The Relationship between Lexical and Grammatical Development in Typical and Brain-damaged Children

by

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Abstract

Although there are many studies about the relationship between grammar and lexicon, there is a lack of studies examining the relationship between the growth of compound words and complex sentences. This study examined the relationship between compound words at the lexical level, and complex sentences, auxiliaries and modals, and coordinated subjects/objects at the grammatical level, for both brain-injured and typically developing children between the ages 4 and 6. For 10 typically developing children, 3091 utterances, and for 18 brain-injured children, 6460 utterances were examined. The results revealed that both groups showed a significant increase in the use of compound words and coordinated clauses. The growth of auxiliary and modal verbs is significant only for typically developing children and the growth of subordinate clauses is significant just for brain injured children. Moreover, there is an interaction between the growth of coordinate clauses and compound words just for brain injured children.

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To the smile of my parents

when they heard my first word

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Chapter 1: Introduction

Two important aspects of language development in first language acquisition are lexical and grammatical development. It has been suggested that language development in children at the lexical and grammatical level is interrelated, and thus their lexical knowledge does not precede their grammatical knowledge in early language development (Dixon and Marchman, 2007). One of the areas that could be used in gaining a better understanding of first language acquisition is comparing language development of typical children and brain injured children. It is said that brain injured children are delayed in language acquisition compared to typically developing children (Thal et al. 1991; Kaffe et al. ,1989). By doing this research, i.e. comparing typical language developing children and brain injured children, one can hopefully find some steps of language acquisition. Consequently, the main purpose of this research is to determine whether or not there is a significant relationship between the growth in complexity at the lexical and grammatical levels for typically developing and brain injured children who are suffering from perinatal brain damage, between the ages 4 and 6. Both groups of children used for the purpose of this research were learning English as their first language. The information about the brain damaged area of the brain injured group is explained in Table (29) in the appendix (A).

In the case of children with perinatal brain injury, language development can be slowed in the early childhood years. According to Thal et al. (1991), perinatal brain injured children have delay in lexical comprehension and production. Moreover, a high proportion of the vocabulary of these children belongs to closed class (grammatical function) words. This is a sign of using different pattern in language acquisition by brain

injured children. In a study carried out by Kaffe et al. (1989), the language abilities of perinatal brain damaged children between the ages 26 and 41 months were studied. The children were exposed to new lexical items and it was found that although the brain injured and the typically developing children learned the same number of new lexical items, new lexical items needed to be displayed more to brain injured children than typically developing children. The brain injured children had more difficulty in producing new items. They concluded that brain injured children could acquire the same language skills as the typically developing children, but in a delayed manner. Specifically, brain damaged children required more exposures to language structures and skills before learning them and this is the reason that these children have delay in acquiring language skills. Kaffe et al. (1989) hypothesized that brain injured children may have difficulty in learning languages during preschool years because in those periods of time a child needs to learn a lot of skills quickly while the exposures of these skills are not enough for a brain damaged child.

The pattern of the complexity in lexical and grammatical development may be different in brain injured and typically developing children. Thus, it is worthwhile to first examine whether these two groups of children follow the same pattern of growth in using compound and complex structures at the lexical and grammatical levels or not and second figure out whether there is a relationship between the growth of these structures at the lexical and grammatical levels or not.

For the purpose of this study, complexity at the lexical and grammatical levels between the two groups of typical and brain damaged children were investigated. The two main structures specified to be used for the purpose of comparison in this research

are compound words at the lexical level and complex structures at the grammatical level. The use of compound words and complex structures are two factors that can be used to measure the complexity at these two levels; and the more complex or compound grammatical and lexical structures a child uses, the more complex the language of that child is (Clark, 2009, 254). To investigate this case, complex sentences as well as auxiliary and modal use and coordinated subject or object were considered for grammatical complexity, and the frequency of compound words were considered for the lexical complexity.

More specifically, to examining the model of the growth of variables and finding the relationship between them, the following questions are addressed in this research. First, which forms have significant growth as the children get older for typically developing children and brain injured children? Second, is there a significant relationship between the increase use of the forms at grammatical and lexical levels for typically developing children and brain injured children between the ages 4 and 6?

As these children improve their language between the studied age group, the hypothesis is that both groups of children have significant growth in using lexical and grammatical components that are examined in this study between the ages 4 and 6. Moreover, in this study it is accepted that the improvement in one area of language has effect(s) on the improvement of the other areas of language development (In Chapter two, the different perspectives about the relationship between lexicon and grammar are discussed). For this reason, in the next step, it is hypothesized that there is a relationship between the growth of complexity at the lexical and grammatical levels. If this hypothesis

proves true, then it can be tested that improving complexity in one area can help complexity improvement in other areas.

Moreover, in previous studies about finding the relationship at the lexical and grammatical levels, there is a lack of investigation as to whether there is a relationship between compound words and complex sentences in both typically developing and brain injured children. This study is intended to address this issue.

In Chapter Two of this thesis, the relationship between grammar and the lexicon is discussed. In Chapter Three, the required terminologies that are used in this study are defined. Chapter Four is discusses the previous research in the acquisition of complex sentences and lexical compounds. The methodology of this study is explained in Chapter Five. After that, Chapter Six presents the results of the research. In Chapter Six, first, the significant growth in lexical and grammatical complexity is analyzed and after that, the possibility of a relationship between the growth of lexical and grammatical areas are analyzed. For this part, those categories that have significant growth in the previous part are used. In Chapter Seven, discussions on the results and findings are presented. Future research trends are also suggested in Chapter Seven.

Chapter 2: The relationship between grammar and the lexicon

There are two different perspectives about the relationship between grammar and the lexicon. Scholars like DiSciullo & Williams (1987) believe that grammar and the lexicon are two separate domains. In their approach, grammar consists of a system of rules and the lexicon is a stored inventory of concepts or forms and these two domains have transaction with each other, i.e. there are some rules for building structure from basic units stored in lexicon. They believe that there are different memory components for these domains. In their opinion, syntactic processes are supported by procedural memory and lexical storage is supported by declarative memory (Ullman, 2001).

On the other hand, in another perspective, the lexicon and grammar are part of a unified system (Bates and Goodman, 1999). This view has different varieties. Some people like Tomasello (2000), believe that there are not any separate representations of grammar and lexicon in the early stages of language acquisition. In their perspective, the separation does appear, but it develops later. Some other people like MacWhinney (2005) specify a "unified acquisition mechanism" with different representational domains. He proposes some related models for lexical, phonological, and syntax acquisition.

Pérez-Leroux et al. (2012) reported that the studies about the relationship between grammar and the lexicon in early child language acquisition have informed a strong longitudinal relationship between these two fields. Bates et al. (1988) studied the relationship between vocabulary size and Mean Length of Utterance (MLU) for English-speaking children. They found that MLU at 28 months is predictable from the vocabulary

size at 20 months. According to their conclusions, MLU and vocabulary size, as two factors of syntax and lexicon, are part of a unified system and develop accordingly.

Anisfeld et al. (1998) examined the new words and new word combinations of five English-speaking children for about 10 months beginning when they were 12-17 months of age. They found that vocabulary size increases significantly after the emergence of word combination and word combination is a motivation for children to learn more new words. Moreover, Dixon and Marchman (2007) studied lexical and grammatical development of English-speaking children aged 16 – 30 months. Their hypothesis was based on the following assumption: "grammar emerges from the mechanisms involved in acquiring the lexicon itself" and they concluded that:

> "The analyses converge on the conclusion that the lexicon and grammar are actually developing in synchrony across the first few years of life" (Dixon and Marchman, 2007: 209).

There has been a lot of research examining the lexicon-grammar associations in various domains of grammar. For example, Marchman and Bates (1994) found a significant relationship between the number of verbs that an English-speaking child acquires and the use of past tense morphology correctly. Robinson and Mervis (1998) found that plural development and vocabulary size are significantly related to each other in English. Bassano et al. (2004) studied the acquisition of auxiliaries and modal verbs in French and Austrian German children. They specifically studied the following forms: 'auxiliary + past participle', 'modal + infinitive', and 'auxiliary + infinitive' structures. Their findings showed that the more verbs the children learn the less grammatical errors

they have in the production of these constructions. As it is explained in each study, there is a relationship between lexical and given grammatical constructions.

Pérez-Leroux et al. (2012) studied the effects of vocabulary growth in morphosyntactic development. Their participants were 110 Spanish-speaking monolingual children between 3 and 5 years. They hypothesized that utterance complexity like sentence length and rates of subordination can be determined according to vocabulary growth. In addition, the acquisition of grammatical markers is affected by vocabulary size. They compared the differential impacts of vocabulary in the omission of definite articles and object clitic pronouns. The results of their study supported the idea of the effects of vocabulary growth in morphosyntactic development. More specifically, they found that vocabulary growth has effect on MLU, subordination rates, the use of definite determiners and object pronouns.

Moyle et al. (2007) did a longitudinal study to compare the lexical and grammatical development between late talking and typically developing children. These children were English-speaking children. Thirty typically developing children and thirty late talking children ages 30- 54 months participated in their study. Their results confirmed that there is a significant relationship between lexical and grammatical developments for typically developing children. For late talking children, lexical and grammatical development was related in all points except at age 4;6; at this point their lexical growth was better than their grammatical growth. Their findings suggests that late-talking children are not learning language the same way that typically developing children are and for these children vocabulary growth was not leading to grammatical growth in the same way. Their finding supports using different patterns of language

acquisition by a group of atypical children. Therefore, brain injured children as an atypical developing group may have a different disordered pattern of development.

Moreover, there are some other studies that have found associations between lexical and grammatical development in groups of older children. For example, Tomblin and Zhang (2006) studied the vocabulary and sentence complexity of children at English kindergarten, second grade, and fourth grade. Their results confirmed very strong correlations between sentence complexity and vocabulary for all of these children (Pérez-Leroux et al., 2012).

All the studies referred in this chapter have looked for a relationship between some aspect of lexical development and some aspect of grammatical development. There are two different perspectives about a relationship between grammar and lexicon. Some schalors like DiSciullo & Williams (1987) believe that lexicon and grammar are two separate areas. On the contrary, some scholars like Bates and Goodman (1999), Tomasello (2000), and MacWhinney (2005) believe that these two areas are interrelated. The present study expands this literature by looking at a variety of lexical and grammatical complexities in English, in children age 4-6. In addition, in this study the pattern of growth of compound and complex structures at the lexical and grammatical levels is compared between typically developing and brain injured children. The results of this study can be helpful to figure out whether these two groups follow the same pattern in expanding lexicon and grammar. Moreover, the results about the relationship between the lexicon and grammar can support one of the previous perspectives.

Chapter 3: Definition of lexical and grammatical complexity in this study

The terms that are used in this thesis are defined in this chapter. These terms are used to show complexity at the lexical and grammatical levels. These terms are lexical compounds, complex sentences, coordinated subject/object, and auxiliaries and modals.

3.1 Lexical compounds

The word "compound", according to Crystal (2008: 96), is a term that is used in descriptive linguistic studies. A compound word is a combination of two or more free morphemes. In this study, compound words are divided into compound verbs and compound non-verbs.

The expansion of verb production of infants occurs some months after their production of other parts of speech. Their verb inventories expand after 20 or 24 months (Waxman and Leddon, 2010). Consequently, there is the possibility that children's capabilities of making compound words might be different for verbs than other parts of speech. For this reason, at the lexical level, compound verbs are distinguished from other compound words in this study. Other compound words i.e., compound nouns, compound prepositions, and compound adverbs are counted as "non-verb".

In English, a compound verb is identified as a construction that contains a simple verb and a preposition (e.g. "come in") (see Crystal 2008: 96). The non-verb compound words that are examined in this study are: compound nouns (e.g. "bathroom"), compound prepositions (e.g. "into"), and compound adverbs (e.g. "anymore"). The proper nouns that are the combination of two nouns like "Jonathan bunny" are counted as compound

non-verb. It is worthwhile to mention that compound verbs are relatively common in the data, where the others are not, and for this reason no attempt is made to distinguish different kinds of non-verb compounds.

3.2 Complex sentences

A complex sentence is a sentence with more than one clause. A complex sentence contains a main clause and a subordinate clause, or at least two coordinated independent clauses. Coordinate and subordinate clauses are defined in the following sections.

3.2.1 Coordinate clauses

Coordinate clauses are clauses that joined together by a coordinating conjunction (Crystal, 2008, 95). A conjunction is a term that is used to connect words, phrases, or sentences. Coordinating conjunctions are used to connect units which have the same syntactic status. Examples of coordinating conjunctions in English are “or”, “and”, “then”, and “but”. Structures are sometimes joined together without any explicit marker. The conjunction “and” is the omitted marker in most of these situations (Crystal, 2008, 101). For example, “and” is omitted to connect the first two sentences in “He came, he ate, and he left”; another way of expressing the same idea is: “He came, and he ate, and he left”.

3.2.2 Subordinate clauses

Diessel (2004, 1) subcategorizes subordinate clauses into three groups: complement clauses, relative clauses, and adverbial clauses. A complement clause is defined as an argument of a main clause. The following sentence is an example of a

sentence that has a complement clause as its object. This sentence was produced by "GR" when he was 5 years old:

(1) He looked both ways and saw **that no cars were coming**.

A relative clause modifies a noun or a noun phrase in a sentence. The following example was produced by "GR" when he was 4;5 years old.

(2) There (i)s a boy **that has a red shirt**.

An adverbial clause is used adverbially and it modifies the main clause or verb phrase. For example, in the following sentence that was produced by "BO" when he was 5 years old, "when he was sleeping" is an adverbial clause of time.

(3) It ran away **when he was sleeping**.

All of these three kinds of subordinate clauses can be finite or nonfinite. Nonfinite subordinate clauses have nonfinite verbs. According to Crystal (2008, 190), a nonfinite verb does not have tense and mood. English has three kinds of nonfinite clauses which are (1) participial infinitives (both *–ing* and *–en*), (2) to-infinitives, (3) bare infinitives (as in "He heard [Mary play the piano]".).

It is possible that a subordinate clause lacks a subordinator. One subordinator that is often omitted is "that" (Aarts, 2006). For example "ME", 4;5 years old, omitted "that" in the following sentence:

(4) Santa Claus didn't bring me that little pillow (that) **I wanted**.

Another common kind of subordinate structure in English is a hortative construction. "Hortative is a term used in the grammatical analysis of verbs to refer to a type of modal meaning in which an exhortation is made. An example of a hortative use is the 'let us' construction in English, like "Let us pray" (Crystal, 2008: 232). Noonan

(2006: 695) mentioned that the sentences that contain hortative structures can be counted as subordinate clauses. In these sentences, the hortative clause is the main clause i.e., “Let us [pray]”.

It is worthwhile to mention that as complement clauses, relative clauses and adverbial clauses develop at different ages, children may follow different patterns in using these structures. However, because of the small data of this study, all these kinds of subordinates are treated as subordinate clauses, in contrast with coordinate clauses.

3.3 Coordinated subject/object and auxiliary and modal verbs

In addition to complex sentences, the acquisition of coordinated subject/object and auxiliary and modal verbs is examined in this study as two other aspects of syntactic complexity.

3.3.1 Coordinated subject/object

Coordinated subject/object is an argument in a clause which consists of more than one coordinated noun phrase or pronoun, as in “the boys and the girls” (Crystal, 2008, 96) and these noun phrase or pronouns are joined by coordinators. In English, the coordinators are “and” (e.g. “the horse and the dog and the sheep”, “knife and spoon”), “or” (e.g. “a hamburger or a cheeseburger”).

3.3.2 Auxiliaries and modals

Auxiliaries and modals in English refer to categories like aspect and modality. In this study, the modals and the auxiliaries that accompany lexical verbs are included under

the definition of "auxiliary and modal verb". Because the use of auxiliaries and modals is more related to the grammatical level, this construction is categorized as an instance of complexity at the grammatical level. For example, the following structures are counted as auxiliary and modal use: "I don't know.", "I am going to take a bath.", "You should listen to me." and "I will come tomorrow."

The list of all the words that are counted as modals in this study is: *Would, will, can, have to (hafta), could, had to, might, may, should.*

The following is the list of the constructions that are counted as auxiliary + verb, in this study: (1) the auxiliary verb *do*, (2) the progressive auxiliary *be*, (3) the perfect auxiliary *have*, (4) the structure *be going to*.

The reason that auxiliary and modal verbs are used as one parameter to show complexity at the grammatical level is that this structure has the combination of a modal/auxiliary and a verb in its verb phrase and these structures superficially resemble compound verbs and therefore these are of particular interest to the present study.

A clitic is a grammatical word that cannot stand on its own and is phonologically dependent upon a neighboring word (its host) in a construction. Examples of clitic forms are the contracted forms of "be", such as "I'm" and "he's" (Crystal, 2008, 80). Although clitics are the combination of more than one word, they are not counted as compounds, because they cannot stand on their own. For example, "'s" is not used separately in "it's". In this study, clitisized forms of auxiliaries in present/past progressive structures are treated under 'auxiliary and modal verbs'.

To sum up, the terms that are counted at lexical and grammatical levels are shown in the following table:

Table 1- The terms that are counted in each level

Lexical level	compound verbs, compound non-verbs
Grammatical level	Coordinate clauses, subordinate clauses, auxiliary and modal verbs, coordinated subject/object

Chapter 4: Literature review

4.1 The acquisition of complex sentences

According to Bowerman (1979), children start to produce complex sentences (sentences including object complement clauses, adverbial clauses, relative clauses, and coordinate clauses) between the ages of 2 and 4.

They first start to make subordinate clauses and then they produce coordinate sentences a few months after. She stated that the first complex sentences of children are sentences with object complements. As an example, the following sentence has a subordinate clause which is an object complement: "I wanna read book" (Bowerman, 1979: 286). By the age of about 2;6, the children can make subordinate clauses that contain wh-words (p. 287). Bowerman emphasized that most of these sentences contain adverbial clauses including time (e.g. "Can I do it when we go home?") and manner (e.g. "I show you how to do it"). After that, the children create relative clauses in their complex sentences. These clauses modify nouns referring to manner (e.g. "This is the way I did it") and place (e.g. "I show you the place I went") (p. 287). Bowerman (1979) explained that the children's first relative clauses lack subordinators and they add relative subordinators such as "that" in the next stages. Bowerman stated that subordinators such as 'before' and 'after' are the last subordinators that children use at about 5 years of age.

Diessel and Tomasello (2000) studied relative clauses used by English-speaking children between the ages of 1;9 and 5;2. They found that practically all the relative clauses that these children produced were like examples (5) and (6). In these kinds of sentences the children introduced a new subject in the main clause using a contracted

form of “that is” and “here is” (or other proforms plus copula) followed by predicate NP which includes a relative clause.

(5) “Here’s the toy that spins around” (Tomasello, 2006: 36).

(6) “That’s the sugar that goes in there” (Tomasello, 2000: 36).

It is worthwhile to mention that there is a contradiction between the studies of Bowerman (1979) and Diessel and Tomasello (2000), i.e., Bowerman suggested that relative clauses are produced some time after 2;6 whereas Diessel and Tomasello suggested that they are acquired starting at 1;9.

A related study of English speaking children between 2 and 5 years old was done by Diessel and Tomasello (2001). They studied the main clauses of complex sentences which have subordinate complement clauses. Their focus was on the structure of the main clauses in these particular types of sentences. They subcategorized the verbs of these kinds of main clauses into epistemic verbs (e.g. “know” and “think”) and attention-getting verbs (e.g. “see” and “look”). They found that in these kinds of complex sentences children used a fixed form of the main clause for epistemic verbs (like “know”) and attention-getting verbs (like “see”). For epistemic verbs children generally did not deviate from using first person singular pronouns and present tense verbs nor did the children use negative structures. For example, they use “I think” or “I know” but not “I thought” or “I don’t know”. They also omit the subordinators like “that”. Children even express uncertainty through epistemic verbs. Thus, they concluded that for children at this level a main clause containing an epistemic verb can be treated as a kind of epistemic adverb like “maybe” rather than as a main clause, and therefore these do not represent true subordinate structures. In regards to attention-getting verbs, their findings were

similar to epistemic verbs in that they were rarely negated or followed by the subordinator 'that', and were typically in imperative form (e.g. "See I have a teeth" (Diesel and Tomasello, 2001: 119)) and they conclude that children use attention-getting verbs in main clause structures for achieving attention. They called these kinds of main clauses "attention markers".

Diessel (2004) continued the studies by doing research about different kinds of subordinate clauses. He studied the complex sentence structures of five English children between the ages of 1;8 and 5;1, using data from the CHILDES database. Diessel's theoretical approach was a combination of construction grammar and the usage-based model. In construction grammar, the primary unit of grammar is grammatical construction which covers any syntactic strings of words such as sentences, phrasal structures, and complex lexemes. These constructions are interrelated and combine together to make a specific function or meaning (Michaelis, 2006). In the usage-based model, grammar is a dynamic system and linguistic structures come from the psychological mechanisms in language use (Diessel, 2004, 12).

Diessel's (2004) findings confirmed the previous works by Diessel and Tomasello (2001) that the main clauses function like epistemic markers. As time goes on, the children start to use embedded structures in their complex sentences. In these cases, the subordinate clause becomes more structurally related to its main clause. For example, they learn to use a complex sentence to relate a situation to a time period. Consequently, children use the subordinate clauses that contain "after" or "before" subordinators. Example (7) is produced by a child at the age of 3;4.

(7) "It's getting crowded **after I put all the dollies in**" (Diessel, 2004: 167).

He stated in his conclusion that although children start to use complex sentences from the age of 2 and by the age of 3 they use different kinds of subordinate structures, most children have difficulty in the comprehension of complex sentences even at the first years of school.

Bowerman (1979) stated that children start to produce coordinate clauses which include the conjunction 'and' when they are about 3 years old. This is the first coordinator that is used by children. The following is an example produced by a child at the age of 3;5:

(8) "This is Paul's and this is yours' (Diessel, 2004, 158).

Diessel (2004) mentioned that "but" is the next coordinator that is used by children. He also argued that most of the coordinate clauses using the conjunction 'but' are similar to example (9), in which the child is coordinating a clause with a clause produced by another person.

(9) "Adult: David doesn't shave yet.

Child: Uhuh. But I shave" (Diessel, 2004, 264).

4.2 The acquisition of compound words

Combining words together to form new words is a way of extending the lexicon. Among different kinds of compound words, compound nouns have the highest frequency in the language used by children. The order of acquiring word structures depends on several factors: the transparency of the meaning of new structures, i.e. the clarity of a compound word's meaning with regards to its components; the productivity of the rules in the language; and the ease of making the structures (Clark, 2009: 255-256).

Following children's developmental stages in language acquisition, they can recognize word roots in lexical compounds around the age of two. In addition, as it is obvious in example (10), they can comment on the elements of compound words that they created by the age of 2;6.

(10) "Child to father, about a favorite stick: This is a running-stick.

Father: A running-stick?

Child: Yes, because I run with it" (Clark, 2009: 257).

However, they may have errors in their analyses of compound word segmentation up to the ages of 4-5 years. Clark (2009) also argues that children have higher perception ability than production capabilities with regards to compounds before the age of five years old.

Due to the limited vocabulary inventory existing in the mind of the children, they tend to rely on derivational methods and/or compounding to compensate for the required non-existing words. For example they use "to car" instead of "drive" or "cup-egg" instead of "boiled egg". Their use of these forms decreases as they learn new words. This is one of the reasons that children actively construct novel compounds in order to supplement their limited vocabularies when they are between two and four years old. By the age of four and five, children produce more adult-like compound and complex words (Clark, 2009: 261).

To sum up, children can segment and consequently interpret compound words when they are between the ages of 2 and 3 years old. Examining the children's paraphrases of new compound words can be one way of understanding the way they

analyze compound words. Moreover, children's capability of analysis new compounds can help them in forming new compound words from the words they already know. However, until the age of 4-5 years old, they still have difficulty in producing compound structures out of the segmented components. Additionally, their relatively small lexical inventories would lead children to create novel compound words.

Chapter 5: Methodology

5.1 Data collection

Feldman et al. (1989, 1994) did a longitudinal study leading to collect data at Children's Hospital in Pittsburgh and documentation stored in the CHILDES database (MacWhinney, 2000). They used the stored data to do longitudinal research on developmental changes in narrative and non-narrative discourse of typical and brain injured children.

The data collected by Feldman et al. (1994) were used for the present research. This dataset has been chosen for two reasons: first, because it is a longitudinal study, and second, because it includes both typically-developing and brain-injured children. A longitudinal study is preferred to cross-sectional study because in a longitudinal study it is possible to examine whether and how production of complex forms changes over the ages studied. Moreover, comparing brain injured and typically developing children allow us to investigate whether these two groups follow the same patterns of using language or not.

The files used here are part of their 'narrative study' of children from age 4 to 6. Data from the narrative study were chosen because narration may contribute to an uninterrupted and smoother flow of speech and may also result in the production of more complex sentences. The present study focuses on 10 typically-developing children and 18 brain-injured children. Detailed information about the number of children in each age group is summarized in Table (2).

The procedure used for the original data for the elicitation of narrative descriptions was the "Picture book story-telling" technique. Feldman and her colleagues used this term to refer to three different tasks. These tasks were performed for each child: script, picture description, and replica play narration. In the script, the child was asked to tell a story about going to the doctor, taking a bath, or going to buy food from a fast food restaurant. In the picture description task, the examiner showed the child a picture such as a kitchen and asked the child to describe the picture. In the replica play task, the child was prompted to narrate a story while playing with a set of play animals.

Table 2- Distribution of children in each age group

Type of children	Typical children	Brain injured children
Number of children for age 4	5	10
Number of children for age 4.5	5	6
Number of children for age 5	7	8
Number of children for age 6	3	9

5.2 Methodology

For the present study, two different analyses have been done for both groups of children. In the first analysis, it is measured whether the growth of each variable, including compound verbs, compound non-verb, coordinate clauses, subordinate clauses, auxiliary and modal verbs, coordinated subject/object, is meaningful at different ages. For this purpose, first the conversation of each child in each session was retrieved and the number of each variable was counted for each child. Detailed information about the software and the method used for retrieving appropriate data for the present study is explained in Appendix (A).

The mixed-effect method is used for this purpose. The R package lme4 (Bates, Maechler and Bolker, 2012) was employed for using mixed-effect method.

5.3 Applicability of mixed-effect method

The mixed-effect method is used in this study because this method is applicable when we have both dependent and independent variables effective in the outcomes of the study (Winter, 2011). Since this is a longitudinal study in which there is dependency among the variables, the use of the mixed-effect method is justifiable. There is a dependency between different variables because in a longitudinal study, the same child has data for different ages. Before using this method three concepts should be clarified which are: random effect, fixed effect and pMCMC (Particle Monte-Carlo Markov chain).

In the mixed effect model defined for the purpose of this research, random effects are the children that participated in this study and fixed effect variable is the age of the children.

Age is considered as a fixed effect because it belongs to a fixed set (it can only take 4, 4.5, 5, and 6). The children is set as random effect because the children's behavior has not been experimentally controlled, and they react differently according to their situations which had not been measured. Factors which have not been experimentally controlled include the intelligence level of the children, their attention to the task at hand, their willingness to cooperate with the researchers, etc. For example, one of the children did not participate in the replica play narration component of the study. In addition, some of the children may be sleepy on the time of recording (like 'ME' at the age of 6), or they may felt unease or missed their parents. Moreover, they are small samples of a large statistical population for both brain injured and typically developing children aged

between 4 and 6, and hence, these children may be a highly generalized statistical sample.

Another tool in the mixed effect method is pMCMC. This tool is used for hypothesis testing within the mixed-effect method. In the present research, for the first part, the null hypothesis is that the variables at lexical and grammatical levels do not change at different ages within each group and for the second part, the null hypothesis is that there is not a relationship between lexicon and grammar at different ages within each group. The hypothesis is rejected if pMCMC < 0.05. It is worthwhile to mention that because the random variables are not distributed normally, the methods and p-values (here pMCMC) are not exact. It is also worthwhile to mention that for calculating pMCMC in R, "pvals.fnc" runs 10,000 simulations, varying the coefficients of the model slightly each time, form random data based on those coefficients, and keeping track of how often those data look like your input.

Chapter 6: Results

For the purpose of this study, the growth of variables mentioned in Chapter 3 and the relationship between the growth of the lexical and grammatical variables is analyzed chronologically for the two groups of children aged 4 to 6 years old. The defined variables at the grammatical level are auxiliary and modals, coordinate clauses, subordinate clauses, and coordinated subjects/objects and at the lexical level are compound verbs and compound non-verbs. These analyses are done first for typically developing children, and then for the children with brain injuries. For those variables that have a meaningful positive growth, it is investigated whether or not a meaningful significant relationship exists between them as they get older.

The data consisted of three kinds of narratives (picture description, narrated play, and describing a trip), consisting of about 30 minutes per child in each session. As the tasks were done in a limited time and the scripts were the same for all ages the analyses are done based on the total number of variables not on the proportion of them in total number of utterances. However, in Table (28) in Appendix (A) the mean use of each variable per utterance at the lexical and grammatical levels for both groups of children at different ages is presented.

According to the discussed definition in section 5.3, the pMCMC is set at 0.05. Therefore, if for a variable pMCMC is less than 0.05, it is safe to conclude that the variable has a meaningful positive growth.

6.1 The analyses of the growth of variables

In this section, applying appropriate statistical procedure, the significant growth of each variable is analyzed first for typically developing and then for brain injured children.

Since the number of children is not the same in different ages, the total count of each variable is not statistically reliable to conclude its rate of growth. Thus, the mean of each variable per child is used for this purpose which is shown in Table (4). However, the total number of variables at each age is mentioned in Table (3) for more information about the total number of each variable use by all children in each group at different ages.

As it has been summarized in Table (4), for both groups of children, at the grammatical level, the production of coordinate clauses at the age of 6 has the highest mean. Furthermore, the production of coordinated subject/object has the lowest mean at the age of 5 for typically developing children and at the age of 4 for brain injured children. In addition, among typically developing children, at the lexical level, production of compound verbs at the age of 6 has the highest mean, and the production of compound non-verbs at the age of 4 has the lowest mean. Moreover, for the brain injured children, at the lexical level, the production of compound verbs has the highest mean at the age of 6 and the lowest mean at the age of 4.

Table 3- Total number of each variable for both groups of children

			Lexical level		Grammatical level			
	age	Utterances	Compound verbs	Compound non-verbs	Coordinate clauses	Subordinate clauses	Auxiliaries and modals	Coordinated subject/object
Typically Developing Children	4	729	77	61	190	104	157	87
	4;5	675	97	66	203	114	172	57
	5	1145	196	125	379	225	296	55
	6	542	93	58	182	87	151	30
Brain Injured Children	4	1732	113	118	139	124	316	28
	4;5	1173	85	79	100	93	138	29
	5	1687	178	142	163	175	277	38
	6	1868	257	161	432	252	414	56

Table 4- The mean of each variable per child for both groups

			Lexical level		Grammatical level			
	age	utterances	Compound verbs	Compound non-verbs	Coordinate clauses	Subordinate clauses	Auxiliaries and modals	Coordinated subject/object
Typically Developing Children	4	145.8	15.4	12.2	38	20.8	31.4	17.4
	4;5	135	19.4	13.4	40.6	22.8	34.4	11.4
	5	163.6	28	17.9	54.1	32.1	42	7.9
	6	180.7	31	18	60.7	29	50	10
Brain Injured Children	4	173.2	11.3	11.8	13.9	12.4	31.6	2.8
	4;5	195.5	14.1	13.2	16.7	15.5	14.2	4.8
	5	210.9	22.3	17.8	20.4	21.9	34.6	4.8
	6	207.6	28.5	17.9	48	28	46	6.2

6.1.1 The growth of each variable for typically developing children

In this section, for typically developing children, the increase in the use of each defined lexical or grammatical component as children get older has been investigated.

The results indicate that in the typically developing children group there is a significant relationship between age and the increase in the use of auxiliaries and modal verbs, coordinate clauses, compound verbs, and compound non-verbs. In addition, at the specified age level, there is not sufficient evidence supporting that there is a significant relationship between the age and the use of coordinated subject/object and subordinate clauses and consequently there is insufficient data to conclude that these children have significant growth in using coordinated subject/object and subordinate clauses between the ages 4 and 6.

In the following sections, figures representing the use of each variable at different ages have been presented. Each line in each figure shows the growth of use of that variable by one child in the studied age groups. The thicker line in each plot is the mean line. The related statistical explanations are also described in the following paragraphs. The details of the statistical results are mentioned in Table (24) in the appendix (A).

6.1.1.1 Auxiliary and modal use in the typically developing children group

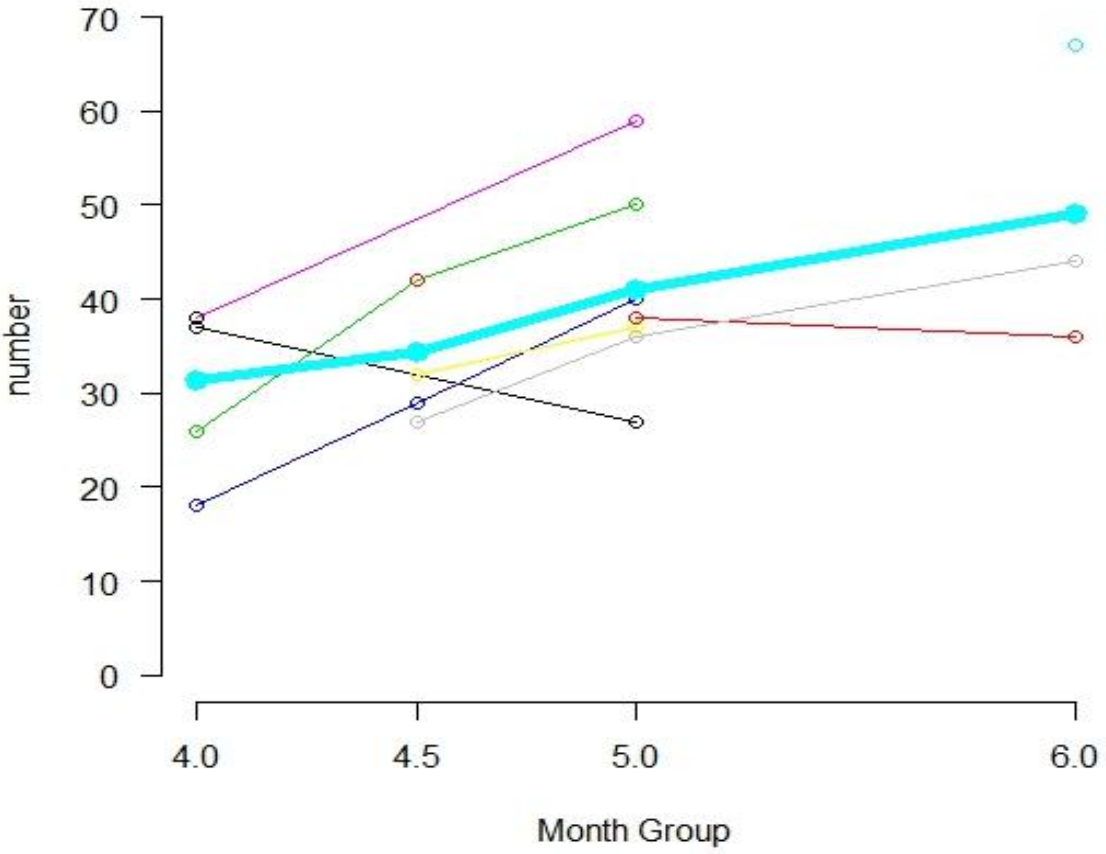
Some samples of the auxiliary and modal use of three typically developing children are listed in Table (5).

Table 5- Samples of auxiliary and modals for typically developing children

Child's code	Age	Sample of auxiliary and modal
GA	4	They were making a pie.
	4;5	You would turn the shower on.
	5	I can't tell you anymore.
GR	4	You hafta get undressed.
	4;5	They're gonna put him in the jungle.
	5	What should I draw?
ME	4;5	I'll put all the money in the bag.
	5	I can't remember everything.
	6	The girl is swinging on the swing.

The plot for auxiliary and modal use of typically developing children during the ages is shown in Figure (1). As it is observable from the thicker line in this figure which shows the mean use of auxiliary and modal verbs for typically developing children between the ages 4 and 6, the highest mean of modal and auxiliary use is for the age of 6, and the lowest mean is for the age of 4. It is worthwhile to mention that two children do not follow the increase pattern for all ages. The use of these variables decreases for one child at the age of 5 and for another one at the age of 6.

Figure 1- Auxiliary and modal use of typically developing children



According to the result from mixed-effect model, summarized in Table (24), the pMCMC is less than 0.05. Therefore, the difference in the use of auxiliary and modal among different studied age groups is significant and these children use more auxiliaries and modals as they get older. Therefore, the two points that have different patterns are not important as these children have significant growth in using these variables in general.

6.1.1.2 Coordinate clause use in the typically developing children group

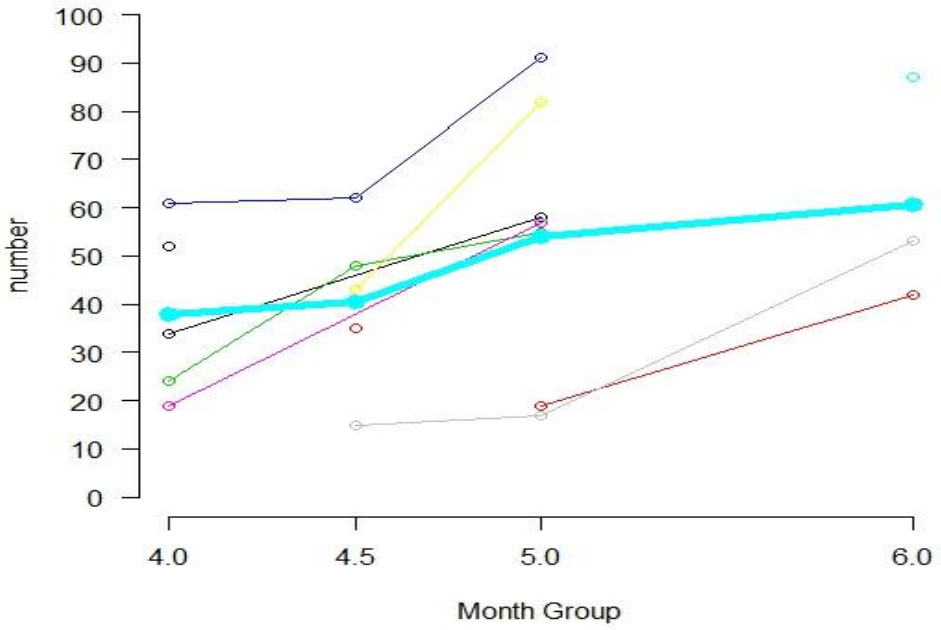
Some samples of coordinate clause use of three typically developing children are summarized in Table (6).

Table 6- Samples of coordinate clauses for typically developing children

Child's code	Age	Sample of coordinate clauses
GA	4	I went ladder again and slide down again.
	4;5	We need this so the farmer can cut the grass.
	5	She was afraid and they thought he was coming after her and then she went into the street (be)cause she saw the car come after her down the sidewalk and she ducked in between them .
GR	4	He runned for it but he didn't notice the big log.
	4;5	They saw a frog rumble tumble rumble tumble but he didn't notice the big frog.
	5	You hafta turn the shower on and then you hafta wash yourself off and then you hafta dry yourself.
ME	4;5	You do all whole the story and then I'll do the other one.
	5	You wait until they give you your food and after you eat, you can in the car and leave.
	6	You get in the bath and you wash off and you get out and dry yourself, get dressed and maybe you can play a little if your mom says so.

In addition, Figure (2) shows the coordinate clause use of each typically developing child among different studied age groups and the thicker line is the mean use of coordinate clauses of these children between the ages 4 and 6. As it is observable from the figure, the highest mean use of coordinate clauses is for the age of 6 and the lowest mean use is for the age of 4 among this group of children. Moreover. The use of coordinate clauses increases for all typically developing children.

Figure 2- Coordinate clause use of typically developing children



According to the result from mixed-effect model, summarized in Table (24), the pMCMC is 0.0000. Consequently, the difference in the use of coordinate clauses among different studied age groups is significant for these children, and they significantly use more coordinate clauses as they get older.

6.1.1.3 Subordinate clause use in the typically developing children group

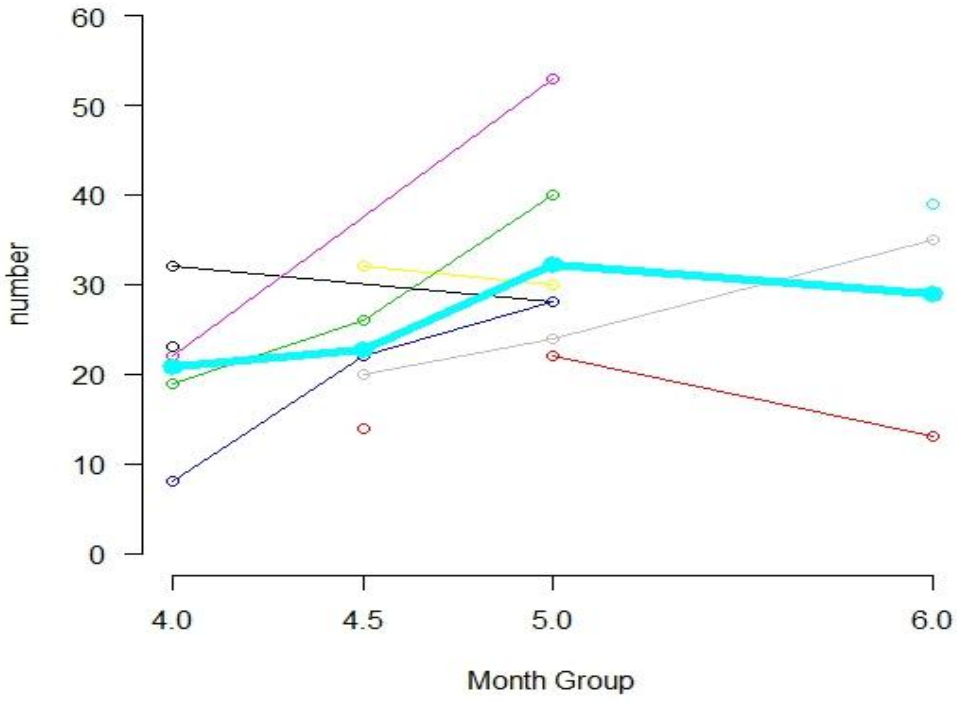
Examples of the use of subordinate clauses of three typically developing children are listed in Table (7).

Table 7- Samples of subordinate clauses for typically developing children

Child's code	Age	Sample of subordinate clause
DR	5	I can do whatever I want
	6	He saw a woman putting some letters in the mailbox.
GR	4	He tried to get the horse to eat some grass.
	4;5	He (i)s not gonna come back because he doesn't belong there.
	5	If you want dessert, you can get dessert.
ME	4;5	I didn't know you had a lion.
	5	Is that what you had to eat?
	6	They're baking (be)cause I see it with my own eyes.

In addition, the plot for subordinate clause use by typically developing children during the studied age groups is shown in Figure (3). According to the thicker line of figure (3), for this group of children, the highest mean use of subordinate clauses is for age 5 and the lowest mean use is for the age 4.

Figure 3- Subordinate clause use of typically developing children



According to the results of mixed-effect model summarized in Table (24), the pMCMC is 0.1. Consequently, the difference in the use of subordinate clauses is not significant for these children and they do not have a significant progress in the use of subordinate clauses from 4 to age 6. According to Figure (3), the use of subordinate clauses does not follow any pattern for typically developing children.

6.1.1.4 Coordinated subject/object use in the typically developing children group

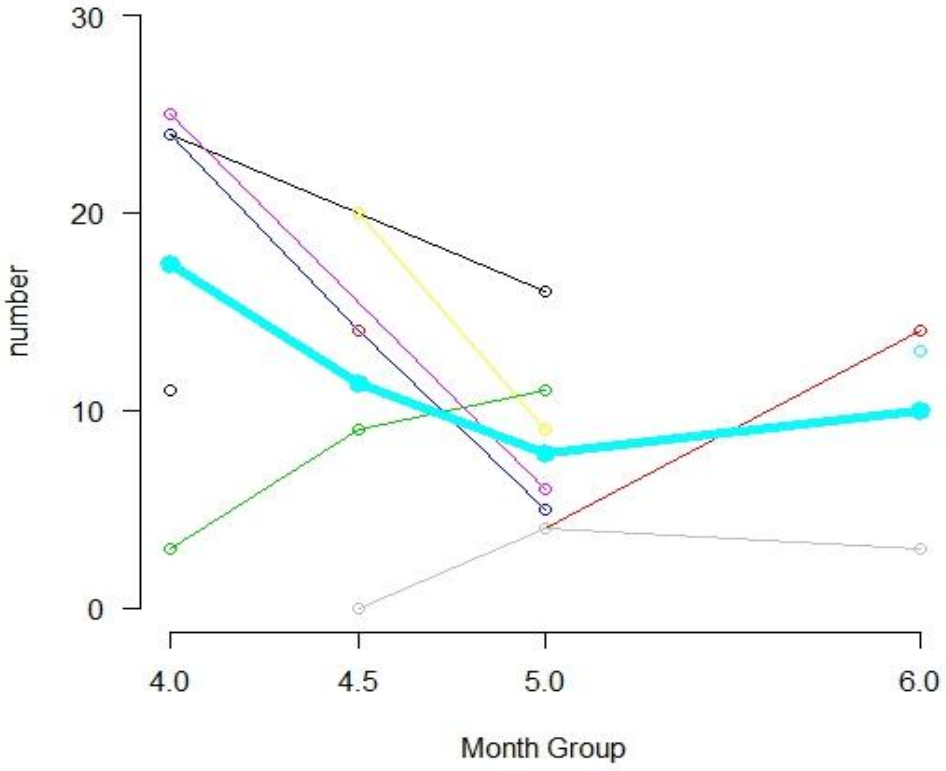
Some samples of coordinated subject/object use of three typically developing children are summarized is listed in Table (8).

Table 8- Samples of coordinated subject/object for typically developing children

Child's code	Age	Sample of coordinate subject/object
BO	4	He pinches me and my sisters.
	5	He and his dog fell in to the pond.
GA	4	He won't know it will be me and hero Superman.
	4;5	Me and Jason always play.
	5	They have a cow and a chicken.
MA	4	So this and the cows can't go away.
	5	We don't even take a bath or a shower.

The plot for coordinated subject/object use in typical children during the ages is shown in Figure (4). As it is observable from the figure, among typically developing children, the highest mean use of coordinated subject/object is for 4 years old, and the lowest mean use is for 5 years old. According to Figure (4), for most of the children, the use of coordinated subject/object decreases from 4 year to 5 year and it does not follow a rule after that. Only two children have growth in using coordinated subject/object from age 4;5 to 5. Moreover, among two children that are observed between the ages 5 and 6, just one of them uses more coordinated subject/object from the age 5 to 6.

Figure 4- Coordinated subject/object use of typically developing children



The results of the mixed-effect method supported this observation. According to the results of mixed-effect model that is shown in Table (24), the pMCMC is 0.1. Consequently, the difference in the use of coordinated subject/object is not significant for these children. Accordingly, they do not progress so much in the use of coordinated subjects/objects from age 4 to 6.

6.1.1.5 Compound verb use in the typically developing children group

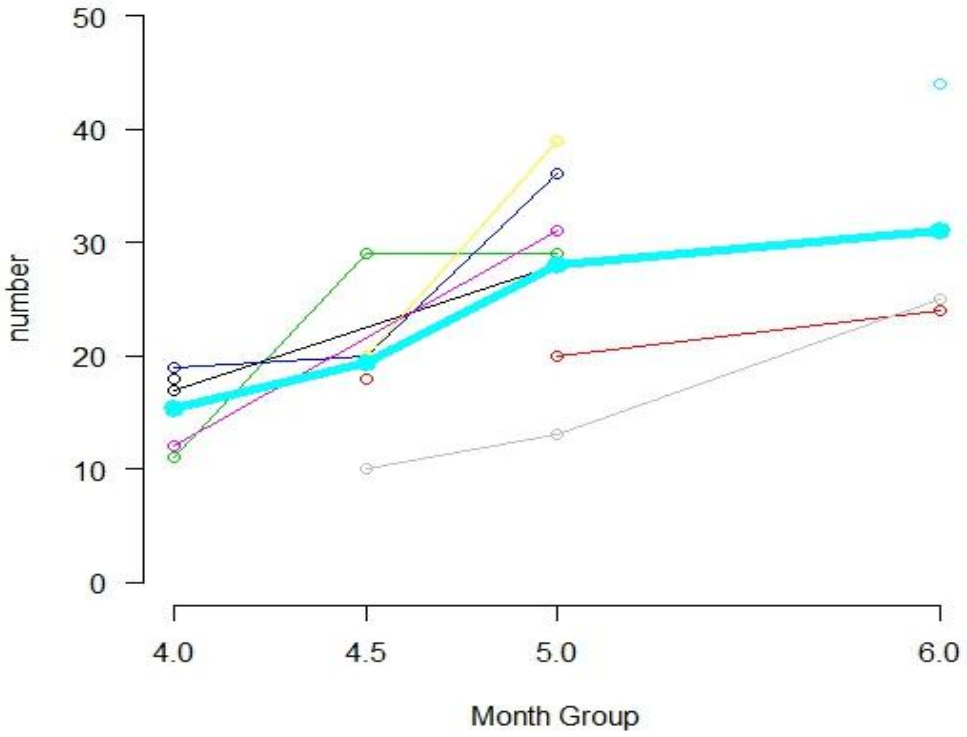
There are some compound verb samples in Table (9) for more clarification. These verbs were used by typically developing children between the ages 4 and 6.

Table 9- Samples of compound verbs for typically developing children

Child's code	Age	Samples of compound verbs
DR	5	Get in, keep out, come in
	6	Turn around, put on, throw away
GR	4	Fall down, put on, get into
	4;5	Come back, find out, wake up
	5	turn on, get out, look out
ME	4;5	Come on, pick up, fall down
	5	Put on, sit down, get away
	6	Come back, look at, come down

Moreover, the plot for compound verb use of typically developing children during the studied ages is shown in Figure (5). According to the thicker line of Figure (5), the lowest mean use of compound verbs is for the age of 4 and the highest use of that is for the age 6. There is only one child that has not increase in the use of compound verb use, i.e., the use of compound verb decreases from the age 4;5 to 5 for this child.

Figure 5- Compound verb use of typically developing children



The results of the mixed-effect method supported the general observation. According to the result from mixed-effect model, summarized in Table (24), the pMCMC is significant at 0.003. Accordingly, the difference in the use of compound verbs during ages is significant for these children and they use more compound verbs as they get older.

6.1.1.6 Compound non-verb use in the typically developing children group

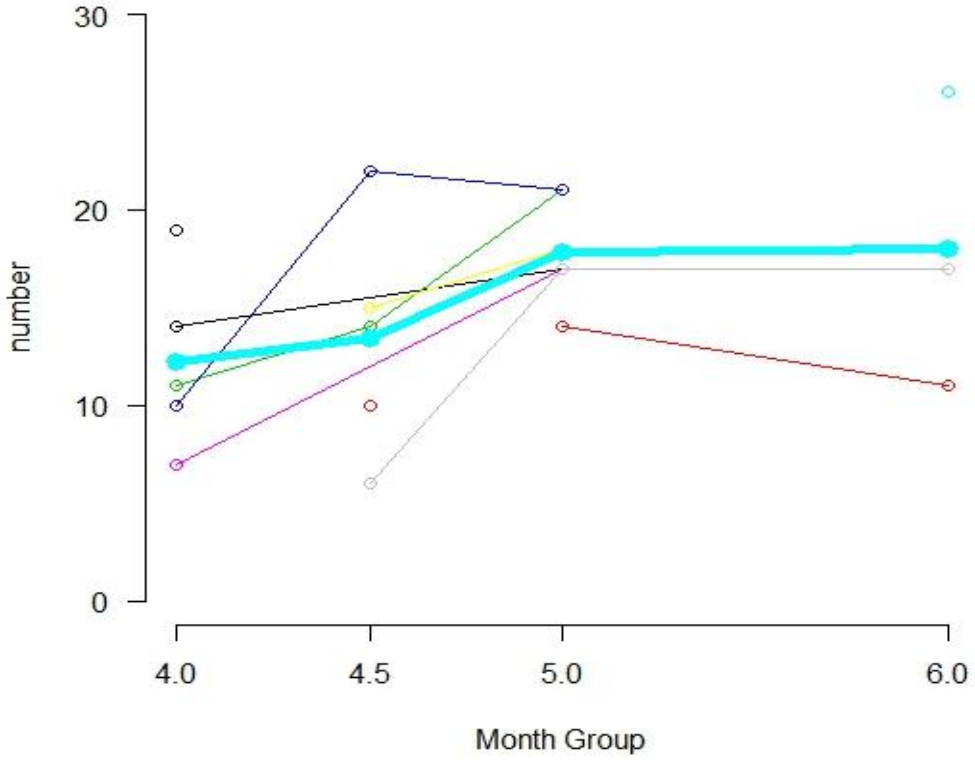
Table (10) indicates some samples of compound non-verbs that were used by three typically developing children at the ages 4, 4;5, and 5.

Table 10- Samples of compound non-verbs for typically developing children

Child's code	Age	Samples of compound non-verbs
BO	4	Grandfather, boyfriend, birthday
	5	Grandkids, mailbox, playground
GR	4	Toothpaste, french-fries, tree-truck
	4;5	Bathroom, outside, inside
	5	Groundhog, toothbrush, sometime
MA2	4;5	Sliding-board, hamburger, something
	5	Ice-cream, everybody, ice-cube

In addition, Figure (6) shows the growth of compound non-verb use by typically developing children among the studied age group. According to the thicker line in Figure (6) the lowest mean use of compound non-verbs is at the age of 4 and the highest mean use of that is at the age of 6. The only two different growth is for one child at between the age of 4;5 and 5 and another child between the ages 5 and 6. The use of compound non-verbs decreases in these span times for these two children.

Figure 6- Compound non-verb use of typically developing children



The results of the mixed-effect method support the general observation. According to the results of the mixed-effect model, summarized in Table (24) in Appendix (A), the pMCMC is 0.04. Thus, the difference in the use of compound non-verbs during the studied age groups is significant for typically developing children and thus they use more compound non-verbs as they get older.

6.1.2 The growth of each variable for brain injured children

In previous section, for typically developing children, it was analyzed whether there is a significant growth in the use of each defined lexical and grammatical component or not. The results indicated that as these children grew older they used more

auxiliaries and modal verbs, coordinate clauses, compound verbs and compound non-verbs. Moreover, in this study, growth was not seen for subordinate clause use and coordinated subject/object use.

In this section, for brain injured children, it is analyzed whether or not the use of each defined lexical or grammatical component increases significantly as these children get older. The results can help in finding whether both groups of children follow the same pattern of growth in using the defined variables or not in the studied age group.

The results indicate that in the brain injured children group there is a significant relationship between age and the increase in the use of coordinate clauses, subordinate clauses, compound verbs, and compound non-verbs. In other words, as the studied children grew older they used more of these linguistic components. On the other hand, there was not sufficient evidence supporting that there is a significant relationship between the age and the use of coordinated subject/object and auxiliaries and modals. The plots for the use of each of these components at different ages and their detailed explanations are described in the following paragraphs. The thicker line in each plot is the mean line. The details of the statistical results are mentioned in Table (25) in the appendix (A).

6.1.2.1 Auxiliary and modal use in the brain injured children group

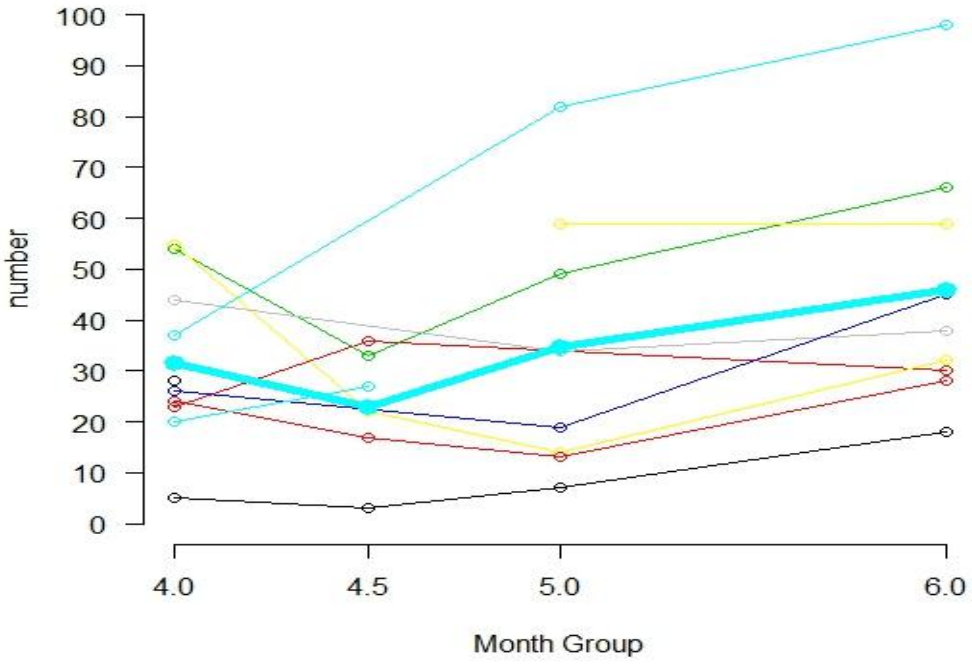
Some samples of the use of auxiliary and modal of three brain injured children are shown in Table (11).

Table 11- Samples of auxiliary and modals for brain injured children

Child code	Age	Sample of auxiliary & modal use
CES	4	They're sliding down the sliding board.
	5	I can't see anything.
	6	You're all done taking a bath.
MAT	4	I do have French-fries in McDonalds.
	5	I don't know this picture.
	6	The cow (ha)s been eating the cabbages.
YUC	4	What else could be in here?
	5	You hafta do it all by yourself.
	6	We gonna do the other silly bag?

The plot for auxiliary and modal use of brain injured children during the ages is shown in Figure (7). As it is observable from the thicker line in this figure which shows the mean use of auxiliary and modal verbs for brain injured children between the ages 4 and 6, the highest mean of modal and auxiliary use is for the age of 6, and the lowest mean is for the age of 4;5. It is worthwhile to mention that the use of auxiliary and modal verbs decreases from the age 4 to 5 for four children and from age 5 to 6 for three other children.

Figure 7- Auxiliary and modal use of brain injured children



According to the results of the mixed-effects model shown in Table (25) in Appendix (A), pMCMC for auxiliary and modal use of these children is 0.06 which is close to 0.05 and is in the marginal of acceptance. Therefore, there is insufficient evidence to say that the use of auxiliary and modal has a significant growth at different ages for these children. However, there is not enough evidence to suggest that these children have significant progress in the use of auxiliary and modal from the age 4 to the age 6.

6.1.2.2 Coordinate clause use in the brain injured children group

Samples of the coordinated clause use by three brain injured children for the ages 4, 5, and 6 is mentioned in Table (12).

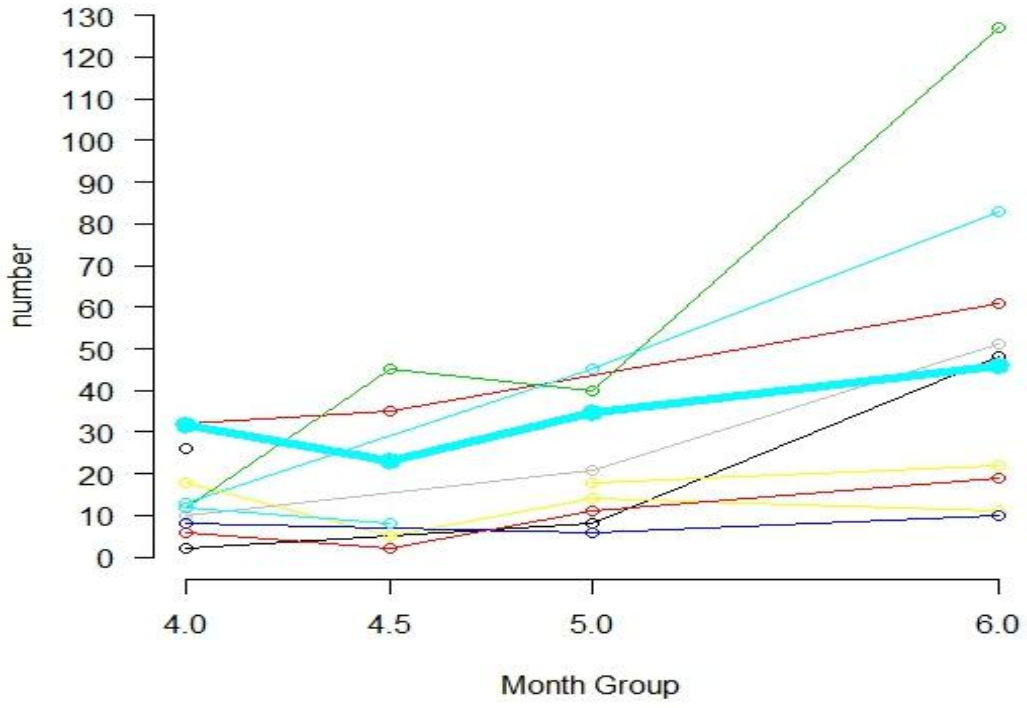
Table 12- Samples of coordinate clauses for brain injured children

Child's code	Age	Sample of coordinate clauses
CAL	4	He run to get a frog then he fall in water.
	5	First you get your food and the next thing you do the money.
	6	Bob was walking and the girl was carrying some papers into the mailbox and they blowed away.
CES	4	You get a hamburger and that's it.
	5	There is a fork and there's a hamburger.
	6	Well you hafta eat your food and you hafta throw everything away and you hafta pay.
DON	4	You hafta put water in there but Bro put water in there.
	5	Go to the bathroom and then wash yourself.
	6	Get your clothes off and take a shower, but I don't hafta take a shower before I go to practice tonight.

As it can be seen in Table (12), in the script narration part, 'CES' explained more about buying food from a restaurant and used more coordinate clauses as he got older. 'DON' used more details when he wanted to narrate how to take a bath as he got older. These examples are representative of using more coordinate clauses by these three children when they got older.

The plot for coordinated clause use by brain injured children at different ages is shown in Figure (8). As it can be seen in Figure (8), the highest value for the mean use of coordinate clauses by brain injured children, is at the age of 6 and the lowest value for the mean use of coordinate clauses by these children is at the age of 4. The only occasional finding in this figure is the decrease from the age 4 to the age 4;5 just for one child and all the other children use more coordinate clauses between the ages 4 and 6.

Figure 8- Coordinate clause use of brain injured children



According to the result of the mixed-effect model analysis represented in Table (25), the pMCMC for this linguistic component is significant at 0.002 and consequently, it can be proposed that the difference in the use of coordinate clauses at the examined ages is significant for these children, and they use more coordinate clauses as they get older between the ages 4 and 6.

6.1.2.3 Subordinate clause use in the brain injured children group

Some samples of the use of subordinate clauses for three children are shown in Table (13).

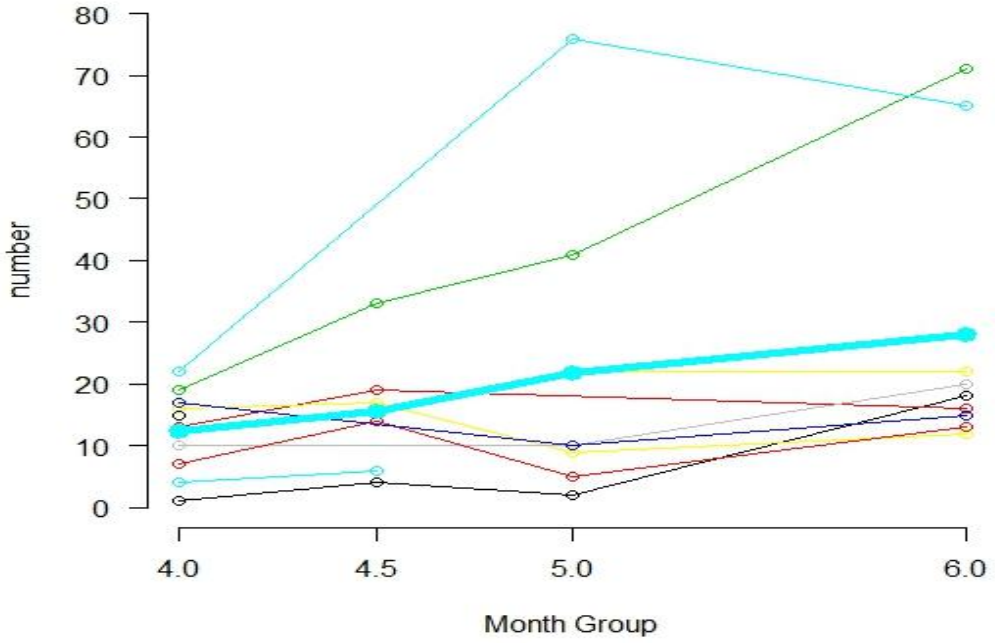
Table 13- Samples of subordinate clauses for brain injured children

Child's code	Age	Sample of subordinate clauses
CAS	4	let (u)s see what else I can find.
	5	I have lots of other things I want you to see.
	6	Do you think I could take that green thing?
MAT	4	let (u)s put this stuff in this bag.

Child's code	Age	Sample of subordinate clauses
	5	I'm not allowed to touch knives.
	6	When they got all tired the monkey finally went away.
YUC	4	He saw a frog sitting on the bank on the lilypad.
	5	Me and my cow worked so hard on it that we don't want them chewed on.
	6	We hafta act this out when I make it up.

In addition, the plot of using subordinate clauses by brain injured children is indicated in Figure (9). As it is observable from the figure, among brain injured children, the highest mean use of subordinate clauses is for 4 year old children, and the lowest one is for 6 year olds. According to this figure, the use of this structure decreases from age 4;5 to 5 for three brain injured children. Moreover, two children have different pattern of growth compared to others. The growth of the use of subordinate clauses is more than twice at the ages 4;5 and 5 for them. However, one of them steadily used a lot of subordinate clauses at the age of 6 and for another one the use of this variable decreased from the age 5 to 6.

Figure 9- Subordinate clause use of brain injured children



According to the result of the mixed-effect model summarized in Table (25), the pMCMC is significant at 0.02. Thus, these children have used more subordinate clauses as they got older between the ages 4 and 6.

6.1.2.4 Coordinated subject/object use in the brain injured children group

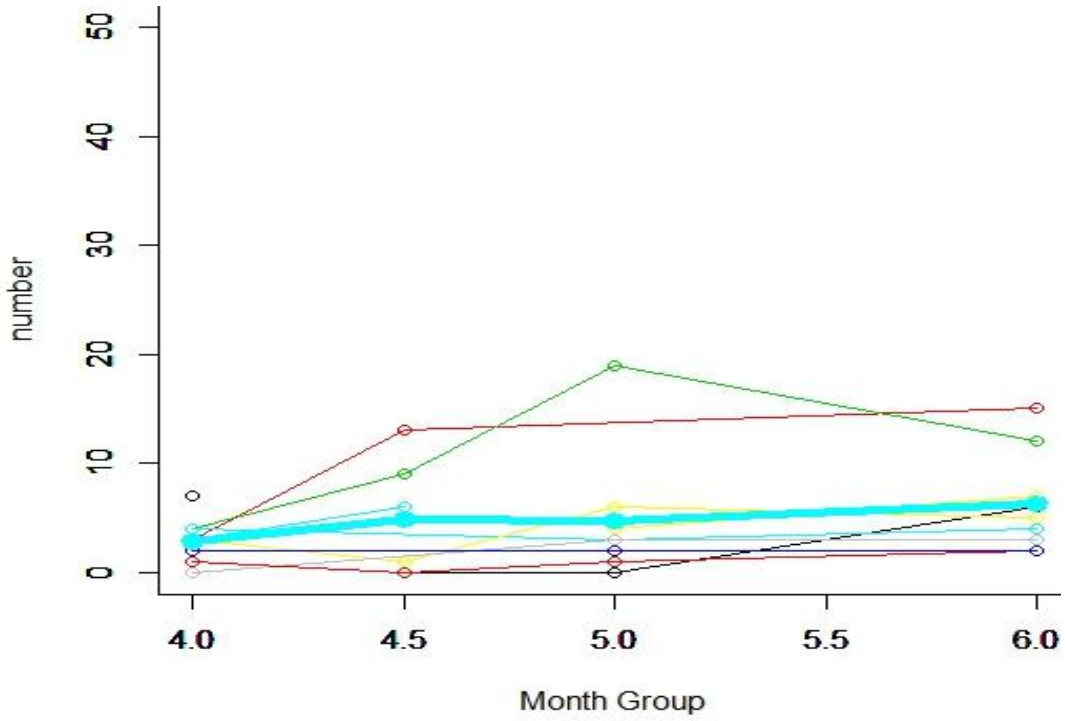
Some samples of coordinated subject/object that were used by brain injured children are listed in Table (14).

Table 14- Samples of coordinated subject/object for brain injured children

Child's code	Age	Samples of coordinated subject/object
CAS	4	Max and Pero fell right into the water
	5	You get fries and Sprite and Coke.
	6	I want a hamburger or a cheeseburger .
MAC	4	Max and a dog named Pero are there.
	4;5	Make the dad then the big brother and big sister then the mommy.
	6	The boy and girl are helping the old man cook.
MAT	4	Sometimes I go to Mcdonalds and Burger_king.
	5	They're using water and stuff right here.
	6	All those growing cabbages and all those berries that he's growing.

In addition, the plot related to the use of coordinated subject/object is shown in Figure (10). As it is observable from the figure, among brain injured children, the highest mean use of coordinated subject/object is for 6 year olds, and the lowest one is for 4 year olds. According to Figure (10), it seems that except for two of brain injured children, the use of coordinated subject/object has remained the same from the age 4 to 6. However, one of the children has shown constant use of this structure after the age 4;5, the other child used more coordinated subject/object from age 4 to 4;5 and his/her use did not improve so much from age 4;5 to 6.

Figure 10- Coordinated subject/object use of brain injured children



According to the results from the mixed-effects model that is shown in Table (25), the pMCMC is 0.06 which is close to be significant. However, as the significant pMCMC

should be less than 0.05, there is insufficient evidence to support the hypothesis that the growth in the use of coordinated subject/object from the age 4 to the age 6 is significant.

6.1.2.5 Compound verb use in the brain injured children group

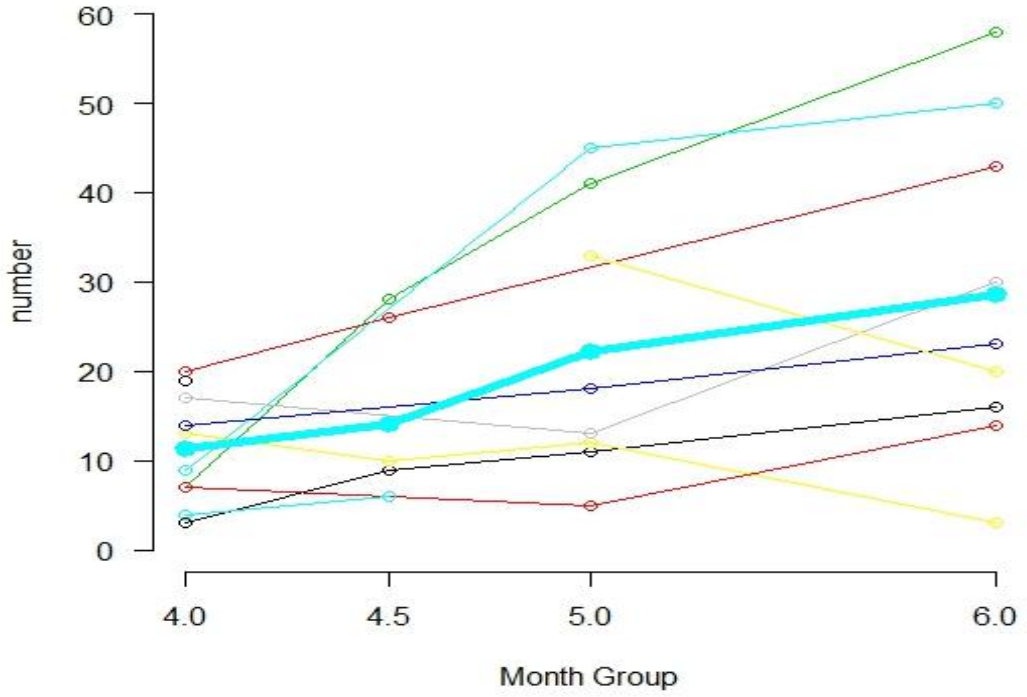
Some of the compound verbs that were used by three brain injured children from age 4 to 6 are mentioned in Table (15).

Table 15- Samples of compound verbs for brain injured children

Child's code	Age	Sample of compound verbs
CAL	4	Get back
	5	Wake up, get back
	6	Fall down
CES	4	get out, take out
	5	Put on, take off
	6	Come in, get out, come over
DAV	4	Get on, get rid of, give back
	5	Set up, get out, pick up
	6	Come in, sit down, turn on

In addition, Figure (11) shows the plot related to compound verb use by brain injured children between the ages 4 and 6 years old. According to the figure, the highest mean use of compound verbs is for the age 6 and the lowest one is for the age 4. The use of this variable decreases from age 4 to 5 just for two brain injured children and from age 5 to 6 just for two others. In general, according to the thicker line, the mean use of compound verbs has positive growth from age 4 to 6.

Figure 11- Compound verb use of brain injured children



The results of the mixed-effect method support this observation. Considering the results of the mixed-effects method that are shown in Table (25), the pMCMC is significant at 0.005 and consequently the use of compound verbs at different ages has a positive growth and these children use more compound verbs as they get older.

6.1.2.6 Compound non-verb use in the brain injured children group

Some samples of compound non-verbs that were used by brain injured children between the ages 4 and 6 are mentioned in Table (16).

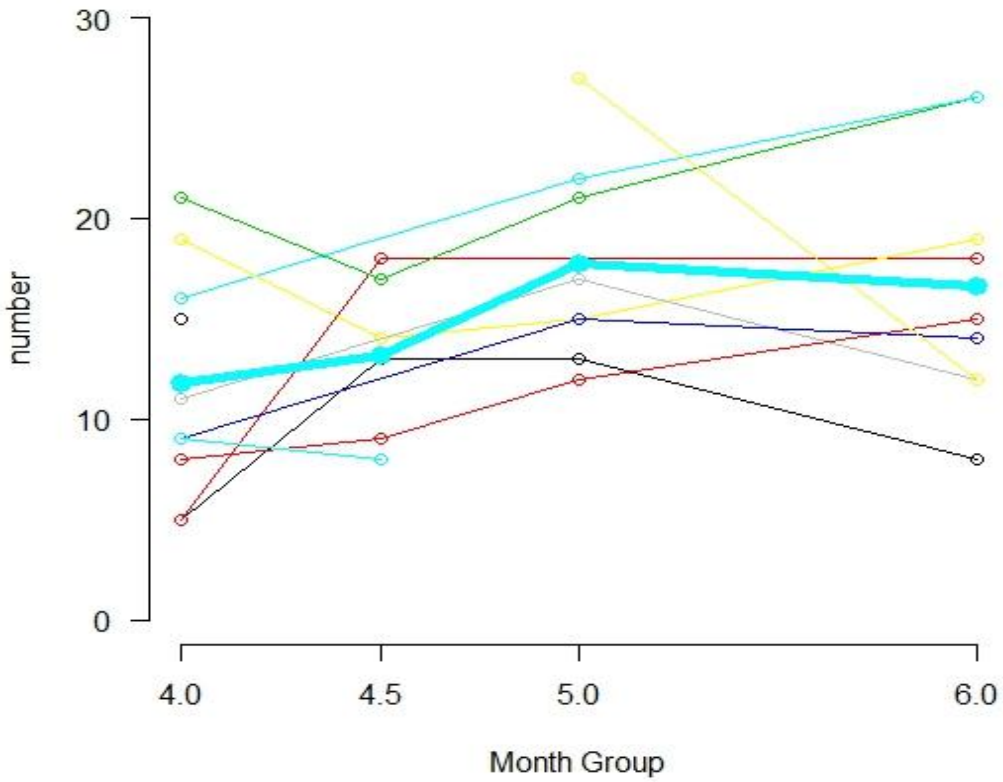
Table 16- Samples of compound non-verbs for brain injured children

Child's code	Age	Sample of compound non-verbs
CES	4	Mailbox, outside, sliding-board, happy-meal
	5	French-fries, toothbrush, inside
	6	Playground, bedroom, washtowel, firetruck
MAT	4	Tunnelslide, upstair, toothpaste
	5	Sometimes, teddy bear, hamburger
	6	Birthstone, farmyard, footprint

Child's code	Age	Sample of compound non-verbs
YUC	4	Something, nighttime, birthday
	5	Bubblebath, rainbow
	6	Washcloth, anymore, everybody

The summary of compound non-verb use by brain injured children between the studied ages is plotted in Figure (12). According to the figure, brain injured children have the highest mean use of compound non-verbs at the age of 5 and the lowest one at the age of 4. The use of this variable decreases for three brain injured children between the ages 4 and 4;5 and for four other children between the ages 5 and 6. However, in general, according to the thicker line the use of this variable increases from age 4 to 6.

Figure 12- Compound non-verb use of brain injured children



The results of the mixed-effect method in Table (25) support the significant growth of this variable for brain injured children for the studied age group. Thus, these children have used more compound non-verbs as they have got older.

6.1.3 Summary of the growth of each variable for both groups of children

The pMCMC of the mixed-effect method for variables at the lexical and grammatical level for both typically developing and brain injured children is summarized in Table (17). As it was mentioned before if for one variable the pMCMC is less than 0.05 then there is enough evidence to support that the variable has significant positive growth between the ages 4 and 6. There is a sign (✓) in the boxes of those variables that are considered to have significant positive growth.

Table 17- The pMCMC for lexical and grammatical area for both group of children

		Typically Developing Children	**Brain Injured Children**
Lexical level	Compound verbs	✓ 0.001	✓ 0.0052
	Compound non-verbs	✓ 0.0145	✓ 0.0420
Grammatical level	Coordinate clauses	0.0000	✓ 0.0022
	Subordinate clauses	0.1004	✓ 0.0276
	Auxiliaries and modals	✓ 0.0039	0.0668
	Coordinated subject/object	0.1359	0.0620

Children with brain injuries used more coordinate clauses, subordinate clauses, compound non-verbs and compound verbs as they got older. They did not show significant positive growth in the areas of coordinated subject/object or auxiliaries and

modals in this period of time. Typically developing children used more compound verbs, compound non-verbs, coordinate clauses and auxiliaries and modals as they got older. These children did not use more coordinated subject/object and subordinate clauses as they got older.

It is worthwhile to mention that just the typically developing children showed a significant increase in the use of auxiliaries and modal verbs, while such an observation was not perceived among the brain injured children.

The total number and the mean use of auxiliary and modal verbs that are used by typically developing children are summarized in Table (18) and Table (19). According to the data (summarized in these two tables), typically developing children use a variety of auxiliary and modal verbs. However, the use of 4 forms increases as they get older: the present tense form of the modal verb "can", the present tense form of the perfect auxiliary "have", and both past and present tense forms of the progressive auxiliary of "be". Also, the growth of using "will" showed a sharp increase at the age of 6 compared to previous years.

Table 18- Total number of auxiliary and modal verbs used by typical developing children

Age	Auxiliary verb "do"	Present progressive aspect	Past progressive aspect	will	Present progressive with "go"	can	Have to	should	could	would	Had to
4	31	41	13	17	19	8	5	1	1	1	1
4;5	39	55	9	12	9	19	5	0	1	7	7
5	41	85	35	16	19	33	22	2	12	6	8
6	15	38	19	25	9	21	12	0	3	4	2

Table 19- Mean of auxiliary and modal verbs used by typical developing children

Age	Auxiliary verb "do"	Present progressive aspect	Past progressive aspect	will	Present progressive with "go"	can	Have to	should	could	would	Had to
4	6.2	8.2	2.6	3.4	3.8	1.6	1	0.2	0.2	0.2	0.2
4;5	7.8	11	1.8	2.4	1.8	3.8	1	0	0.2	1.4	1.4
5	5.9	12.1	5	2.3	2.7	4.7	3.1	0.3	1.7	0.9	1.1
6	5	12.7	6.3	8.3	3	7	4	0	1	1.3	0.7

Regarding residuals, just one typical child used sentences with "should", "could", "would", and "had to" at the age of 4. These sentences are:

(11) This should push back.

(12) He couldn't even fit it in the freezer.

(13) He had (t)a eat it right away .

(14) Why would you rip that?

The modal "may" was used just once by a child at the age of 6:

(15) Now you may come and visit.

From the above description, it is possible to conclude that the variety of auxiliary and modal verbs used by typically developing children increased between the ages 4 and 6.

There is insufficient evidence to conclude that the brain injured children had growth in the use of auxiliary and modal verb use between the ages 4 and 6. However, these are some examples that have been produced by these children between the ages 4 and 6:

(16) Can I hold it? (CES at the age of 4)

(17) I could want it to be brownies (DON at the age of 4;5).

(18) He's riding on the horse (CES at the age of 5).

(19) You hafta get washed (CAS at the age of 6).

6.2 Lexical and grammatical interaction for typically developing and brain injured children

In this section, the mixed effect method is used to find out whether there is a relationship between grammatical and lexical growths of children in each group, and only those parameters that have a positive and significant growth at different ages in the above section are analyzed. Consequently, as summarized in Table (17) and summarized in section (6.1.3), at the lexical level, for typically developing children and brain injured children, compound verbs and compound non-verbs have significant positive growth at different ages. At the grammatical level, for brain injured children, subordinate clauses and coordinate clauses have positive significant growth in different ages, and for typically developing children, auxiliary and modal verbs and coordinate clauses have positive significant growth. The lexical and grammatical areas that have significant growth are summarized in Table (20).

Table 20- Lexical and grammatical areas that have significant growth

Type of children / Language area	Brain Injured Children	Typically Developing Children
Lexical	Compound verb, compound non-verb	Compound verb, compound non-verb
Grammatical	Subordinate sentence, coordinated clause	Auxiliary and modal, coordinated clause

Consequently, this data support the idea that typically developing and brain injured children develop in parallel for lexicon, but they do not do so for grammatical structures.

6.2.1 Lexical and grammatical interaction for typically developing children

In this section, the results of the mixed-effect method used for evaluating the relationship between the following variables is discussed: 1) coordinate clauses and compound verbs, 2) coordinate clauses and compound non-verbs, 3) auxiliary and modal verbs and compound verbs, 4) auxiliary and modal verbs and compound non-verbs.

The pMCMC of the mixed-effect model for calculating the interaction of lexical and grammatical growth for typically developing children is shown in Table (21).

Table 21- The pMCMC for interaction of lexical and grammatical growth for typically developing children

Lexical part / Grammatical part	Compound non-verbs and ages	Compound verbs and ages
Auxiliaries and modals	0.1294	0.2218
Coordinate clauses	0.5050	0.7566

Based on this table, using R software (2012), the mixed-effect formula for calculating the interaction between compound verbs and coordinate clauses is as follows:

$$\text{lmer}(cs \sim cv \times age2 + (0 + age2|namegroup), \text{data} = NarCont2)$$

In this formula, "NarCont2" is the table that contains information for variables related to typically developing children, "cv" is a variable for compound verb and "age2" is a variable for age. The formula ($cv \times age2$) calculates the interaction between compound verbs and ages and the pMCMC for this interaction evaluates whether the relationship between coordinate clauses and compound verbs is significant as the children get older or not. According to this table, for typically developing children the pMCMC between compound non-verbs and ages or compound verbs and ages for both auxiliaries and modals and coordinate clauses is more than 0.05. Therefore, there is not a significant relationship between the growth of coordinate clauses and compound verbs/non-verbs or auxiliary and modal verbs and compound verbs/non-verbs at different ages.

6.2.2 Lexical and grammatical interaction for brain injured children

The pMCMC of the mixed-effect model for calculating the interaction of lexical and grammatical growth for brain injured children is shown in Table (22).

Table 22- The pMCMC for interaction of lexical and grammatical growth for brain injured children

Lexical part / Grammatical part	Compound non-verbs and ages	Compound verbs and ages
Subordinate clauses	0.0564	0.8118
Coordinate clauses	0.0148	0.0012

According to this table, the pMCMC of the interaction between ($cv \times age2$) and coordinate clauses is significant for brain injured children. Therefore, there is a significant relationship between the growth of coordinate clauses and compound verbs as they get older.

In a similar way, the relationship between coordinate clauses and compound non-verbs for that period of time can be examined. The results reveals that the pMCMC for ($NCW^1 \times age2$) is also significant and consequently, there is a significant relationship between the growth of coordinate clauses and compound non-verbs for brain injured children as they get older.

The similar formulas are used for calculating the relationship between the growth of subordinate clauses and compound verbs and non-verbs. The pMCMC for ($cv \times age2$) is 0.8 and for ($NCW \times age2$) is 0.056. Thus there is not enough evidence to say that there is a significant relationship between the use of subordinate clauses and compound verbs and non-verbs for brain injured children at different ages.

[1] NCW stands for compound non-verb

6.2.3 Summary of lexical and grammatical interaction for typically developing and brain injured children

The pMCMC of the mixed-effect model for the interaction at the lexical and grammatical levels for both groups is summarized in Table (23). There is a sign (✓) in the boxes of those variables that are considered to have significant positive interaction.

It looks like for typically developing children, there is no specific relationship between the use of lexical compounds and complex sentences, or the use of lexical compounds and auxiliary and modal verbs when they are between 4 and 6 years old. On the other hand, for brain injured children, there is a significant relationship between the use of lexical compounds and subordinate clauses from age 4 to 6. However, for brain injured children, there is not a significant relationship between the use of lexical compounds and coordinate clauses for the ages 4 to 6.

Table 23- The pMCMC for the interaction at the lexical and grammatical levels for both groups

Lexical part / Grammatical part	Compound verbs and ages		Compound non-verbs and ages	
	Typically developing children	Brain injured children	Typically developing children	Brain injured children
Subordinate clauses	-	0.8118	-	0.0564
Coordinate clauses	0.2218	✓ 0.0012	0.1294	✓ 0.0148
Auxiliary and modal verbs	0.7566	-	0.5050	-

Chapter 7: Discussion

The main purpose of this research was to determine whether or not there is a significant relationship between the growth in complexity at the lexical and grammatical levels for brain injured and typically developing children. It is said that brain injured children are delayed in language acquisition compared to typically developing children (Thal et al. 1991; Kaffe et al., 1989). Thus, the results of this research can help scholars to find different patterns of growth at the lexical and grammatical levels that typically developing and brain injured children use between the ages 4 and 6. After explaining the importance and the goals of this study in the Chapter One, previous studies dealing with the lexicon and the grammar were discussed in Chapter Two. In Chapter Three, the definitions of complexity at these two levels were stated and the terms that were used in this thesis were defined. The estimation of complexity at the lexical level was done by counting the number of uses of compounds, both verb and non-verb. The estimation of complexity at the grammatical level was done by counting the number of uses of coordinate clauses, subordinate clauses, auxiliary and modal verbs, and coordinated subjects/objects. Some related literature reviews were described in Chapter Four. In Chapter Five, the methodology and the data were introduced. Part of the CHILDES database was used for this study. The mixed-effect method was used for evaluating the growth of each construction for both groups of children. After that, in Chapter Six, those constructions that have positive significant growth at each level were selected and it was measured whether there is a significant relationship between the growth of these constructions at the lexical and grammatical level. In this chapter, based on the findings

of this research, the questions that were asked in Chapter One will be answered. Moreover, these findings are compared with the findings of previous studies.

7.1 Discussion of the growth of variables

Contrary to what might be the general expectation, i.e., that both typically developing children and brain injured children in the studied age groups would show an increase in the use of all grammatical structures as they get older, this study suggested that these assumptions are not supported for all structures. According to the results of this study, the growth is significant in both groups just in lexical compounds, both verb and non-verb, and coordinate clauses. Neither of the groups showed significant growth in the use of coordinated subject/object structures. Only the typically developing children showed a significant increase in the use of auxiliary and modal verbs, while the use of subordinate clauses increased just for brain injured children. For a summary of the primary results, Table (17) and Table (20) in Chapter Six can be consulted.

At the grammatical level, both groups of children have significant growth in using coordinate clauses. According to Table (3) and Table (4), the use of coordinate clauses is almost twice in all ages for typically developing children compared to brain injured children.

At the lexical level, both groups showed significant growth in using compound verbs and non-verbs. According to Table (3) and Table (4), the mean of compound verb and compound non-verb use is higher in all studied age groups for typically developing children compared to brain injured children.

In addition, regarding grammatical development, just the typically developing children showed a significant increase in the use of auxiliaries and modal verbs, while such an observation was not perceived among the brain injured children. The mean use of auxiliary and modal verbs per utterances is summarized in Table (28) in the appendix (A). Referring to this table, the brain injured children did not show an increase in the use of auxiliary and modal verb use at the age of 4;5 and 5.

Moreover, according to the data explained in Table (18) and Table (19) (in Section 6.3.1), it is possible to conclude that the variety of auxiliary and modal verbs used by typically developing children increased between the ages 4 and 6. The growth in the use of auxiliary and modal verbs by typically developing children can be inferred as a sign of acquiring their target language. On the other hand, there is insufficient evidence to conclude that the brain injured children had significant growth in the use of auxiliary and modal verb use between the ages 4 and 6.

Again, both groups of children showed increase in the use of coordinate clauses between the ages 4 and 6. However, only the brain injured children showed increase in the use of subordinate clauses for the studied age groups. It is difficult to account for the fact that brain injured children, unlike typically developing children, have significant growth in the use of subordinate clauses. One possible explanation deals with the natural order of language acquisition.

Literature on the natural order of language acquisition has shown that for typically developing children, subordinate clauses are produced prior to coordinate clauses. The former appear at the age of 2 and the latter appear at the age of 3 (Bowerman ,1979;

Diessel, 2004). The studied typically developing children clearly prefer using coordinate clauses between the ages 4 and 6. For this group of children, the use of coordinate clauses steadily increased up to age 6. For a summary of the information Table (4) in Chapter 6 can be consulted.

Subordinate clauses increase the complexity of a sentence (Cheung and Kemper, 1992; Szmrecsanyi, 2004). In addition, coordinate clauses are easier to process than subordinate clauses (Givón, 1991). The results of this study suggest an unusual findings about language acquisition of typically developing children between the ages 4 and 6, i.e., in terms of the use of subordination, typically developing children use less complexity in their language during the studied age groups. A possible explanation for the significant growth in coordinate clauses and not in subordinate clauses relies on economic language use principles. According to Vicentini (2003), there is a tendency to have least effort in using language. Thus, the typically developing children rely on the minimum means of linguistic communication in transmitting their messages. They use the least amount of linguistic effort to communicate their messages through providing less frequent number of subordinate clauses.

On the other hand, the brain injured children of this study showed significant growth in both coordinate and subordinate clauses. However, at the age of 6, these children began to follow the development of typically developing children, i.e., the growth in the use of coordinate clauses began to exceed the growth of subordinate clauses. For more information about the numbers Table (4) in Chapter 6 can be consulted.

It can be concluded that the difference in the growth of complex sentences in the two groups may simply be a reflection of delayed acquisition in the brain injured group. Thus, it is possible that the brain injured children are still in the process of developing/internalizing the previous stage structure(s), i.e. subordinate clause development, so they use that construction more over the time. Since they have not finished one stage of language development and at the same time have entered the next stage, i.e. coordinate clause construction, they continue to use both of them significantly more frequently. However, for the typically developing children, as they can produce most kind of subordinate clauses by the age of 4 (the age of acquiring subordinate and coordinate clauses is explained in Chapter 4), and are in the process of mastering the production of coordinate clauses, they tend to show significant increase in the use of just coordinate clauses.

The insignificant growth in the use of coordinated subject/object constructions in both groups of children may convey their preference for reducing the number of noun phrases per clause. For example, CAL used “I have a towel and soap” at the age of 4, but he preferred to say “I have a towel and I have soap” at the age of 5.

It is worthwhile to mention that only the brain injured children in this study used non-existent compound words. Some examples of these words are: “sad-meal”, “polar water”, “tunnel-slide”, and “wash-towel”. This fact supports Clark’s (2009) findings. According to her perspective that is mentioned in Chapter (4), because children have limited vocabulary inventory, they combine the words that they have in their inventories together and make nonce compound words. However, the typically developing children

in this study did not produce any non-existent compound words between the ages 4 and 6. Perhaps, making these kinds of words occurs more for brain injured children because their vocabulary knowledge is less than typical developing children.

In general, the findings of this study support the hypothesis in the first chapter about the significant growth of structures at the lexical level for both groups of children about having significant growth in using compound verbs and non-verbs. Furthermore, at the grammatical level, the findings of this study support the hypothesis in the first chapter about the significant growth for both groups in using coordinate clauses and subordinate clauses just for brain injured children and auxiliaries and modals just for typically developing children. In other words, the results of this study do not support the hypothesis about the significant growth in using coordinated subject/object for both groups, auxiliary and modal verbs for brain injured children and subordinate clauses for typically developing children.

7.2 Discussion of the interaction between the growth of variables

In looking at the relationship between the growth of the different variables as defined through lexical and grammatical constructions, there is insufficient evidence supporting a significant relationship between the growth of the constructions at the lexical and grammatical levels for typically developing children. This is in contrast with the findings of Perez-Leroux et al. (2012). They suggested that the vocabulary growth in general has effect on subordination rates. However, according to the findings of the present study there is not such a relationship between specific parts of vocabulary growth,

i.e., lexical compounds, and subordinate clause growth for typically developing children between the ages 4 and 6.

In the brain injured children, there is not enough evidence supporting a significant relationship between the growth of lexical compounds and syntactic subordination, but there is a significant relationship between the growth of lexical compounds, both verb and non-verb, and coordinate clauses.

The number of coordinate clause use is approximately twice the number of lexical compound use at all ages for typically developing children. On the other hand, the coordinate clause use and lexical compound use have approximately the same rate of growth for brain injured children. An explanation could be that the typically developing children may have shown a similar relationship between the lexical and grammatical levels at earlier ages, i.e. before age 4, they may also have similar rate for lexical compounds and coordinate clauses. But in the studied age span, 4-6 years old, they invest more time in expanding their grammatical area than their lexical area. Future research is needed for investigating the validity of this hypothesis. Therefore, the interaction between the growth of coordinate clauses and lexical compounds in brain injured children may be due to the fact that the brain injured children may be delayed in language acquisition. Thus they exhibit an interaction that may be found in typically developing children before the age 4.

Therefore, it may be that the brain injured children, unlike typically developing children, showed an interaction between coordinate clauses and lexical compounds between the ages 4 and 6 because they are delayed in language acquisition. To evaluate

the idea that the interaction between coordinate clauses and lexical compounds is/is not related to specific age spans, further research regarding comparing these aspects of brain injured and typically developing children at younger and older ages is required. Following that, another interesting line of research would be to explore whether or not different types of brain injuries would lead to similar pattern in coordinate clauses and lexical compounds interaction.

7.3 Summary

Studies by scholars like Dixon and Marchman (2007), Pérez-Leroux et al. (2012), Bates et al. (1988), Anisfeld et al. (1998), Marchman and Bates (1994), Robinson and Mervis (1998), and Bassano et al. (2004) confirmed the existence of the relationship between lexical development and given grammatical constructions development for children at different ages. In the purpose of the present study, the work done by Perez-Leroux et al. (2012) appears to be the most relevant. They found that vocabulary growth has an effect on MLU, subordination rates, and the use of definite determiners and object pronouns. However, the findings of the present research are in contrast with the findings of Perez-Lerouz et al. (2012) in terms of having a relationship between the growth in the use of a specific part of vocabulary, (i.e., lexical compounds) and the growth in the use of subordinate clauses.

The main object of this study was to determine if there is a significant relationship in the acquisition of complex lexical structures (as measured by lexical compounds) and complex syntactic structures (as measured by coordinate clauses, subordinate clauses,

auxiliary and modal verbs, and coordinated subjects/objects) in both typically and brain injured children between the ages of 4 and 6.

According to the present study, such a relationship was found only between the acquisition of lexical compounds and coordinate clauses for brain injured children. However, as there were only three typically developing children at the age of 6, it is suggested to repeat the experiments for more samples in typically developing.

Some interesting trends have emerged in this research which warrants further investigation:

(1) In this study the significant growth was not seen for the increase in the use of subordinate clauses between the ages of 4 and 6 for typically developing children, although some examples were seen. This study was done based on the data collected on a story telling task and the limited use of subordinate clauses for these children may be a result of the kind of language examined. Exploring the same observations using data collected in other contexts, like conversations, would contribute to the reliability of the conclusions. Comparing the results of the present study with the studies using a conversation task can help us in finding children's style of language use in different situations. For example, if it turns out that typically developing children show significant growth in using subordinate clauses in other contexts, then it can be concluded that these children use less complex structures for narrating a situation comparing to the use of language in a conversation.

(2) In section 7.1, it was mentioned that the difference in the pattern of the growth of subordinate clauses between typically developing and brain injured children was due to the delay of brain injured children in language acquisition. According to Cheung and Kemper (1992), the complexity of the adult language decreases between the ages 60 to 90. Thus, it can be concluded that typically developing children do not have increase in the use of subordination because their language becomes more adult-like after age 4 and the brain injured children show an increase because they are still developing. If this conclusion is true then younger typically developing children should have significant growth in using subordinate structures, while older brain injured and typically developing children should not show significant growth in using subordinate structures. For evaluating this hypothesis, related studies should be done for younger and older children in both groups of children.

(3) The analysis of this study was done based on the total number of variables not on the proportion of them in total number of utterances. Another survey can be done to figure out whether or not the results of this study are the same by analyzing the mean use of each variable per utterance at the lexical and grammatical levels for both groups of children at different ages. It is worthwhile to mention that according to Table (28) in the appendix (A), the proportion of the mean use of those variables per utterance that have significant growth in this study increases as the children get older. Moreover, those variables that do not have significant growth do not have a positive growth in their mean use per utterance at all ages. Consequently, the

hypothesis is that repeating the analysis of this study for the mean use of variables per utterance could have the same results.

(4) In this study, at the lexical level, because of the lack of data, the compound non-verbs were not distinguish to compound nouns, compound prepositions, compound adjectives, and compound adverbs. Future work should definitely find a way to look more closely at these kinds of structures and evaluate whether or not all of these compound structures follow the same pattern.

(5) In this study growth was not seen in the use of coordinated subject and object between the studied age groups although some examples were seen in both groups between the ages 4 and 6. Repeating the experiment for younger and older children can help finding a pattern for the growth of using coordinated subject and object for them when they are younger. The experiment can be set in a situation that the children are asked to talk about some pictures. Some people or animals that are doing the same jobs can be shown in these pictures. The children can narrate the pictures in different ways. For example, they can say “Mary is going to school and Tom is going to school.” or “Mary and Tom are going to school.”

Moreover, measuring the growth of coordinated subject and object for adult can help to find out when the children prefer to follow the adult pattern for using this variable.

(6) There is insufficient evidence to conclude that the brain injured children show increase in the use of auxiliary and modal verbs between the ages of 4 and 6.

Appendix (A)

Table 24- mixed-effects model for typically developing children

Auxiliary & modal	> test = lmer(auxv~ageGroup+(1|namegroup),data = NarCont2) > pvals.fnc(test) $fixed Estimate MCMCmean HPD95lower HPD95upper pMCMC Pr(>|t|) (Intercept) -10.26 -6.565 -40.246 26.99 0.6864 0.5081 ageGroup 10.35 9.410 2.583 16.56 0.0134 **0.0039** $random Groups Name Std.Dev. MCMCmedian MCMCmean HPD95lower HPD95upper 1 namegroup (Intercept) 6.5796 1.8045 2.1958 0.0000 6.2492 2 Residual 7.5528 9.4203 9.6693 6.5181 13.3611
Subordinate clauses	> test = lmer(sub~ageGroup+(1|namegroup),data = NarCont2) > pvals.fnc(test) $fixed Estimate MCMCmean HPD95lower HPD95upper pMCMC Pr(>|t|) (Intercept) -7.380 -1.553 -37.783 32.23 0.9370 0.6564 ageGroup 7.106 5.877 -1.464 13.15 **0.1004** 0.0490 $random Groups Name Std.Dev. MCMCmedian MCMCmean HPD95lower HPD95upper 1 namegroup (Intercept) 5.4463 1.5120 2.0438 0.0000 6.2137 2 Residual 8.5900 9.7682 10.0089 6.7584 13.7791
Coordinate clauses	> test = lmer(cs~ageGroup+(1|namegroup),data = NarCont2) > pvals.fnc(test) $fixed Estimate MCMCmean HPD95lower HPD95upper pMCMC Pr(>|t|) (Intercept) -83.84 -29.79 -106.3865 46.06 0.4156 0.0008 ageGroup 27.75 16.26 0.7151 32.12 0.0472 0.0000 $random Groups Name Std.Dev. MCMCmedian MCMCmean HPD95lower HPD95upper 1 namegroup (Intercept) 21.2722 7.5919 7.4460 0.0000 15.7323 2 Residual 8.3751 19.1149 19.6234 11.9941 28.6140
Compound non-verbs	> test = lmer(NCW~ageGroup+(1|namegroup),data = NarCont2) > pvals.fnc(test) $fixed Estimate MCMCmean HPD95lower HPD95upper pMCMC Pr(>|t|) (Intercept) -5.459 -2.217 -18.6593 15.479 0.7932 0.4950 ageGroup 4.377 3.686 0.2004 7.263 0.0418 **0.0145** $random Groups Name Std.Dev. MCMCmedian MCMCmean HPD95lower HPD95upper 1 namegroup (Intercept) 2.5752 0.6902 0.9528 0.0000 2.9343 2 Residual 4.1388 4.7199 4.8181 3.2993 6.6762
Compound verbs	> test = lmer(cv~ageGroup+(1|namegroup),data = NarCont2) > pvals.fnc(test) $fixed Estimate MCMCmean HPD95lower HPD95upper pMCMC Pr(>|t|) (Intercept) -32.32 -21.911 -49.310 5.367 0.1090 0.0093 ageGroup 11.70 9.463 3.858 15.218 0.0022 **0.0001**

	$random Groups Name Std.Dev. MCMCmedian MCMCmean HPD95lower HPD95upper 1 namegroup (Intercept) 5.7569 1.9280 2.0685 0.0000 5.3015 2 Residual 5.2696 7.2493 7.4291 4.7702 10.3933
Coordinated subject/object	> test = lmer(csbj~ageGroup+(1|namegroup),data = NarCont2) > pvals.fnc(test) $fixed Estimate MCMCmean HPD95lower HPD95upper pMCMC Pr(>|t|) (Intercept) 30.233 30.697 5.795 56.079 0.0186 0.0218 ageGroup -3.892 -4.014 -9.200 1.234 0.1224 **0.1359** $random Groups Name Std.Dev. MCMCmedian MCMCmean HPD95lower HPD95upper 1 namegroup (Intercept) 2.6262 0.8893 1.3273 0.0000 4.2198 2 Residual 6.7593 7.1324 7.3046 4.8932 9.9271

Table 25- Mixed-effects model for Brain Injured children

Auxiliary & modal	> lmer(auxv~age2 +(1|namegroup)+(0+age2|namegroup),data = NarSub2) > pvals.fnc(test) $fixed Estimate MCMCmean HPD95lower HPD95upper pMCMC Pr(>|t|) (Intercept) 34.824 34.356 26.1289 42.79 0.0001 0.0000 age2 6.728 7.549 -0.7034 15.51 **0.0668** 0.0852 $random Groups Name Std.Dev. MCMCmedian MCMCmean HPD95lower HPD95upper 1 namegroup (Intercept) 15.7857 8.9405 8.9682 0.0000 14.7940 2 namegroup age2 8.2973 2.2787 3.1474 0.0000 9.7833 3 Residual 11.1722 16.5042 16.8237 11.9956 22.6241
Coordinate clauses	> test2 = lmer(cs~age2 +(1|namegroup)+(0+age2|namegroup),data = NarSub2) > pvals.fnc(test2) $fixed Estimate MCMCmean HPD95lower HPD95upper pMCMC Pr(>|t|) (Intercept) 23.26 23.24 14.607 32.13 0.0002 0.0000 age2 16.43 17.35 7.411 27.55 **0.0022** 0.0086 $random Groups Name Std.Dev. MCMCmedian MCMCmean HPD95lower HPD95upper 1 namegroup (Intercept) 14.5486 8.2459 8.0844 0.0000 15.1996 2 namegroup age2 17.0509 6.4869 6.5029 0.0000 14.6756 3 Residual 9.2760 19.0421 19.2407 12.6045 25.9161
Subordinate clauses	> test2 = lmer(sub~age2 +(1|namegroup)+(0+age2|namegroup),data = NarSub2) > pvals.fnc(test2) $fixed Estimate MCMCmean HPD95lower HPD95upper pMCMC Pr(>|t|) (Intercept) 18.698 18.589 11.6999 25.77 0.0001 0.0001 age2 7.143 7.685 0.6096 14.46 **0.0276** 0.0445

	$random Groups Name Std.Dev. MCMCmedian MCMCmean HPD95lower HPD95upper 1 namegroup (Intercept) 13.1762 7.4902 7.4454 0.0000 12.3892 2 namegroup age2 8.6828 2.4414 3.0374 0.0000 8.8369 3 Residual 8.0359 13.8226 14.0875 9.3705 18.9279
Compound verbs	> test2 = lmer(cv~age2 +(1|namegroup)+(0+age2|namegroup),data = NarSub2) > pvals.fnc(test2) $fixed Estimate MCMCmean HPD95lower HPD95upper pMCMC Pr(>|t|) (Intercept) 19.173 18.328 13.233 23.61 0.0001 0.0000 age2 7.644 8.696 2.793 14.11 **0.0052** 0.0218 $random Groups Name Std.Dev. MCMCmedian MCMCmean HPD95lower HPD95upper 1 namegroup (Intercept) 9.0817 4.8909 4.8443 0.0000 8.8147 2 namegroup age2 9.0171 2.7559 2.9749 0.0000 7.5681 3 Residual 5.4455 10.7064 10.8876 7.4687 14.5938
Compound non-verbs	> test2 = lmer(NCW~age2 +(1|namegroup)+(0+age2|namegroup),data = NarSub2) > pvals.fnc(test2) $fixed Estimate MCMCmean HPD95lower HPD95upper pMCMC Pr(>|t|) (Intercept) 14.561 14.539 12.3652 16.758 0.0001 0.0000 age2 2.299 2.435 0.0209 4.699 **0.0420** 0.0243 $random Groups Name Std.Dev. MCMCmedian MCMCmean HPD95lower HPD95upper 1 namegroup (Intercept) 3.5359 1.9365 1.9027 0.0000 3.7773 2 namegroup age2 0.0000 0.2134 0.5831 0.0000 2.1782 3 Residual 4.1958 4.9317 5.0001 3.5483 6.5075
coordinated subject/object	> test2 = lmer(csbj~age2 +(1|namegroup)+(0+age2|namegroup),data = NarSub2) > pvals.fnc(test2) $fixed Estimate MCMCmean HPD95lower HPD95upper pMCMC Pr(>|t|) (Intercept) 4.512 4.431 2.5972 6.197 0.0001 0.0003 age2 1.875 1.700 -0.0169 3.483 **0.0620** 0.0105 $random Groups Name Std.Dev. MCMCmedian MCMCmean HPD95lower HPD95upper 1 namegroup (Intercept) 3.2442 1.8587 1.8471 0.000 3.1570 2 namegroup age2 0.0000 0.1984 0.4696 0.000 1.7120 3 Residual 2.9509 3.6468 3.7071 2.632 4.9378

Table 26-Calculating the correlation between the complexity of lexicon and sentences for typically developing children

<table>
<tr><td rowspan="2">Coordinate clauses</td><td>Compound verbs</td><td>> test3 = lmer(cs~age2*cv +(1|namegroup)+(0+age2|namegroup),data = NarCont2)
> pvals.fnc(test3)
$fixed
Estimate MCMCmean HPD95lower HPD95upper pMCMC Pr(>|t|)
(Intercept) 7.6889 -8.2689 -25.666 9.465 0.3310 0.2534
age2 -8.4357 -10.8884 -35.800 11.682 0.3440 0.2027
cv 1.5614 2.3984 1.639 3.135 0.0001 0.0000
age2:cv 0.7907 0.1398 -0.765 1.090 0.7566 0.0057
$random
Groups Name Std.Dev. MCMCmedian MCMCmean HPD95lower HPD95upper
1 namegroup (Intercept) 15.2698 3.1701 3.2585 0.0000 7.7747
2 namegroup age2 0.0000 0.5787 1.5920 0.0000 5.9603
3 Residual 2.6775 10.0198 10.3014 6.2048 14.6549</td></tr>
<tr><td>Compound non-verbs</td><td>> test3 = lmer(cs~age2*NCW +(1|namegroup)+(0+age2|namegroup),data = NarCont2)
> pvals.fnc(test3)
$fixed
Estimate MCMCmean HPD95lower HPD95upper pMCMC Pr(>|t|)
(Intercept) 33.7238 3.4003 -26.8836 32.557 0.8162 0.0235
age2 12.5465 -6.0115 -45.3693 32.216 0.7442 0.4711
NCW 0.8497 2.8183 0.9486 4.659 0.0040 0.2720
age2:NCW 0.6094 0.6409 -1.6355 2.874 0.5050 0.5733
$random
Groups Name Std.Dev. MCMCmedian MCMCmean HPD95lower HPD95upper
1 namegroup (Intercept) 18.1135 2.6827 3.5918 0.0000 10.7197
2 namegroup age2 0.0000 0.6022 2.3128 0.0000 9.1078
3 Residual 10.1272 16.5929 17.0507 11.0994 24.1155</td></tr>
<tr><td rowspan="2">Auxiliary and modals</td><td>Compound verbs</td><td>> test3 = lmer(auxv~age2*cv +(1|namegroup)+(0+age2|namegroup),data = NarCont2)
> pvals.fnc(test3)
$fixed
Estimate MCMCmean HPD95lower HPD95upper pMCMC Pr(>|t|)
(Intercept) 38.0080 25.9542 11.4258 39.654 0.0022 0.0000
age2 20.6719 -6.4423 -25.8017 13.992 0.4946 0.0012
cv 0.1169 0.4549 -0.0999 1.099 0.1202 0.1608
age2:cv -0.4870 0.4672 -0.3234 1.245 0.2218 0.0003
$random
Groups Name Std.Dev. MCMCmedian MCMCmean HPD95lower HPD95upper
1 namegroup (Intercept) 8.3786 1.3686 1.8303 0.0000 5.5521
2 namegroup age2 12.2531 0.4916 1.3531 0.0000 5.0606
3 Residual 0.7582 8.4777 8.7062 5.6453 12.1671</td></tr>
<tr><td>Compound non-verbs</td><td>> test3 = lmer(auxv~age2*NCW +(1|namegroup)+(0+age2|namegroup),data = NarCont2)
> pvals.fnc(test3)
$fixed
Estimate MCMCmean HPD95lower HPD95upper pMCMC Pr(>|t|)
(Intercept) 22.1660 24.9310 10.9571 39.681 0.0024 0.0046
age2 -4.7174 -7.5511 -27.1241 11.954 0.4248 0.5897
NCW 1.0260 0.7782 -0.1979 1.621 0.0930 0.0207
age2:NCW 0.6672 0.8959 -0.3203 2.029 0.1294 0.2161
$random
Groups Name Std.Dev. MCMCmedian MCMCmean HPD95lower HPD95upper
1 namegroup (Intercept) 6.4114 1.8050 2.0796 0.0000 5.6353
2 namegroup age2 0.0000 0.4619 1.3256 0.0000 5.0344
3 Residual 6.2394 8.3165 8.5727 5.4063 12.0473</td></tr>
</table>

Table 27- Calculating the correlation between the complexity of lexicon and grammar for Brain Injured children

<table>
<tr><td rowspan="2">Coordinate clauses</td><td>Compound verbs</td><td>> test = lmer(cs~age2+cv+cv*age2 + (0+age2|namegroup),data = NarSub2)
> pvals.fnc(test)
$fixed
Estimate MCMCmean HPD95lower HPD95upper pMCMC Pr(>|t|)
(Intercept) 5.3553 4.2493 -4.7547 13.5857 0.3504 0.1645
age2 -12.9435 -9.8077 -21.1636 0.7871 0.0436 0.0291
cv 0.6443 0.7622 0.2488 1.2724 0.0048 0.0041
age2:cv 1.0742 0.9105 0.3796 1.4103 0.0012 0.0001
$random
Groups Name Std.Dev. MCMCmedian MCMCmean HPD95lower HPD95upper
1 namegroup age2 10.3390 3.3903 3.5204 0.0000 8.5529
2 Residual 8.9352 11.8800 12.1143 8.4015 16.4019</td></tr>
<tr><td>Compound non-verbs</td><td>> test = lmer(cs~age2+NCW+NCW*age2 + (0+age2|namegroup),data = NarSub2)
> pvals.fnc(test)
$fixed
Estimate MCMCmean HPD95lower HPD95upper pMCMC Pr(>|t|)
(Intercept) -1.297 -1.380 -20.5591 17.236 0.8890 0.8807
age2 -19.978 -17.672 -43.2240 7.255 0.0516 0.1668
NCW 1.443 1.467 0.1923 2.682 0.0242 0.0145
age2:NCW 2.197 2.062 0.4269 3.650 0.0148 0.0181
$random
Groups Name Std.Dev. MCMCmedian MCMCmean HPD95lower HPD95upper
1 namegroup age2 13.3896 4.5129 4.9583 0.000 13.0175
2 Residual 16.1731 18.6413 18.9109 13.753 24.1691</td></tr>
<tr><td rowspan="2">Subordinate clauses</td><td>Compound verbs</td><td>> test = lmer(sub~age2+cv+cv*age2 + (0+age2|namegroup),data = NarSub2)
> pvals.fnc(test)
$fixed
Estimate MCMCmean HPD95lower HPD95upper pMCMC Pr(>|t|)
(Intercept) -1.3431 -1.2862 -8.2806 5.6660 0.7156 0.7003
age2 -2.5613 -2.7157 -11.4316 6.1583 0.5302 0.5513
cv 1.0893 1.0830 0.6971 1.4739 0.0001 0.0000
age2:cv 0.0372 0.0484 -0.3414 0.4667 0.8118 0.8514
$random
Groups Name Std.Dev. MCMCmedian MCMCmean HPD95lower HPD95upper
1 namegroup age2 0.0000 0.6632 1.4152 0.0000 5.0410
2 Residual 10.4912 10.5866 10.7421 8.0243 13.5936</td></tr>
<tr><td>Compound non-verbs</td><td>> test = lmer(sub~age2+NCW+NCW*age2 + (0+age2|namegroup),data = NarSub2)
> pvals.fnc(test)
$fixed
Estimate MCMCmean HPD95lower HPD95upper pMCMC Pr(>|t|)
(Intercept) -9.473 -9.442 -22.9869 4.362 0.1672 0.1636
age2 -12.666 -12.619 -30.8977 3.602 0.1418 0.1415
NCW 1.815 1.815 0.9080 2.712 0.0002 0.0003
age2:NCW 1.066 1.063 -0.0172 2.149 0.0564 0.0541
$random
Groups Name Std.Dev. MCMCmedian MCMCmean HPD95lower HPD95upper
1 namegroup age2 3.0479 1.4467 2.2154 0.0000 7.2724
2 Residual 13.0094 13.1594 13.3688 9.9872 17.0830</td></tr>
</table>

Table 28- Mean use of each variable per utterance for both groups

			Lexical level		Grammatical level			
	age	Utterances	Compound verbs	Compound non-verbs	Coordinate clauses	Subordinate clauses	Auxiliaries and modals	Coordinated subject/object
Typically Developing Children	4	145.8	0.11	0.08	0.26	0.14	0.2	0.12
	4;5	135	0.14	0.09	0.3	0.17	0.25	0.08
	5	163.6	0.171	0.10	0.33	0.19	0.258	0.05
	6	180.7	0.172	0.11	0.34	0.16	0.28	0.06
Brain Injured Children	4	173.2	0.065	0.06	0.08	0.07	0.18	0.02
	4;5	195.5	0.07	0.07	0.09	0.08	0.12	0.02
	5	210.9	0.11	0.08	0.1	0.1	0.16	0.02
	6	207.6	0.14	0.09	0.23	0.13	0.22	0.03

Table 29- Information about the damage parts of brain of children in this study

Name	**Comments**
CAL	Diffuse PVE injury
CAS	Bilateral injury in preterm infant
CES	Bilateral injury in preterm infant
DAV	Right hemisphere porencephaly
DON	Diffuse injury in full-term infant
FRI	Diffuse injury in preterm infant
HIN	Diffuse injury in preterm infant
MAC	Diffuse injury in preterm infant
MAT	Diffuse injury in preterm infant
YUC	Diffuse white matter lesion in preterm infant

Appendix (B)

Because there is not any list of all compound non-verbs in English, it is not possible to find them directly. So first of all, the following command is used in CLAN to retrieve all the words that a child used in each session:

freq +t*CHI +f

Then, the compound non-verbs are selected among them. For compound verbs, subordinate clauses, auxiliary and modals, compound verbs, and coordinate clauses, first of all, the following command is used in CLAN to retrieve everything that a child said in each session:

kwal +t*CHI +d +f *.cha

In the next step, the number of each parameter for each child is calculated and stored in an excel file. R is used for plotting the results and for statistical analysis.

References

Aarts, B. (2006). Subordination. *In Encyclopedia* of *Language* & *Linguistics*, (2nd edition), Keith Brown (ed.), 248-254. Amsterdam: Elsevier.

Anisfeld, M., Rosenberg, E. S., Hoberman, M. J., & Gasparini, D. (1998). Lexical acceleration coincides with the onset of combinatorial speech. *First Language*, 18, 165–184.

Bassano, D., Laaha, S., Maillochon, I., & Dressler, W. U. (2004). Early acquisition of verb grammar and lexical development: Evidence from periphrastic constructions in French and Austrian German. *First Language, 24*, 33–70.

Bates, E., Bretherton, I., & Snyder, L. (1988). *From first words to grammar: Individual differences and dissociable mechanisms*. New York, NY: Cambridge University Press.

Bates, E., & Goodman, J. C. (1999). On the emergence of grammar from the lexicon. In B. MacWhinney (Ed.), *The emergence of language* (pp. 29–70). Mahwah, NJ: Erlbaum.

Bowerman, M. (1979). The acquisition of complex sentences, in Paul Fletcher and Michael Garman (eds.), *Language Acquisition: Studies in First Language Development*, 285–305, Cambridge: Cambridge University Press.

Cheung, H., Kemper, S (1992). Competing complexity metrics and adults' production of complex sentences. Applied Psycholinguistics, 13, pp 53-76.

Clark, E. V. (2009) *First Language Acquisition* (2nd edn). Cambridge: Cambridge University Press. [xii, 490pp.]

Diessel, H., & Tomasello, M. (2000). The development of relative constructions in early child speech. *Cognitive Linguistics, 11*, 131 – 152.

Diessel, H., & Tomasello, M. (2001). The acquisition of finite complement clauses in English: A corpus-based analysis. *Cognitive Linguistics, 12*, 97 – 141.

Diessel, H. (2004). *The acquisition of complex sentences*. Cambridge: Cambridge University Press.

Di Sciullo, A., Edwin W. (1987). *On the definition of word*. Cambridge, MIT Press, pp.118.

Dixon, J. Marchman, V. (2007). Grammar and the lexicon: Developmental ordering in language acquisition. *Child Development*, 78, 190–212.

Douglas B., Maechler, M., Bolker, B (2012). lme4: Linear mixed-effects models using S4 classes. R package version 0.999999-0. http://CRAN.R-project.org/package=lme4.

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D. J., & Pethick, S. J. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development*, 59 (5, Serial No. 242).

Givón T. (1991). Markedness in grammar: distributional, communicative and cognitive correlates of syntactic structure. *Studies in Language*, vol. (15/2): 335-370.

Hemphill, L., Feldman, H., Camp, L., Griffin, T., Miranda, A. E. & Wolf, D. P. (1994). Developmental changes in narrative and non-narrative discourse in children with and without brain injury. *Journal of Communication Disorders*, 27, 107–133.

Keefe, K. A., Feldman, H. M., & Holland, A. L. (1989). Lexical learning and language abilities in preschoolers with perinatal brain damage. *Journal of Speech and Hearing Disorders*, 54, 395–402.

MacWhinney, B. (1995). *The CHILDES Project. Tools for Analyzing Talk*, 2nd Edition. Hillsdale, NJ: Lawrence Erlbaum.

MacWhinney, B. (2000). *The CHILDES Project: Tools for Analyzing Talk*. 3rd Edition. Mahwah, NJ: Lawrence Erlbaum Associates.

MacWhinney, B. (2005). A unified model of language acquisition. In J. F. Kroll & A. DeGroot (Eds.), *Handbook of bilingualism* (pp. 49–67). Oxford, UK: Oxford University Press.

Michaelis, Laura A. (2006). Construction Grammar. . *In Encyclopedia* of *Language* & *Linguistics*, (2nd edition), Keith Brown (ed.), 73-84. Oxford: Elsevier.

Moyle, M. J., Weismer, S. E., Evans, J. L., & Lindstrom, M. J. (2007). Longitudinal relationships between lexical and grammatical development in typical and late-talking children. *Journal of Speech, Language, and Hearing Research*, 50, 508–528.

Noona, M. (2006). Complement clauses. *In Encyclopedia* of *Language* & *Linguistics*, (2nd edition), Keith Brown (ed.), 694-697. Amsterdam: Elsevier.

Pérez-Leroux, Ana Teresa, Castilla-Earls Anny Patricia, Brunner Jerry (2012). General and specific effects of lexicon in grammar: determiner and object pronoun omissions in child Spanish. *Journal of Speech, Language, and Hearing Research* 55(2):313.

R Development Core Team (2012). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org.

Robinson, B., & Mervis, C. (1998). Disentangling early language development: Modeling lexical and grammatical acquisition using an extension of case study methodology. *Developmental Psychology*, 34, 363–375.

Szmrecsanyi, B. (2004). On operationalizing syntactic complexity. In *Le poids des mots. Proceedings of the 7th International Conference on Textual Data Statistical Analysis.*

Louvain-la-Neuve, March 10–12, 2004, ed. by G. Purnelle, C. Fairon, and A. Dister. Louvain-la-Neuve: Presses universitaires de Louvain, 1032–39.

Thal, D., Marchman, V., Stiles, J., Aram, D., Trauner, D., Nass, R., & Bates, E. (1991). Early lexical development in children with focal brain injury. *Brain and Language, 40*, 491-527**.**

Tomasello, M. (2010). Language Development. *The Wiley-Blackwell Handbook of Childhood Cognitive Development, 22*, 239.

Ullman, M. (2001). The declarative/procedural model of lexicon/grammar. *Journal of Psycholinguistic Research*, 30, 37–69.

Vicentini, A. (2003). The Economy Principle in Language. Notes and Observations from Early Modern English Grammars. Mots, Palabras, Words 3, 37-57.

Waxman, L. (2010). Early Word - Learning and Conceptual Development. *The Wiley-Blackwell Handbook of Childhood Cognitive Development, 22*,180-209.

Winter, B. (2011). A very basic tutorial for performing linear mixed effects analyses. http://www.bodowinter.com/tutorial/bw LME tutoial.pdf (accessed 02.03.13).