000, p. 490). Analyses of children's naturalistic communication data yielded an overuse of arguments. Further analyses that considered informativeness as a factor, however, revealed that this pattern is systematical and pragmatically appropriate.

When Allen operationalized the binary features,[10, 11] that influence argument representation across languages and included these as the factors in her analysis (Clancy 1980; Greenfield and Smith 1976; Givón 1983; Chafe 1987; Du Bois 1987), it became apparent that children use informative arguments significantly more often when compared to uninformative ones (Allen 2000, p. 511). This result points to a sensitivity to discourse-pragmatic factors in overt or null argument selection in child speech.

These results may also have crosslinguistic implications. For instance, they might explain argument omission of English-speaking children in the earlier stages of language acquisition (Allen 2000, p. 486). This is arguably because at the earlier stages they rely on discourse factors when choosing an overt or a null argument, whereas, upon realizing that English requires overt arguments obligatorily, they start producing an increasing number of uninformative overt arguments. Thus the discourse-pragmatic account proposed here successfully predicts the argument choice of children across discourse contexts (Allen 2000, p. 514).

Overall, children behave non-target-like in production of interface-syntax structures. However, this non-target-like pattern in children's speech does not yield overuse or random use; children choose the interface syntax structures in line with language-specific pragmatic rules and crosslinguistic tendencies.

2.2.2.2 High Sensitivity to Pragmatic Properties in Children: Evidence from Language Comprehension

Hoop and Krämer (2006) investigated the interpretation of referential status of subject and object arguments in children. Regardless of the constituent order or

[9]Inuktitut is a language of the Eskimo-Aleut family spoken in parts of northeastern Canada.

[10]A value is uninformative if it makes the identity of the referent less certain (new), while the other is informative if it makes the identity of the referent more certain (given).

[11]The absence or newness of a referent, whether a referent is contrasted to or differentiated from another in the context, and animacy and person number of the referent were among the factors examined (Allen 2000, pp. 488, 489).

grammatical properties that may influence the referentality of arguments, children tend to perceive indefinite objects as non-referential, and indefinite subjects as referential (Hoop and Krämer 2006, p. 103). For instance, English-speaking children and adults differ in their interpretation of the sentence in (10) (Lidz and Musolino 2002), taken from Hoop and Krämer (2006, S. 103):

(10) Donald didn't find two guys.

Adults provide two alternative readings for the sentence; in one, the object noun phrase is non-referential, as in (11a), and in the other it is referential, as in (11b). Children, on the other hand, consistently provide one type of reading, in which the object is non-referential as in (11a), taken from Hoop and Krämer (2006, p. 104):

(11) **a.** It is not the case that Donald found two guys, maybe he found one guy.

b. There are two specific guys that Donald didn't find; he may have found several other guys but not those two.

The Dutch-speaking children show a similar tendency (Krämer 2000). In Dutch, the indefinite object noun phrase can occur either to the right of the adverbial phrase (referred to as the scrambled position), as in (12), or to the left of it (referred to as the unscrambled position) as in (13), taken from Hoop and Krämer (2006, p. 106):

(12)	*Je*	*mag*	*twee*	*keer*	***een***	***potje***	*omdraaien*
	You	may	two	time	a	pot	around-turn
	'You may turn a pot twice.'						

(13)	*Je*	*mag*	***een***	***potje***	*twee*	*keer*	*omdraaien*
	You	may	a	pot	two	time	around-turn
	'You may turn a pot twice.'						

In Hopp and Krämer's (2006) study, both children and adults perceived objects in the unscrambled position as referential, but they differed in their interpretation of the objects in scrambled position; children (aged between 4; 0 and 8; 0) assigned a non-referential status to these objects, whereas adults assigned referential. Another study showed this pattern to persist till the age of 12 (Unsworth 2005).

English-speaking children correctly read the indefinite subjects as referential, as in (14) (Musolino 1998), and in Dutch, as in (15) (Klein 1996), examples taken from Hoop and Krämer (2006, p. 106):

(14) Some horses won’t jump over the fence.

Children understand that some horses jumped over the fence and some did not in (14). They understand that ‘a certain girl’ is the agent in (15) (Dutch does not allow a non-referential reading for this sentence):

(15)	*Een*	*meisje*	*gleed*	*twee*	*keer*	*uit.*
	A	girl	slipped	two	time	out

‘A girl slipped twice.’

The subject-object asymmetry extends to the perception of indefinite subjects as well. Although adults opt for a non-referential interpretation, children assign a referential interpretation to the subject of the sentence in (16) (Termeer 2002), taken from Hoop and Krämer (2006, p. 106):

(16)	*Er*	*ging*	*twee*	*keer*	*een*	*jongen*	*van*	*de*	*glijbaan*	*af.*
	There	went	two	time	a	boy	from	the	slide	off

‘A boy went down the slide twice.’

To summarize, children invariably perceive objects as non-referential and subjects as referential, regardless of the constituent order or any other grammatical feature such as definiteness. The non-target-like trend in argument interpretation of children accords with the crosslinguistic observations (Hoop and Krämer 2006, p. 107). Crosslinguistically, the subjects tend to be referential, definite, topical, animate, and high-prominent, whereas objects tend to be non-referential, indefinite, inanimate, and low-prominent in the discourse (Aissen 2003; Comrie 1989; Lee 2003). Thus, typological generalizations can be suggested to explain the nature of non-target-like patterns in child speech.

Taken together, the findings discussed in this section show that the semantic and pragmatic features control the production and interpretation of interface-syntax structures, which results in patterns that accord with linguistic universals. What seems to be an overuse or random use/interpretation might indeed yield systematicity. Thus typological insights may shed light on the speakers’ behavioral and grammar representational patterns regarding interface-syntax.

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