Grammar as a Maturationally Controlled Behavior: Minimality in Development and Impairment

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Much is already present in the organism, only needing to be activated.
—Noam Chomsky

1. Introduction

In his seminal book on the *Biological Foundations of Language*, Eric Lenneberg proposed that a critical period similar to the one necessary for maturational controlled behaviors applies also to language acquisition (Lenneberg 1967). The notion of a critical period, a maturational stage during which the nervous system is sensitive to specific aspects of the environment, has been considered crucial for language acquisition theories based on the assumption of a biologically predetermined language faculty that needs to be activated by favourable internal and environmental circumstances. Chomsky wrote:

> A consideration of the character of the grammar that is acquired, the degenerate quality and narrowly limited extent of the available data, the striking uniformity of the resulting grammars, and their independence of intelligence, motivation and emotion state, over wide ranges of variation, leave little hope that much of the structure of the language can be learned by an organism initially uninformed as to its general character.
>
> (Chomsky 1965: 58)

The crucial assumption of the critical period hypothesis, as originally proposed, was that language acquisition has an immediate onset for its natural acquisition, and this onset is as early as birth, if not before. Language acquisition has also a predetermined offset, an ideal final state that needs to be completed/activated for reaching a full competence (see Meisel 2013 for a review). This makes the language acquisition process tailored to a restricted time window in which our cognitive development is sensitive to capture human language properties. Already in the 1980s, those who actually studied language development in children as young as newborns found that children quickly began to use a wide variety of cues during their critical period, including syntactic, semantic, and prosodic information. Many studies have investigated the timing and the nature of these cues implicated in the activation of the process of language acquisition in typical developing children, and there is general consensus on a very early onset of the critical period and

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benefit for early exposure to a rich linguistic environment, including during simultaneous acquisition of more than one language (see for example Mehler et al. 1988, Dehaene-Lambert et al. 2006; Nazzi & Ramus 2003).

A different issue is posed by the study of the other side of the critical period hypothesis, the biological timing for an offset of the language acquisition process. This offset, in other words, involves the occurrence of a biological stage for optimal acquisition linked to early maturational factors that ended early, favouring learning of increasingly complex skills at sequent stages.

A very early offset for the acquisition of language was recently proposed by Friedmann and Rusou in a paper reviewing data on syntax—in particular derived sentences with long distance dependencies—in children with hearing loss from birth and adults with a special case of malnutrition, a thiamine deficiency occurring during the first year of life (Friedmann & Rusou 2015, Friedmann & Szterman 2006, Fattal, Friedmann & Fattal-Velevsky 2011). The fundamental argument in these studies is that some aspects of syntax are affected by lack of language input (as in the case of hearing loss) or by a neurocognitive deficiency (as in the thiamine deficiency group) as early as one year old. This very early offset for language advocates for an urgent requirement to activate the acquisition process. Furthermore, the idea is that selective aspects of the language system require early acquisition and that this is particularly true for syntax. Aspects of language acquisition, such as lexical knowledge, could be acquired after the critical period offset, while syntactic knowledge crucially requires optimal internal and external conditions very early. The consequence of the proposal of an early offset for syntax is that specific and well-known aspects of sentence structures, such as movement-derived sentences—or grammatically based intervention structures that will be described below—although occurring later in life (many crosslinguistic studies reported above chance comprehension and production for object moved sentences after 7 years old) require appropriate input and typical development of the neurological substrate of our receptive system during the first year of life.

Pursing the hypothesis of an early offset for syntax has the main logical consequence of a *strictu senso* neurobiological maturation approach for language, where we could suppose that the sentence has evolved because the brain has evolved. The opposite occurs with no exposure to a rich set of linguistic input or with a lack of a proper neurological condition, both being necessary for the complex process of the acquisition of syntax. Early cases of non-appropriate circumstances for language acquisition, such as the one discussed above, together with evidence of selective developmental disorders in specific areas of the language faculty, as the syntactic Specific Language Impairment (SLI) that will be discussed below, are often presented in support of the crucial role of a biological predetermined knowledge for language acquisition that needs to be activated by environmentally and biologically driven principles.

As linguists, we should reflect on the description of linguistic knowledge and its integration with a plausible developmental process compatible with the critical period hypothesis. This is still not clearly defined by theoretical models and criticism coming from neurodevelopmental psychologists on the insufficient level of integration of descriptive language models with biological principles of language

acquisition needs to be taken in consideration, aiming at convergent approaches for the study of language maturation in children:

> The problem is that the theories are derived from a consideration of adult language, and take no account of the process of development. There is a fundamental problem with an essential premise about what is learned that has led to years of confusion and sterile theorising.
>
> (Bishop 2012)

Many questions around how grammar is acquired, and what are the possible routes for understanding late emergence of some aspect of grammar, are still at the center of the debate in developmental language with little productive collaborations between linguists and developmental psychologists and many unresolved problems. Although the definition of the knowledge of language acquisition milestones has now reached incredible levels of detail, due to the amplification of crosslinguistic studies in different populations (see Guasti 2017 for an overview of the growth of grammar and Friedmann & Rizzi 2000 on the acquisition of syntax), the questions of which are the units for language acquisition and which are the developmental stages are still not clearly addressed.[1]

The main purpose of this paper is to point out that although the learning task for the emergence of grammatical knowledge remains a largely unaddressed issue, with no systematic or longitudinal studies on the acquisition of specific aspects of the grammar, a biological perspective, similar to the one proposed in Lenneberg's seminal work in the chapter on "Language in the context of growth and maturation," should be adopted to discuss some recent evidence coming from the studies of sentences with long distance dependencies. In particular, although difficulties with these kinds of structures were reported in diverse populations, the atypical production or comprehension in different populations can have different biological sources of differentiations. This is the case of children with syntactic SLI, a selective disturbance in syntactic dependencies and adults with aphasia, an acquired language disorder. Superficial similarities in the grammatical behaviours in these two atypical populations are based on different sources of impairment, fundamentally representational in children with syntactic SLI due to a disturbed critical period and caused by a lack of more general resources necessary for grammatical processing in adults with aphasia.

The biological perspective on the acquisition of language, like the one proposed in Lenneberg's seminal book, considers language as a maturationally controlled behavior (MCB). Any MCB is defined by a set of properties:

(A) a regular sequence of milestones correlated with age and other developmental factors;

(B) environmental stimulation as an opportunity for use;

[1] The lack of dialogue between linguistic theory and the neurobiological development of language, the so called Linking problem (see Fodor 2001) was not limited to the parameter-setting account, which described language acquisition as a process of "setting a switch" for a number of innately-determined parameters. Evidence, though, that children's grammars actually changes in discrete steps, is lacking and it is not clear which aspects of syntactic knowledge should be considered parametric and which is not part of the setting process.

(C) the emergence of the behavior before its use; and

(D) the evidence that this is not a sign of a goal-directed practice.

Points (A) and (B) are accounted for in any approach on language development, with obvious consequences and with several studies reporting data on cases of language deprivation (see Curtiss 1977, Crain 1991). More important for the syntax early offset hypothesis is to address the issue of precursors for the emergence of a specific grammatical behavior. What kind of potentialities of a given grammatical behavior need to be activated during language acquisition (point C) and as a consequence, are these "protogrammatical behaviors" used in diverse contexts, beyond imitation (point D)?

Starting from point (C), in the field of developmental psychology, the ability often reported as a precursor for grammatical learning is the one to extract regularity from the input. This is called statistical learning (see Obeid et al. 2016 for a recent review). Statistical learning accounts have been proposed as optimal tools to study the process beyond grammatical learning. Sensitivities to regularities of the input is considered an asset for learning, but not specific for language learning.

The main idea beyond grammar as MCB is that the properties to be acquired are internal to the grammatical system and are not based on frequency of exposure or cognitive general abilities of extracting regularities. The antithetic argument proposed in statistical learning approaches compared to an approach based on the maturation of grammatical knowledge is that instead of assuming that children start with knowledge of linguistic categories, categories are abstracted from statistical regularities in the input. An obvious argument in favour of the grammatically based maturational approach comes from study of discontinuous behaviours in grammatical development. Data on discontinuous development in the acquisition of grammar are scarce, but the few that are available support of emergence of grammar where exposure alone cannot account for the growth and development of grammar as an organic system (see for example Riches & Garraffa 2017 for a study on intervention effects in children).

This brief contribution illustrates the relation between the acquisition of grammatical knowledge, in particular long distance dependencies subject to intervention, and the accompanying deployment systems required to develop this grammatical knowledge.

The first section is devoted to the illustration of the syntactic phenomenon under investigation. The following two sections discuss special circumstances of acquisition and loss of competence with intervention structures, such as in the case of children with language impairment and adults with aphasia. Both cases are of considerable interest for theoretical models, given that both populations are far more sensitive to grammatically-based intervention effects compared to expert speakers due to their atypical computational system (see Garraffa & Grillo 2008 for language disorders in adults and Friedmann et al. 2009 for language acquisition, as well as Tsimpli et al. 2017 for an overview on language pathology in linguistics).

2. Grammatically-Based Intervention Structures

The last ten years have seen a proliferation of research on intervention effects in language impairment, processing and acquisition benefiting from the application

of the minimality framework, as originally proposed in linguistic theory studies (Rizzi 1990, 2004, Chomsky 1995). Focusing on language acquisition, minimality assumes that the nonadultlike behaviours during comprehension of Object Relative clauses or Object-extracted wh-elements can be described as a case of immature knowledge predicted by an immature grammatical system (see Friedmann, Belletti & Rizzi 2009, Belletti 2017). Children with poor production and comprehension of sentences based on intervention, and in particular sentence with structural similarity between the moved object and the intervening subject (as in 1a), are adopting a restricted version of locality and they are more sensitive to locality constraints. In particular, the model makes clear predictions for the syntactic context not fully developed in child systems, any representations similar to the one described in (1a) and (1b).

(1) a. +A ... +A ... <+A> (identity)
b. +A, +B ... +A ... <+A, +B> (inclusion)
c. +A ... +B ... <+A> (disjunction)

Between-group differences in both comprehension and production of sentences where minimality can induce grammatically-based interference effects have been found to be greater in conditions where there is overlap of features between lexically-restricted NPs (see Friedmann, Belletti & Rizzi 2009). This is fully represented in the identity condition, (1a), where there is no feature distinction between positions, making this structure highly complex. Subject dependencies are excluded in this system, since they do not include an intervener between the target and the trace and they do not induce intervention effects. Object dependencies may be a challenging structure to acquire, depending on the internal structure of the moved constituent and of the intervening element, the subject. The generalisation which emerges is that if the target of the movement and the intervening subject are sufficiently different in their internal structure, the configuration is unproblematic, where the critical differential element appears to be the presence or absence of a lexical NP restriction. This model assumes that the source of difficulties in children's grammatical development is based on a partial encoding of the grammatical information, not sufficient to parse (1a). Children adhere to a literal version, or stricter version of the locality principle, requiring distinct feature specifications for the target and for its intervener, and imposing a disjoint specification.

In these immature grammatical systems, an internal grammatical pressure of coping with the next level of the configuration, such as the one manifesting the hardest intervention configuration, could end with production of sentences barely used in adults and not attested in standard languages. This is the case for example of the avoidance strategies reported in children's production of passives in Italian and its substitution with a set of unattested forms in the matched adult competence (see Belletti 2017 for details).

Another important aspect of the acquisition of the grammatically-based intervention structures is the assumption of a genuine operation that needs to be acquired, or in biological terms, the assumption of a dissociation between general language abilities and performance on a specific operation. Dissociations between aspects of language competence are consistent with maturational accounts of language acquisition (Borer & Wexler 1987, Wexler 2003). For example, Wexler

(2003) notes that the disappearance of optional infinitives is completely uncorrelated with maternal education, IQ, or vocabulary scores, factors which are likely to be closely associated with general language learning abilities. This dissociation arises, according to Wexler, because the relevant linguistic knowledge (expressed as a parameter) adheres to a genetically-determined time frame. A similar argument could be put forward to explain the data reported in a recent study on intervention structures in children, where the performance on Object which-questions was reported as not correlated with aspects of performance on sentence comprehension in different grammatical conditions, such as subject-extracted questions or binding (Riches & Garraffa 2017). Intervention effects may be subject to a maturational constraint based on intervention and consequently they are divorced from other domain-general language abilities. By contrast, non-intervention structures which are not governed by such a constraint should show a stronger relationship with overall language abilities.

If this is the case, we should aspect to find in nature a developmental disorder selective for this operation, a dissociation in the process of acquisition of grammatical based intervention structures compared to the acquisition of other linguistic operations. We will now discuss some evidence in support of a selective impairment in grammatically-based intervention structures in children with developmental language disorders.

3. Developmental Language Disorders (DLD): The Case of Syntactic SLI

Lenneberg wrote:

> The development of children with various abnormalities provides the most convincing demonstration that the onset of language is regulated by a maturational process, much the way the onset of gait is dependent upon such a process but at the same time the maturational process is independent of motor-skeletal maturation. (Lenneberg 1967: 131)

According to this approach, internally to language mechanisms we can find a natural extension of basic principles of organization of behavior, which are adapted to the specific function of language. This function under natural conditions evolves to a richer level of organization of the stimuli surrounding a child.

> Both the perceived patterns and the self-produced patterns become organized or grouped in functional categories and hierarchies of category. Members of a particular category are functionally equivalent because they either elicit an identical response or they serve one and the same function within the over-all structure of a particular behavioral pattern. It is the general principles of differentiation and categorization that appear in specialized form in verbal behavior. (Lenneberg 1967: 325)

Interesting evidence for an impairment in linguistic knowledge as an effect of a divergent maturation of the grammatical system is the case of syntactic SLI children (Friedmann & Novogrodsky 2007). While typically-developing children with immature linguistic knowledge may nonetheless display appropriate interpretive behavior because of the way this partial knowledge is deployed (as presented in

section 2), children with syntactic SLI reveal a selective impairment of grammatical competence with no sign of immature behavior and no opportunities for natural development of the operation. These children have severe difficulties in understanding and producing movement-derived sentences subject to interferences, such as Object Relative clauses and Object Questions. Their problem is not related to the syntactic structure but to the mechanism to assign thematic roles in highly complex configurations as (1a). It is interesting to note that there is a consensus in the literature in identifying subgroups of language disorders in the large spectrum of developmental language impairment, with many studies reporting dissociations between different linguistic capacities (children with lexical retrieval deficit and intact syntax and children with poor phonological processing and no impairment of syntactic structures).

More important for the biological argument proposed here is the lack of evidence of development of the grammatical behavior in children with syntactic SLI, with no instances of grammatical strategies in their speech, for example to avoid complex sentences, and no indication of an immature propositional attitude as a source of delay. There is no syntactic adaptation in children with syntactic SLI and syntactic knowledge cannot develop independently to specific structure-frames. Similar evidence was reported in clinical studies: after training with a particular construction type, fluent automatic comprehension was not achieved in impaired children (Bishop, Adams & Rosen 2006).

More research on the mechanisms of grammatical learning and the role of effective input is needed in these children, to better define the optimal condition for input exposure, measuring the interaction between grammatical competence and exposure.

Recently, syntactic priming has been adopted to track the learning of a grammatical behavior in children with syntactic SLI (Garraffa, Coco & Branigan 2015). Syntactic priming, the tendency of reusing a structure previously used, has been proposed as an optimal tool for investigating children development of grammar, making it possible to track both the learning of a structure and the grammatical behavior beyond the attempted production in a predicted setting (Leonard 2011). Being primed by a recently heard structure is evidence of sensitivity for a grammatical pattern, but current studies on structural priming are not guided by theoretically-based predictions (though see Oltra-Massuet, Sharpe, Neophytou & Marantz 2017).

Preliminary results on the acquisition of subject relative clauses suggest that the impairment in children with syntactic SLI involves reduced initial learning from each syntactic experience, rather than atypically rapid decay following unimpaired initial learning. This result makes it necessary to better define the source of poor learning rates attested in these children, with in-depth investigations of their grammatical competence. Some studies found a deficit in children with syntactic SLI selective for comprehension of intervention structures, where children are avoiding structure with intervention, but it is not clear if the source of this lack of competence lays in a specific syntactic operation or if for some of them the deficit goes deeper in the tree-structure (Friedmann, Yachini & Szterman 2015). Language competence in children with syntactic SLI should be investigated within a richer model of the grammatical development, including sentences not attested in adult speech but grammaticalised in an immature system. The model of grammar should con-

sider grammar as a maturational behaviour and describe which grammatical behaviours are considered benchmarks for typical language acquisition, framing the research on language development with targets mirroring the children's biological system and not the adult competence.

4. Asyntactic Comprehension in Aphasia

Adults with non-fluent aphasic speech were extensively studied in their comprehension of syntactic structures, reporting a well-attested deficit in sentence comprehension of intervention-based effects (see Grillo 2008, Friedmann & Shapiro 2003, as well as Druks 2017 for a review of the theories on agrammatic aphasia).

While neurolinguistic studies have investigated the operational nature of Broca's area, aphasiology has not reached a level of integration with the theoretical models for the investigation and design of therapeutic programs. The lack of integration between linguistic theory and the neurobiology of language is not unique to aphasiology. It is a pervasive problem that still persists in the cognitive neuroscience of language at large, also in the absence of pathology (Poeppel & Embick 2005/2013). The role of Broca's area in language processing is still contested, whereas some researchers have attempted to link it to the neural network correlated with the computation Merge (Zaccarella & Friederici, 2015), while yet other researchers argue for an understanding of Broca's area as a kind of memory buffer.

Degrees of the activation of Broca's area were reported to depend on the number of interveners in a function magnetic resonance imaging (fMRI) study (see Santi & Grodzinsky 2007), supporting the idea that Broca's area is involved specifically in the processing of syntactic operations and that modulation of the activation is visible by manipulating the number of interveners in the sentence. Other recent evidence of a modular language-specific role of this area comes from research using transcranial direct current stimulation (tDCS; Garraffa & Sedda 2017). In this study, Broca's area (Brodmann areas [BA] 44/45) was temporarily inhibited in a group of healthy participants, while a sentence comprehension task was carried out. A second group of participants received the same stimulation in the temporal area (BA 22) of the left hemisphere, during the same comprehension task. An effect in term of reduction in the sentence comprehension was reported only for the group with the inhibition of Broca's area, supporting the hypothesis for a core functional engagement for syntactic processing with no involvement of the left temporal area for core processing of syntax.

The loss of (syntactic) processing abilities has been proposed to be at the core of the deficit in individuals with non-fluent aphasia, with some models aiming at integrating linguistic theory and syntactic processing. A first attempt to integrate both processing-based and representationally-based accounts was recently proposed in the investigation of the poor comprehension of long-distance dependencies. The hypothesis proposed that the processing deficit at the core of the acquired language deficit is what compromises the representation of the full array of morphosyntactic features normally associated with syntactic elements, thereby giving rise to Minimality Effects in specific syntactic configurations (see Garraffa &

Grillo 2008).[2] The cause of aphasics' limited processing capacities with non-local dependencies is in their impairment in retaining the activation of the representation of all the morphosyntactic features associated with syntactic nodes. Thus some of the features needed for the computation of structures involving dependencies over possible interveners may be absent with a consequent underspecification of the structure; compare (2a) with (2b). While expert speakers can differentiate the element due to their structural position and composition, those individuals with an acquired deficit do not have enough resources for maintaining active the full representation. A crucial consequence of the model presented below is that the deficit is not selective to people with agrammatic aphasia, but it can be adapted to any instance of poor processing resources.

(2) a. … X … Z … Y *Expert speakers*
$[\dots]_Q$ $[\dots]_A$ $[\dots]_Q$
b. … X … Z … Y *Impaired speakers*
$[\dots]_A$ $[\dots]_A$ $[\dots]_A$

This leads us to expect an asymmetry in aphasic treatment of dependencies: those involving one NP crossing over another similar one are reported to be more problematic than those that do not involve such a configuration. The asymmetry reported in many studies between aphasic comprehension of object movement (which implies crossing of the subject NP) versus subject movement (which does not imply crossing of any NP) supports the intervention hypothesis (Sheppard, Walenski, Love & Shapiro 2015).

This approach to aphasic comprehension and to grammatical deficit in general has interesting consequences for the definition of a theory of the grammatical nature of linguistic processing. For example, in much work on sentence processing there is an explicit reference to the concept of complexity (see Just, Carpenter & Keller 1996). Their model is based on the assumption that a working memory for language functionally separated from the representation of linguistic knowledge is at the core of the deficit reported in people with non-fluent aphasia. To define more clearly what complexity is, linguistic knowledge is required. Without a clear description of complexity and a theoretically motivated set of predictions, the best we could hope to achieve would be a list of structures ordered by their complexity judged according to empirical measures. We will thus know which structures are easier and which are more difficult to process, but we will not know why this is so nor will we have a definition of complexity, merely a descriptive tool. Underspecification in individuals with aphasia would be caused by any (permanent or temporal) reduction of syntactic processing capacities. General slowing of lexical activation and a concomitant delay in the formation of syntactic dependencies involving "moved" constituents and empty elements was reported in many studies with people with aphasia (Love, Swinney, Walenski & Zurif 2007).

On the basis of minimality, it is possible to provide a definition of complexity unfolding the composition of the structure and its number and quality of morphosyntactic features which need to be maintained active in the syntactic representation in order for the computation not to crash. A clear set of predictions can be

[2] The reader is referred to Starke (2001), Rizzi (2004), and Grillo (2008), for the original formulation of Minimality Effects in term of classes of features.

generated on the basis on the nature of the comprehension deficit in people with aphasia with specific crosslinguistically predicted differences.

The rationale behind this approach is that the full representation of the morphosyntactic feature structure of a syntactic constituent has a processing cost and that a computational system driven by (among other factors) economy considerations might try to avoid those costs. Delaying the representation of required feature structure implies delaying the representation of required positions in the structure; for example, a delay in the representation of a feature on the head of a relative clause implies that the chain member in CP will not immediately be represented, with predictable consequences once the parser encounters evidence for the necessity of the postulation of those features/members.

An advantage of the formulation of the acquired impairment in terms of feature structure is that not only we can predict the nature of the source of a preferred structure, on the basis of minimality, we can also predict in what kind of environments this preference for less costly structures will turn into a mistake. Furthermore, this approach has the clear advantage of treating mistakes as structures ruled out by grammatical principles. Generation of featurally impoverished syntactic structures allows us to rule them out on a par with other more standard cases of syntactic violation.

5. Conclusion

As Lenneberg pointed out in his monograph, accounts of language should consider it as an MCB—a maturationally-controlled behavior—and investigate the evolution of coherent developmental stages predicted by both neurodevelopmental growth and a rich language environment as a trigger for acquisition. In the case of developmental language impairment, we should be conducting research to find out what kinds of input are most effective for children who are at genetic risk. It is possible that rather than more language input, they may do best with a different kind of language input, specifically tailored to take into account children's cognitive strengths and weaknesses.

For adults with aphasia, there is a need for developing training based on language exposure to specific grammatical properties, aiming at generating effects of short-term cortical plasticity after specific language learning tasks. It seems that short training of less than an hour of high cognitive demand can induce microstructural changes in the cortex, suggesting a rapid time scale of neuroplasticity (Hofstetter, Friedmann & Assaf 2017). At the moment there are no intervention programs for people with aphasia designed with insights from linguistic theory and the neurobiology of language. The absence of theoretically-motivated programs is a lack of evidence for informing both language recovery and language retention.

References

Belletti, A. 2017. Internal grammar and children's grammatical creativity against poor Inputs. *Frontiers in Psychology* 8, 2074. doi:10.3389/fpsyg.2017.02074.

Bishop, D. V. M. 2006. What causes specific language impairment in children? *Current Directions in Psychological Science* 15, 217–221.

Bishop, D. V. M. 2012. What Chomsky doesn't get about child language. http://deevybee.blogspot.co.at/2012/09/what-chomsky-didnt-get-about-child.html (11 December 2017).

Bishop, D. V. M., C. V. Adams, & S. Rosen. 2006. Resistance of grammatical impairment to computerized comprehension training in children with specific and non-specific language impairments. *International Journal of Language and Communication Disorders* 41(1), 19–40.

Borer, H. & K. Wexler. 1987. The maturation of syntax. *Parameter Setting*. 123–172.

Chomsky, N. 1965. *Aspects of the Theory of Syntax*. Cambridge, MA: MIT Press.

Chomsky, N. 1980. On cognitive structures and their development: A reply to Piaget. In M. Piattelli-Palmarini (Ed.) *Language and Learning: The Debate Between Jean Piaget and Noam Chomsky*. Cambridge, MA: Harvard University Press. 35–52.

Chomsky, N. 1986. *Knowledge of Language: Its Nature, Origin, and Use*. Westport, CT: Praeger.

Chomsky, N. 1995. *The Minimalist Program*. Cambridge, MA: MIT Press.

Crain, S. 1991. Language acquisition in the absence of experience. *Behavioural and Brain Science* 14(4), 597–612.

Curtiss, S. R. 1977. *Genie: A Linguistic Study of a Modern Day "Wild-Child"*. New York, NY: Academic Press.

Dehaene-Lambertz, G., L. Hertz-Pannier, & J. Dubois. 2006. Nature and nurture in language acquisition: Anatomical and functional brain-imaging studies in infants. *Trends in Neurosciences* 29(7), 367–373.

Druks, J. 2017. *Contemporary and Emergent Theories of Agrammatism. A Neurolinguistics Approach*. New York, NY: Routledge.

Evans, J., J. Saffran, & K. Robe-Torres. 2009. Statistical learning in children with specific language impairment. *Journal of Speech, Language and Hearing Research* 52, 321–335.

Fattal, I., N. Friedmann, & A. Fattal-Valevski. 2011. The crucial role of thiamine in the development of syntax and lexical retrieval: A study of infantile thiamine deficiency. *Brain* 134(6), 1720–1739.

Fodor, J. D. 2001. Setting syntactic parameters. In M. Baltin and C. Collins (Eds.), *The Handbook of Contemporary Syntactic Theory*. Oxford, Endland: Blackwell. 730–767.

Friedmann, N., & R. Szterman. 2006. Syntactic movement in orally trained children with hearing impairment. *Journal of Deaf Studies and Deaf Education* 11(1), 56–75.

Friedmann, N. & R. Novogrodsky. 2007. Is the movement deficit in syntactic SLI related to traces or to thematic role transfer? *Brain and Language* 101(1), 50–63.

Friedmann, N., & D. Rusou. 2015. Critical period for first language: The crucial role of language input during the first year of life. *Current Opinion in Neurobiology*. doi:10.1016/j.conb.2015.06.003.

Friedmann, N., A. Belletti, & L. Rizzi. 2009. Relativized relatives: Types of intervention in the acquisition of A-bar dependencies. *Lingua* 119, 67–88. doi:10.1016/j.lingua.2008.09.002.

Friedmann, N., M. Yachini, & R. Szterman. 2015. Relatively easy relatives: Children with syntactic SLI avoid intervention. In E. Di Domenico, C. Hamann, & S. Matteini (Ed.), *Structures, Strategies and Beyond. Studies in Honour of Adriana Belletti*. Amsterdam, The Netherlands: John Benjamins. 303–320.

Friedmann, N., & L. P. Shapiro. 2003. Agrammatic comprehension of simple active sentences with moved constituents: Hebrew OSV and OVS structures. *Journal of Speech Language and Hearing Research* 46, 288–297.

Friedemann, M.A. & L. Rizzi (Eds.). 2000. *The Acquisition of Syntax: Studies in Comparative and Developmental Linguistics*. London, England: Longman.

Garraffa, M. & N. Grillo. 2008. Canonicity effects as a grammatical phenomenon. *Journal of Neurolinguistics* 21(2), 177–197.

Garraffa, M., M. Coco, & H. Branigan. 2015. Effects of immediate and cumulative syntactic experience in language impairment: Evidence from priming of subject relatives in children with SLI. *Language Learning and Development* 11(1), 18–40.

Garraffa, M. & Sedda, A. (2017). Core regions for syntactic processing? A tDCS study on the language network. *Stem-, Spraak- en Taalpathologie* 22(2), 47–49.

Jacques, G. & J. Mehler. 2010. Speech perception and language acquisition in the first year of life. *Annual Review of Psychology* 61, 191–218.

Grillo, N. 2008. *Generalized Minimality: Syntactic Underspecification in Broca's Aphasia*. Doctoral dissertation, University of Utrecht, The Netherlands.

Guasti, M.T. 2017. *The Growth of Grammar*. Cambridge, MA: MIT Press.

Hofstetter, S., N. Friedmann, & Y. Assaf. 2017. Rapid language-related plasticity: Microstructural changes in the cortex after a short session of new word learning. *Brain Structure and Function* 222(3), 1231–1241. doi:10.1007/s00429-016-1273-2.

Just, M. A., P. A. Carpenter, & T. A. Keller. 1996. The capacity theory of comprehension: New frontiers of evidence and arguments. *Psychological Review* 103, 773–780.

Lenneberg, E. H. 1967. *Biological Foundations of Language*. New York, NY: Wiley.

Leonard, L. 2011. The primacy of priming in grammatical learning and intervention: A tutorial. *Journal of Speech, Language, and Hearing Research* 54, 608–621.

Levy, H. & N. Friedmann. 2009. Treatment of syntactic movement in syntactic SLI: A case study. *First Language* 29, 15–50. doi:10.1177/0142723708097815.

Love, T., D. Swinney, M. Walenski, & E. Zurif. 2007. How left inferior frontal cortex participates in syntactic processing: Evidence from aphasia. *Brain and Language*. doi:10.1016/j.bandl.2007.11.004.

Mehler, J., P. Jusczyk, G. Lambertz, N. Halsted, J. Bertoncini, & C. Amiel-Tison. 1988. A precursor of language acquisition in young infants. *Cognition* 29(2), 143–178.

Meisel, J. M. 2013. Sensitive phases in successive language acquisition: The critical period hypothesis revisited. In C. Boeckx & K. K. Grohmann (Eds.), *The Cambridge Handbook of Biolinguistics*. Cambridge, UK: Cambridge University Press. 69–85.

Nazzi, T. & F. Ramus. 2003. Perception and acquisition of linguistic rhythm by infants. *Speech Communication* 41(1), 233–243.

Obeid, R., P. Brooks, K. Powers, K. Gillepsie-Lynch, & J. Lum. 2016. Statistical learning in Specific Language Impairment and Autism Spectrum Disorder: A meta-analysis. *Frontiers in Psychology*. doi:10.3389/fpsyg.2016.01245.

Oltra-Massuet, I., V. Sharpe, K. Neophytou, & A. Marantz. 2017. Syntactic priming as a test of argument structure: A self-paced reading experiment. *Frontiers in Psychology* 8, 1311. doi:10.3389/fpsyg.2017.01311.

Poeppel, D. & D. Embick. 2005/2013. Defining the relation between linguistics and neuroscience. In A. Cutler (Ed.), *Twenty-First Century Psycholinguistics: Four Cornerstones*. New York, NY: Psychology Press. 103–118.

Riches, N. G. & M. Garraffa. 2017. A discourse account of intervention phenomena: An investigation of interrogatives. *Glossa: A Journal of General Linguistics* 2(1), 74. doi:10.5334/gjgl.100.

Rizzi, L. 1990. *Relativized Minimality*. Cambridge, MA: MIT Press.

Rizzi, L. 2004. Locality and left periphery. In A. Belletti (Ed.), *Structures and Beyond: The Cartography of Syntactic Structures*. New York, NY: Oxford University Press. 223–251.

Santi, A. & Y. Grodzinsky. 2007. Working memory and syntax interact in Broca's area. *NeuroImage* 37(1), 8–17.

Sheppard, S. M., M. Walenski, T. Love, & L. P. Shapiro. 2015. The auditory comprehension of wh-questions in aphasia: Support for the intervener hypothesis. *Journal of Speech, Language and Hearing Research* 58, 781–797.

Starke, M. 2001. *Move Dissolves into Merge: A Theory of Locality*. Doctoral dissertation, University of Geneva, Switzerland.

Tsimpli, I. M., M. Kambanaros, & K. K. Grohmann. 2017. Language pathology. In I. Roberts (Ed.), *The Oxford Handbook of Universal Grammar*. Oxford, Endland: Oxford University Press. 486–508.

Wexler, K. 2003. Lenneberg's dream: Learning, normal language development, and specific language impairment. In Yonata Levy & Jeannette C. Schaeffer (Eds.), *Language Competence Across Populations: Toward a Definition of Specific Language Impairment*. Mahwah, NJ: Lawrence Earlbaum. 11–61

Wright, H., R. Downey, M. Gravier, T. Love, & L. Shapiro. 2007. Processing distinct linguistic information types in working memory in aphasia. *Aphasiology* 21, 802–813.

Zaccarella, E. & A. D. Friederici. 2015. Merge in the human brain: A sub-region based functional investigation in the left pars opercularis. *Frontiers in Psychology* 6, 1818. doi:10.3389/fpsyg.2015.01818.

Zurif, E., D. Swinney, & M. Garrett. 1990. Lexical processing and sentence comprehension in aphasia. In A. Caramazza (Ed.), *Cognitive Neuropsychology and Neurolinguistics: Advances in Models of Cognitive Function and Impairment*. Mahwah, NJ: Lawrence Earlbaum. 123–136.

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