Simulating Developmental Patterns in the Cross-linguistic Acquisition of Inflectional Morphology

Themis Karaminis (tkaram01@students.bbk.ac.uk)
Department of Psychological Sciences, Birkbeck College, University of London,
Malet Street, London WC1E 7HX, UK

Michael S. C. Thomas (m.thomas@bbk.ac.uk)
Department of Psychological Sciences, Birkbeck College, University of London,
Malet Street, London WC1E 7HX, UK

Abstract

We present a connectionist model of a general system for producing inflected words. The Multiple Inflection Generator (MIG) combines elements of several previous models (e.g., multiple inflections for a grammatical class: Hoeffner & McClelland, 1993; lexical-semantic input: Joanisse & Seidenberg, 1999; multiple grammatical classes: Plunkett & Juola, 1999). MIG assumes that the goal of this component of the language system is to output a phonological form appropriate to the grammatical context in which the word appears. We show that this model captures developmental patterns in the acquisition of morphology in two different languages: one with a simple morphological system (English), and one characterized by rich morphology and absence of default forms (Modern Greek). When MIG is trained under conditions of atypical computational constraints, it reproduces developmental patterns symptomatic of Specific Language Impairment particular to each language.

Keywords: Inflectional Morphology; Specific Language Impairment; Cross-linguistic Language Acquisition; Neural Network Modeling

Introduction

The model of Rumelhart and McClelland (1986) for the acquisition of the English past-tense was the first model to apply the principles of Parallel Distributed Processing in the domain of inflectional morphology. This influential model showed that a two-layered feed-forward neural network architecture could learn mappings between phonological representations (Wickelfeature representations) of stems and corresponding past tense forms of English verbs. The model also simulated a wide range of phenomena reported in empirical studies of the acquisition of morphology, such as frequency effects, and the U-shaped learning curve for the acquisition of irregulars (Brown, 1973).

The model of Rumelhart and McClelland (1986) demonstrated that an explicit representation of rules was not necessary for the acquisition of morphology. Instead, rule-like behavior was an emergent property of the learning system and reflected statistical regularities in the mappings of the training set. Rumelhart and McClelland challenged the existing ‘symbolic’ views, which proposed the dual-route account for morphological development (Pinker, 1984). According to this account, two separate mechanisms were involved in the learning of morphology. A rule-based system supported the learning of regular mappings, while a rote-memory system supported the learning of irregular mappings. The so-called 'past tense debate' emerged within the field of language acquisition.

Criticisms against the connectionist approach (e.g., Pinker & Prince, 1988) ranged from those pointing out implementational issues (e.g., the psycholinguistic implausibility of Wickelfeature representations) to those questioning the ability of the connectionist framework to address certain aspects of language acquisition (e.g., generalization). Subsequent connectionist studies addressed many of these criticisms by proposing more detailed models morphology. For example, Plunkett and Marchman (1993) refined the general principles of the model of Rumelhart and McClelland (1986) in a three-layered feed-forward architecture which employed more realistic phonological representations. Other studies incorporated Lexical Semantics in the connectionist architecture to address dissociations in the learning of regular and irregulars (e.g., Joanisse & Seidenberg, 1999). Plunkett and Juola (1999) studied the acquisition of noun plural and verb past tense in a single connectionist network, while Hoeffner and McClelland (1993) considered multiple verb inflections. Finally, some other studies demonstrated that implementing a developmental deficit in connectionist architectures could simulate the acquisition of morphology in atypical language development. (e.g., Joanisse, 2004; Hoeffner & McClelland, 1993; Thomas & Karmiloff-Smith, 2003).

In this study, we are interested in addressing the developmental patterns in the acquisition of morphology cross-linguistically. We consider two different languages: one with simple morphology and wide use of default forms (English), and one with rich morphology and no default forms (Modern Greek).

We also consider generality. We combine elements of older connectionist models of morphology to implement a general system for producing inflected words: the Multiple Inflections Generator (MIG).

MIG learns to output a phonological form appropriate to the grammatical context in which the word appears. The model simulates qualitative developmental patterns in the acquisition of English and Modern Greek. Under conditions of initial computational constraints the model simulates the qualitative profile of atypical language development.

Acquisition of inflectional morphology in English

English inflectional morphology is characterized by its simplicity, manifested by the extensive use of default (base or uninflected) forms. For example, noun inflection does not consider gender and does not distinguish between the nominative and the accusative case. Psycholinguistic studies of inflectional morphology in English often focus on the domain of the past-tense. This paradigm is of particular theoretical interest because it is quasi-regular. The majority of verbs form their past tenses through stem-suffixation (e.g., walk/walked). A rule determines the appropriate allomorphic suffix (/t/, /d/, or /^ed/) based on the last phoneme of the stem. However, a significant number of verbs form their past-tenses irregularly (e.g., swim/swam, hit/hit, go/went).

Early studies on child language (e.g., Berko, 1958; Brown, 1973; de Villiers & de Villiers, 1973) established that different inflections in English are acquired in a consistent order along development. For example, the progressive of the verbs is acquired earlier than the past tense. Other studies addressed the profile of individual inflections in greater detail (e.g., van der Lely & Ullman, 2001). Such studies showed that accuracy rates are greater for regular than for irregular inflections. Accuracy also depends on type and token frequency. Frequency effects are more pronounced in irregular inflections (the so-called frequency by regularity interaction). Finally, children are efficient in generalizing the rule to novel forms (e.g., wug/wugged).

Morphological development is characterized by developmental error patterns. For example, children often produce base forms in contexts in which grammatical marking is obligatory (e.g. *He *come* home / He comes home). This type of error is referred to variously as a *no-mark error, no-change error* or *omission error*. Rice, Wexler, et al. (1993) suggested that omission errors define an early stage in language development, in which morphological marking is not applied consistently on the base forms. They termed this stage as the Optional Infinitive (OI) stage. Zero-mark errors occur in greater percentages in irregular inflections (e.g., Matthews & Theakston, 2006; van der Lely & Ullman, 2001).

Another prototypical error pattern is the *overregularization* or *overgeneralization.* This type of error refers to the (incorrect) application of a rule on irregular stems (e.g. **thinked* / thought). Overregularization errors appear later in development (in Brown's stage II; Brown, 1973) than omission errors do. As a result, a sudden drop in the production of correct irregular forms is observed. This phenomenon is often described in terms of a U-shaped learning curve of irregulars. Overregularization errors provide evidence for the productive use of rules in child language (Marcus, 2000). Finally, a related error type is the *blend error* or *double-marked error* (e.g., Kuczaj, 1978). These errors refer to cases in which children apply a rule to an irregularly inflected form (e.g. **wented* / went).

SLI and acquisition of inflectional morphology Specific Language Impairment (SLI) is diagnosed when children fail to develop age-appropriated language, in the absence of factors usually concomitant with language learning problems (e.g., hearing impairment, frank neurological damage or low non-verbal IQ test scores) (Leonard, 1998). SLI is characterized by a great degree of heterogeneity. Many different areas of language use and learning exhibit deficits. However, most children with SLI present deficits in morphology and grammar. These deficits are often considered behavioral markers of the impairment (Rice, 2000).

Morphological deficits in SLI present an uneven profile. For example, the deficit in the progressive or the plural is less serious than the deficit in 3rd singular and past tense (Leonard, 1998). Both regular and irregular inflections are affected in SLI (e.g., van der Lely & Ullman, 2001). Frequency effects are more pronounced, and generalization of inflectional rules on novel items is poor (Leonard, 1998).

SLI is characterized by increased percentages of omission errors. Based on this, Rice, Wexler et al. (1995) put forward the Extended Optional Infinitive (EOI) account of the impairment. According to this account, SLI presents a specific deficit in the tense marking of verbs. Because of this deficit, the OI stage is protracted in the impairment. Children with SLI also present reduced rates of overgeneralization errors.

Acquisition of inflectional morphology in Modern Greek

Modern Greek is a language with a rich morphological system. As Stephany (1997) describes, there are no default forms of words in Modern Greek. Instead, many different grammatical features are fused in single word forms. For example, nouns have grammatical gender, and are inflected with respect to case and number. Verbs are inflected with respect to person, tense, aspect and voice.

Modern Greek also presents different conjugational classes in nominal and verbal inflection, challenging the dichotomy between regular and irregular inflectional categories. For example, studies on the perfective past tense (e.g., Stavrakaki & Clahsen, 2001) consider three main classes of verbs with respect to the marking of the perfective aspect: first, the 'sigmatic' class, a major class of verbs in which the aspectual marker /s/ is added to the stem; second, a class of verbs which does not use the aspectual marker, but employs a rule-based modification of the stem; third, a class of verbs with idiosyncratic past tenses.

Stephany (1997) studied the production data of three children. Based on these data she suggested an order for the acquisition of different grammatical inflections and different grammatical features in Modern Greek. For example, tense is acquired earlier than aspect. Also, rare nominal conjugational categories are acquired late in development.

As default forms are missing in Modern Greek, it has been suggested that the optional infinitive stage is realized by production of certain frequent forms in inappropriate contexts. Stephany (1997) observed that children undergo an early stage of development (up to 3 years old) in which they produce a lot of 3rd singular forms instead of the correct verbal inflections. Thus, 3rd singular forms could be considered an analogue of root infinitives in English (Varlokosta, Vainikka, et al., 1998).

With regards to the perfective past tense, Stavrakaki and Clahsen (2009) found that the 'sigmatic' rule is overgeneralized in verbs belonging to non-sigmatic categories. The 'sigmatic' rule is also is preferred for the production of past tenses of novel verbs.

Acquisition of inflectional Morphology in Greek SLI
Data on the morphological abilities of Greek children with SLI are sparse. Dalalakis and Clahsen (1999) studied the production of a Greek child with SLI (CA: 5;5). These authors reported deficits in subject-verb agreement rather than in tense marking. They also found that this child, continued to produce 3rd singular forms, suggesting an analogue of an EOI stage.

Simulations

Design

We combined elements of previous connectionist models of morphology (e.g., multiple grammatical classes: Plunkett & Juola, 1999; multiple inflections for a grammatical class: Hoeffner & McClelland , 1993; lexical-semantic input: Joanisse & Seidenberg , 1999) to implement a generalized inflectional system. The Multiple Inflectional Generator (MIG) considered three grammatical classes (nouns, verbs, and adjectives) and multiple inflections for each grammatical class (e.g., nouns: base, plural, and possessive). The aim of MIG was to output a phonological form appropriate to the grammatical context in which the word appeared.

We constructed two training sets based on artificial languages that reflected the basic features of the morphological systems of English and Modern Greek.

We also considered an impaired version of MIG to simulate an acquisition profile symptomatic of SLI. Based on pilot simulations, the impaired version employed fewer units in the hidden layer and less salient phonological representations. This implementation was parallel to theoretical accounts suggesting that a domain-general deficit underlies SLI, e.g., limited processing capacity (Leonard et al; 1992), limited phonological working memory (Gathercole & Baddeley, 1990), or a perceptual deficit (Talal & Piercy, 1973).

Four sets of simulations were performed. In the first two sets, the 'default' and the 'impaired' version of MIG were trained using the English training set. In the next two simulation sets, the two versions of MIG (typical and impaired) were trained on the Greek training set. In each condition, we contrasted the learning profile of MIG to corresponding data from empirical studies on the acquisition of morphology outlined above.

Architecture

As shown in Figure 1, MIG employed a three-layered feed-forward neural network architecture. Four sources of information (cues) were presented in the input layer. Input Phonology encoded the phonological properties of base forms using 19 articulatory features for each phoneme (Thomas & Karmiloff-Smith, 2003). Lexical Semantics provided representations of the meaning of each base form. Grammatical Category provided part-of-speech information, while Target Inflection provided information on the type of inflection the network should consider (e.g., base, past tense, 3rd singular or progressive). The network was required to produce a phonological representation of the appropriate inflected form in the output layer (Output Phonology).

In order to address morphology in Greek, only limited changes were made to the architecture. These solely reflected differences in the morphological structure of Modern Greek. Thus, the Target Inflection cue was expanded to include gender, number and case information for nouns and adjectives, as well as tense and person information for verbs. Also, Input Phonology provided phonological representations of word stems, without considering any inflectional suffixes.

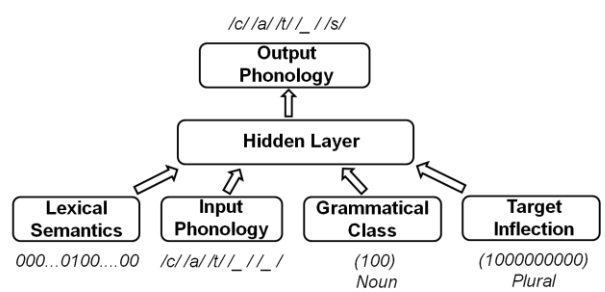

Figure 1: The architecture of MIG with an example of input-output mappings.

Training Sets

English Training Set. A training set for English was constructed based on measurements of type frequencies of different grammatical categories, different inflections or allomorphic subcategories of the same inflection. These measurements were derived from the tagged Brown corpus (Francis and Kucera, 1999) with computational linguistics methods. The training set consisted of 1600 artificial monosyllabic words (800 verbs, 400 nouns, and 400 adjectives) following a three-slot scheme (CCV, VCC and CVC templates; see Plunkett & Marchman, 1993). Ten different inflection types were considered in the training set (nouns: base form, plural, possessive; verbs: base form, progressive, 3rd singular, past tense;

adjectives: base form, comparative, superlative). In effect, the English training set consisted of 5200 different mappings. Output Phonology considered a five-slot scheme.

A generalization set was also created. It consisted of three subsets of stems with differing degrees of similarity to the training set.

Modern Greek Training Set. For the training set for Modern Greek, type frequencies of different inflections and different conjugational categories, etc were derived from the Hellenic National Corpus Institute of Speech and Language Processing (ISLP) (http://hnc.ilsp.gr/en/). When information was not available, type frequencies were based on descriptions of Stephany (1997) or, in the absence of any other constraints, were made parallel to type frequencies of the English training set. For further details see Karaminis (in preparation). The Modern Greek training set consisted of a vocabulary of 800 verbs, 400 nouns and 400 adjectives. Items were dissyllabic, and conformed to the phonotactics of Modern Greek. Both Input and Output Phonology were expanded (5 and 12 slots, respectively). Nouns were inflected in the nominative, the genitive and the accusative case of the singular and plural number. Verbs were inflected with respect to person (1^{st}, 2^{nd}, and 3^{rd}), number (singular, plural) and tense (present, perfective past, imperfective past). Adjectives were inflected with respect to gender, case and number. The Modern Greek training set consisted of a total of 26,400 mappings. A generalization set was also constructed.

Training

Networks were trained for 400 epochs, using the Backpropagation of Error algorithm (Rumelhart, Hinton, & Williams, 1986). In each epoch, the network was exposed to 35% of the total number of mappings. Mappings were presented probabilistically (with replacement), conforming to the type frequency structure of different inflections. Length of training and rate of exposure were set to achieve final ceiling levels of performance.

Simulating SLI

The impaired version of MIG employed 35 hidden units in the hidden layer, instead of 75 units in the default version. The less salient phonological representations scheme was parallel to that of Hoeffner and McClelland (1993). In particular, the average strength of the input and output phonological representations was reduced by 20% by setting the level of the logical '1' value in these representations to 0.8 (from 1.0 in the default model). For word-final stops and fricatives, the phonemic strength was reduced by 36% (the logical '1' level was set at 0.64).

Results

Network output was evaluated considering a variant of the Nearest Neighborhood algorithm. Each phoneme was made equal to its nearest neighbor in the Euclidean space to grant a phoneme string. The string was then assessed against predefined categories (e.g., correct, omission errors, etc).

In this section we present results from the four simulations. For reasons of space, we focus on the domains of the past tense in English, and the perfective past tense in Modern Greek. These domains allow a detailed comparison of the simulation output to data from behavioral studies.

Simulation 1: Default MIG trained on the English Training Set

The simulation results were parallel to the acquisition profile of the English past tense in several ways. Accuracy rates were higher for regulars than for irregulars. Type frequency effects were more pronounced for irregulars. MIG reproduced an OI stage, characterized by high percentages of omission errors for both regulars and irregulars. The rates of no-mark errors were higher for irregulars than for regulars. MIG also simulated overgeneralization errors and blend errors. Finally, the past tense rule was efficiently generalized in novel items with accuracy rates of 88%, 86%, and 43% for novel stems most to least similar to stems in the training set. For the latter errors went up to 83% when errors in the reproduced stem were ignored.

Figures 2 and 3 contrast the learning trajectory of MIG (the first 100 epochs of training) and corresponding behavioral data from van der Lely and Ullman (2001) for regular and irregular past tense. MIG results are averaged across 10 runs. It is possible to identify a window in the training time of the model (e.g., epochs 20-70) in which the modeling results and the behavioral data could be quantitatively matched.

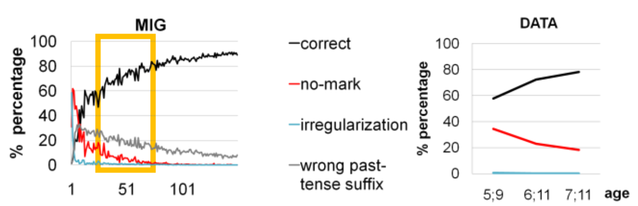

Figure 2: Regular past-tense in MIG compared to data on regular past tense from van der Lely & Ullman (2001).

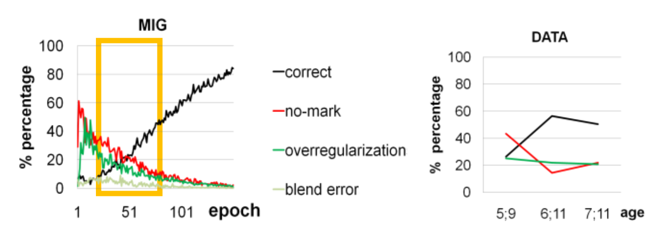

Figure 3: Irregular past-tense in MIG compared to data on regular past tense from van der Lely & Ullman (2001).

Simulation 2: Impaired MIG trained on the English Training Set

Introducing a developmental deficit in MIG reproduced a pattern of performance symptomatic of SLI with respect to six criteria. First, accuracy rates were lower for both regular and irregular inflections. Second, token frequency effects were more pronounced. Third, omission errors were increased, and the Optional Infinitive stage was protracted. Fourth, the rates of overgeneralization errors were decreased. Fifth, generalization of the rule on novel items was particularly affected. Finally, individual variability was increased.

Figure 4 compares the learning profile of irregular past tense in the impaired version of MIG (the first 100 epochs) to corresponding behavioral data from van der Lely and Ullman (2001). It is possible to observe the protraction of the OI stage (red line, compared to the profile in Figure 3). Also, taking into account the mean chronological age of the group of children with SLI in this study, and the time interval considered in Simulation 1, we performed comparisons considering the performance of the model around epoch 100. At this point of training time the modeling results and the behavioral data are quantitatively comparable.

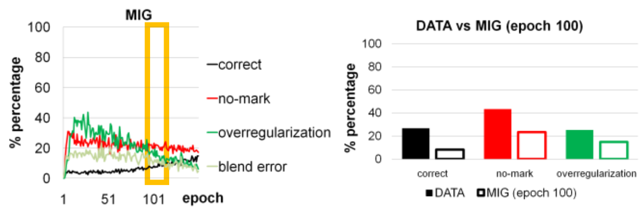

Figure 4: Irregular past tense in MIG compared to regular past tense from van der Lely and Ullman (2001).

Simulation 3: Default model trained on the Modern Greek Training Set

MIG was also able to learn the complex mappings of the Greek training set, and generalize these inflections on novel items. The model simulated phenomena described in studies of the acquisition of Greek. The order of acquisition of different inflections presented similarities to the order reported in Stephany (1997). For example, the genitive case was acquired later than the nominative and the accusative, while rare conjugational categories were acquired later than the main categories.

The model also captured the major types of developmental error patterns. In verbal inflections, MIG simulated an early phase in which 3rd singular forms were produced in inappropriate contexts. With regards to the domain of the perfective past tense, MIG captured the pattern of overgeneralization of the 'sigmatic' rule in non-sigmatic conjugational classes. Both of these error patterns are depicted in Figure 5, which compares the learning profile of MIG in the 2nd person singular non-sigmatic category and corresponding data by Stavrakaki and Clahsen (2009).

Figure 5: Non-sigmatic perfective past tense in MIG and data from Stavrakaki & Clahsen (2009)

Simulation 4: Impaired model trained on the Modern Greek Training Set

When exposed on the Modern Greek training set, the impaired version of MIG experienced difficulties in all types of inflections. Similarly to Simulation 2 (Impaired MIG trained on the English training set), the learning trajectory of the impaired model was characterized by low percentages of generalization, increased frequency effects, and a greater degree of individual variability.

With regards to the developmental error patterns in past-tense, the impaired version of MIG simulated a protracted phase of production of 3rd singular forms, consistent with the data of Dalalakis and Clahsen (1999). Rates of overgeneralization of the 'sigmatic' rule in non-sigmatic classes were lower.

Conclusions

Overall, the simulation results were consistent with data from empirical studies on the acquisition of morphology. MIG captured the order of emergence of different inflections, frequency effects, and major developmental error patterns in both languages. Under conditions of the same atypical initial computational constraints, MIG demonstrated a learning profile parallel to SLI in both English and Modern Greek, even though the behavioral characteristics of children with SLI differ across these languages (e.g., with respect to default forms).

Across development, MIG integrates multiple cues (Phonology, Lexical-Semantics, Grammatical Class, and Grammatical Context Information) to output the appropriate inflected form. The multiple-cues approach presents cross-linguistic flexibility, and contributes a generalized view of the inflectional system within the connectionist framework. The multiple cues approach is also applicable to developmental deficits.

The simulations demonstrate the viability of more general developmental models of inflectional morphology in two senses. First, the model is general across grammatical categories and inflectional classes. Second, it is general across languages with marked different levels of morphological complexity.

Acknowledgments

This work was supported by UK MRC Grant G0300188 and the European Commission Grant NEST-029088 (ANALOGY) to the second author. The studies of the first author are funded by the Greek State Scholarship Foundation (IKY) and the Greek Ministry of Education.

References

Berko, J. (*1958*). The child's learning of English morphology. *Word, 14,* 150-177.

Brown, R. (1973). *A first language: The early stages.* London: George Allen & Unwin Ltd.

Clahsen, H., & J. Dalalakis (1999). Tense and agreement in Greek SLI: A case study. *Essex Research Reports in Linguistics, 24,* 1-25.

de Villiers, J.G., & de Villiers, P.A. (1985). Acquisition of English. In D. Slobin (Ed.), *The crosslinguistic study of language acquisition: Vol. 1. The data* (pp. 27-140). Hillsdale, NJ: Lawrence Erlbaum.

Francis, W.N., & Kucera, H. (1979). *Manual of Information to Accompany a Standard Sample of Present-day Edited American English , for Use with Digital Computers.* Original ed. 1964, revised 1971, revised and augmented 1979. Department of Linguistics, Brown University, Providence, R.I.

Gathercole, S. E., & Baddeley, A. D. (1990). Phonological memory deficits in language disordered children: Is there a causal connection? *Journal of Memory and Language 29,* 336–360.

Hoeffner, J. H., & McClelland, J. L. (1993). Can a perceptual processing deficit explain the impairment of inflectional morphology in developmental dysphasia? A computational investigation. In E. V. Clark (Ed.*), Proceedings of the 25th Child Language Research Forum.* Palo Alto, CA: Stanford University Press.

Joanisse, M.F. (2004) Specific language impairments in children: Phonology, semantics and the English past tense. *Current Directions in Psychological Science, 13,* 156-160.

Joanisse, M.F., & Seidenberg, M.S. (1999). Impairments in verb morphology following brain injury: A connectionist model. *Proceedings of the National Academy of Science USA, 96,* 7592-7597.

Kuczaj, S.A. (*1977*). The acquisition of regular and irregular past tense forms. *Journal of Verbal Learning and Verbal Behavior*, 16, 589-600.

Leonard, L.B. (1998). *Children with specific language impairment.* Cambridge, MA: MIT Press.

Leonard, L., Bertolini, U., Caselli, M., McGregor, K. & Sabbadini, L. (1992). Morphological deficits in children with specific language impairment: The status of features in the underlying grammar. Language Acquisition, 2, 115-179.

Matthews, D. E., & Theakston, A. L.(2006) 'Errors of omission in English-speaking children's production of plurals and the past Tense: The effects of frequency, phonology, and competition', *Cognitive Science: A Multidisciplinary Journal, 30: 6,* 1027 — 1052

Marcus, G. F. (2000). Children's Overregularization and Its Implications for Cognition. In P. Broeder, & J. Murre (eds). *Models of Language Acquisition: Inductive and deductive approaches.* Oxford: Oxford University Press, pp 154-176.

Pinker, S. (1984). *Language learnability and language development*. Cambridge, MA: Harvard University Press

Pinker, S., & Prince, A. (1988). On language and connectionism: Analysis of a parallel distributed processing model of language acquisition. *Cognition, 28*, 73–193

Plunkett, K., & Juola, P. (1999). A connectionist model of English past tense and plural morphology. *Cognitive Science, 23,* 463-490.

Plunkett, K., & Marchman, V. (1993). From rote learning to system building: Acquiring verb morphology in children and connectionist nets. *Cognition, 48*, 21-69.

Rice, M.L. (2000). Grammatical symptoms of specific language impairment. In: D.V.M. Bishop & L.B. Leonard (Eds.), *Speech and Language Impairments in Children: Causes, characteristics, intervention and outcome* (pp.17-34). Hove, England: Psychology Press.

Rice, M, Wexler, K. & Cleave, P. (1995). Specific Language Impairment as a period of extended optional infinitive. *Journal of Speech and Hearing Research, 38,* 850-863.

Rumelhart, D. E., Hinton, G. E., & Williams, R.J. (1986). Learning internal representations by error propagation. In D. E. Rumelhart, J. L. McClelland and The PDP Research Group, *Parallel distributed processing: Explorations in the microstructure of cognition. Volume 1: Foundations* (pp. 318–362). Cambridge, MA: MIT Press.

Rumelhart, D. E. & McClelland, J. L. (1986). On learning the past tense of English verbs. In J. L. McClelland, D. E. Rumelhart and PDP Research Group (Eds), *Parallel distributed processing: Volume 2: Psychological and Biological models.* (pp. 216-271). Cambridge, MA: MIT Press.

Stavrakaki, S. & Clahsen, H. (2009). The perfective past tense in Greek child language. *Journal of Child Language, 36,* 113-42.

Stephany, U. (1997). The Acquisition of Greek. In: Slobin, D. I. (ed.). *The cross-linguistic study of language acquisition 4* (pp.183-333).Hillsdale, NJ: Erlbaum.

Tallal, P., & Piercy, M. (1973). Defects of non-verbal auditory perception in children with developmental aphasia. *Nature, 241,* 468-469.

Thomas, M.S.C. & Karmiloff-Smith, A. (2003). Modelling language acquisition in atypical phenotypes. *Psychological Review, 110, 4,* 647-682.

van der Lely, H. K. J., & Ullman, M. (2001). Past tense morphology in specifically language impaired children and normally developing children. *Language and Cognitive Processes, 16,* 177-217.

Varlokosta, S., Vainikka, A., & Rohrbacher, B. (1998). Functional projections, markedness, and ‚root infinitives' in early child Greek. *The Linguistic Review* 15:187-207.