

AN NLP-BASED ASSISTIVE TOOL FOR AUTISTIC AND MENTALLY RETARDED CHILDREN: AN INITIAL ATTEMPT*

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Abstract: It is both a legal and conscientious responsibility of the society to enable children with disabilities to have access to and receive education and training as easily and effectively as possible. Assistive technology offers great opportunities for disabled students to participate in educational activities fully and adequately. This paper presents a software tool developed to assist the education and training of autistic and mentally retarded children. The tool is intended to help the disabled child establish the bridge between expressions and the concepts they refer to via relevant images. Taking into consideration the fact that enabling the user to interact with the system using natural language expressions will be much more effective compared to a system constraining the communication to a limited set of isolated keywords, the tool has been equipped with a Natural Language Processing (NLP) module. This module functions as the backbone of the tool. It analyzes natural language expressions into semantic frames using a unification-based grammar. Input expressions are mapped onto relevant images via the mediation of semantic frames. As these semantics frames represent the content of images, rather than their formal aspects, the system is able to operate on a flexible basis.

Keywords: Assistive Technology, Autism, Natural Language Processing (NLP), Semantic Frames

Otistik ve Zihinsel Engelli Çocuklar için Doğal Dil İşleme Tabanlı Bir Yardım Aracı: Bir Başlangıç Çalışması

Özet: Engelli çocukların, eğitim ve gelişim olanaklarına mümkün olduğunca kolay ve etkin bir biçimde erişebilmesinin sağlanması, toplum için hem yasal hem de vicdani bir sorumluluktur. Yardımcı teknolojiler, engelli çocukların eğitim faaliyetlerine tam ve yeterli biçimde katılabilmesi için büyük olanaklar sunarlar. Bu makale, otistik ve zihinsel engelli çocukların eğitim ve öğretimine yardımcı olmak için geliştirilen bir yazılım aracını sunmaktadır. Bu araç ile engelli çocukların ifadeler ve onlara karşılık gelen kavramlar arasında resimler aracılığıyla bağlantı kurmalarına yardımcı olmak amaçlanmaktadır. Kullanıcının sistemle olan etkileşiminin doğal dil ifadeleriyle kurulmasını sağlamanın, iletişimi kısıtlanmış anahtar kelimelerle sınırlandırmaktan daha etkin olduğu gerçeğini dikkate alarak aracımızı bir Doğal Dil İşleme (DDİ) modülü ile donattık. Bu modül aracın omurgası olarak görev yapmakta ve doğal dil ifadelerini birleşme tabanlı (unification-based) bir dilbilgisi kullanarak anlamsal çerçeveler şeklinde çözümlenmektedir. Giriş ifadeleri, ilgili resimlerle anlamsal çerçeveler aracılığıyla eşleştirilmektedir. Bu anlamsal çerçeveler, resimleri biçimsel bakımdan değil, içerikleri açısından temsil ettiği için, sistem esnek bir şekilde çalışabilmektedir.

Anahtar Kelimeler: Yardımcı Teknoloji, Otizm, Doğal Dil İşleme (DDİ), Anlamsal Çerçeveler

1. Introduction

As stated in Article 23 of the United Nations Convention on the Rights of the Child,† the disabled child shall be allowed to have effective access to and receive “education, training, health care services, rehabilitation services, preparation for employment and recreation opportunities in a manner conducive to the child’s achieving the fullest possible social integration and individual development, including his or her cultural and spiritual development.” That is, it is not only a conscientious responsibility but also a legal obligation to enable disabled children to have equal opportunities and rights when accessing to and receiving education and training. With personal computers that have advanced by leaps and bounds and become cheap enough to be ubiquitous in the last

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† The convention was signed by Turkey on the 13th of January, 1999.

thirty years, assistive computer hardware and software tools have served a great deal to bring to students with disabilities a whole new world of learning opportunities. Below is a non-exhaustive list of computer-based products that can be used for this purpose.‡

One of the most promising technologies for developing user-friendly and efficient assistive tools is the Graphical User Interface (GUI), which is a particular case of user interface for interacting with a computer which employs graphical images. GUI technology was developed in the 1960s by Douglas Engelbart and refined in the mid-1970s at Xerox Corporation. In 1984, Apple introduced the Lisa, its first computer with a GUI. As Poole et al (2005) point out, “[w]hile the GUI was not designed for people with disabilities, it made the computer more accessible for them just as it has made the computer more accessible to the general population” (p. 401) [24].

IBM has a long history of developing technology to assist disabled people. The following is a list of relevant products supplied by this company: the Model 1403 Braille Printer (1975), a talking typewriter for blind people (1980), a talking display terminal (1981), a screen reader for the sight impaired (1984), a talking web browser (Home Page Reader) for the visually-impaired and the elderly (1998), and a speech recognizer (namely, ViaVoice) that enables users to interact with the computer using voice commands.

Various versions of Microsoft’s Windows OS, in particular Windows XP, have included a range of accessibility options which are designed specifically to assist users with vision, hearing, and mobility impairments [17].

The World Wide Web Consortium (W3C), established shortly after the invention of the World Wide Web in 1991, has defined accessibility guidelines for the World Wide Web which requires the Web content provider to be aware of assistive technologies designed to facilitate access to the Web for users who have a disability. The full description of these guidelines is available on the Web site of the consortium [30].

Besides, there are various other companies and institutions that supply assistive products for people with varying disabilities. Among these are a group of products that are referred to as Augmentative and Alternative Communication (AAC) tools [2]. EZKeys by Words+ Inc.[29], Clicker5 by Crick Software Ltd.[5], Switch Access for Windows by the ACE Centers in the UK [1], Plockaw by the National Swedish Agency for Special Education and Boardmaker by Mayer-Johnson LLC [16] are in this group. These tools widely make use of pictures and icons and can assist the population with severe speech or auditory impairments.

This study focuses on the problems of children with autism and propose a software system that is intended to alleviate these problems to a modest extent. In what follows, firstly problems concerning autism are briefly explained (Section 2). Afterwards, the proposed system is presented in terms of its technical aspects (Section 3). Then, the capabilities of the system are illustrated using several examples (Section 4). The paper ends with a brief explanation that justifies our or similar work within the context of the problems encountered in the education of autistic and mentally retarded children and with some proposals relating to possible directions along which the system can be developed in the future (Section 5).

2. Background Knowledge About Autism

Autism is a developmental disability that typically appears during the first three years of the life. Being the result of a neurological disorder that affects functioning of the brain, autism and its associated behaviors occur in approximately in 15 of every 10.000 individuals. Autism interferes with the normal development of the brain in communicative, cognitive and social areas. Let us have a brief look at the deficiencies individuals with autism typically have in each of these areas.

Problems concerning communication include the following:

- under-developed language skills;
- use of words without attaching the usual meaning to them;
- communication with gestures instead of words; and
- short attention spans.

Griswold, Barnhill, Myles, Hagiwara and Simpson [13] list the following cognitive problems exhibited by individuals with autism:

- poor comprehension of abstract concepts;
- too-literal interpretation of information;
- poor comprehension of figures of speech;
- diminished ability to solve problems; and
- inability to distinguish pertinent information and stimuli from the irrelevant. As for social problems, individuals with autism:

‡ See Poole et al [24] for a comprehensive and detailed account of computer-based technologies that can serve to include people with disabilities into the mainstream of society.

- spend time alone rather than with others;
- show little interest in making friends;
- are less responsible to social cues such as eye contact or smiles; and
- are aggressive and anxious.

Many problems that autistic children experience can be alleviated through special education. However, traditional methods may not always be as appropriate or productive as desired in the education of children with autism. Assistive Technology, increasingly used in special education, has been suggested as a means of enabling new ways of learning and teaching in such children where traditional education fails [25, 26].

3. Design of the System

3.1 Architectural Design

The system is composed of four main components: a Graphical User Interface (GUI), a Semantic Frame Generator (SFG), a Query Generator (QG), and an Image Database (IDB). Figure 1 shows the interaction of these components in terms of data flow between them:

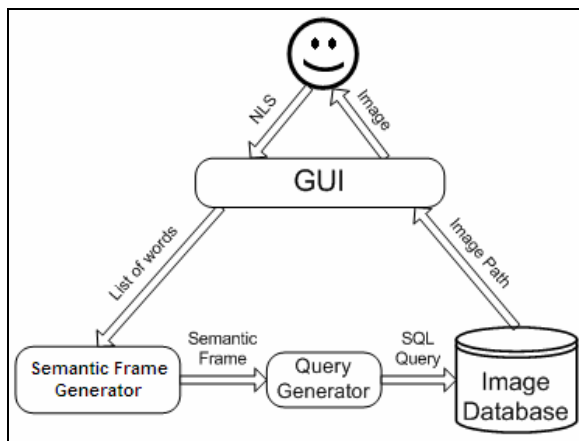


Figure 1. The architectural design of the system

The GUI serves as an interface between the user and the system. More specifically, it takes in a natural language sentence in a written format from the user and provides the user with an image representing the semantic content of that sentence. The input to the SFG is the list of words yielded by the GUI. The output of this component is a semantic frame representing the meaning of the input sentence in a structured way. The QG takes the semantic frame generated by the SFG as input and translates it into an SQL query. As should be expected, the IDB serves as a store of paths leading to the images used to visually represent the contents of input sentences.

3.2 Detailed Design

To start with the development environment within which the tool has been developed, four different software environments have been used while encoding the components constituting the system. The GUI and QG components have been entirely coded using the JAVA programming language. The IDB stores the pictorial data (which includes about three thousands images) in MS Access and uses the Java Database Connection (JDBC) in order to access this database. The core part of the system, i.e. the SFG, has been implemented using SWI Prolog and the Attribute Logic Engine (ALE) which is a logic programming and grammar parsing and generation system. Let us have a detailed look at each of the components starting from the GUI.

Even though the GUI is a translator from a natural language sentence to an image, this is the function corresponding to its external facet. In its internal facet, the GUI performs two different sorts of transformation process. Firstly, it transforms the given natural language sentence into a list containing the words of the sentence with any capital letters and punctuation removed away. As the aspects of interpretation encoded by capital letters and any kinds of punctuation fall outside the scope of this work, the input to the SFG must be free of these orthographic elements. Secondly, the GUI interacts with the IDB. It takes an image path from this component and attempts to fetch and display the image associated with this path. In order for the system to be considered as having achieved the overall requirement imposed on it, the displayed image must be relevant to the input sentence.

The SFG carries the main burden of what is expected from the system: it processes natural language expressions in order to extract their semantic content. This process is driven by a strongly typed unification-based grammar. What strong typing means is that every structure used in the description of the grammar comes with a type. These types are arranged in an inheritance hierarchy, whereby type constraints on more general types are inherited by their more specific subtypes. This leads to inheritance-based-polymorphism, which is a cornerstone of object-oriented programming. Feature structures serve as the main representational device in the framework adopted in this study. A feature structure consists of two pieces of information: a type (which every feature structure must have) and a finite set of feature-value pairs (which can possibly be empty). A feature-value pair is defined recursively, where the value itself is a feature structure which can also be an atomic object. As for the notion of unification, this refers to an operation which has gained widespread recognition as a general tool in computational linguistics since Kay's [14] seminal work. This is an operation defined over pairs of feature structures that combines the information contained in both of them if they are consistent and fails otherwise. §

The internal structure of the SFG is as shown in figure 2:

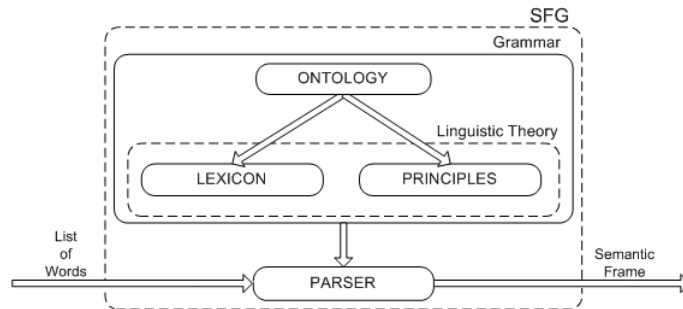


Figure 2. The internal structure of the Semantic Frame Generator (SFG)

This component consists of two main parts: a grammar and a parser. The grammar itself is split into three subparts: an ontology, a lexicon and a set of linguistic principles, where the latter two can be thought of as the linguistic theory embedded in the system. The ontology is the inventory of universally available types of linguistic entities, together with a specification of their appropriate features and their value types. The types in this inventory are organized into a hierarchy, which is, in fact, a semi-lattice. In the ontology, every object is assigned exactly one most specific type, and in case a feature is appropriate for some object, then it is appropriate for all objects of this type. The lexicon is a system of lexical entries and lexical rules. The relevant words of the natural language (which is Turkish in this study) are either first-hand entries in the lexicon or generated by appropriate lexical rules. The principles include universal and language specific constraints which every linguistic structure to be generated by the system must obey. That is, the principles serve as a filter which the parser uses to check the legitimacy of input phrases.

As for the parser, it is the component that assigns a structure to grammatically legitimate natural language expressions, whose legitimacy it checks using the grammar described above. When doing this, it performs two major functions, which actually constitute the main functionality of parsers in general. Firstly, it ensures that the words constituting the input expression belong to the object language (i.e. Turkish). Secondly, it combines the words and phrases into larger phrasal units strictly obeying the principles encoded in the grammar.

The component responsible for the parsing process is the Attribute Logic Engine (ALE) (version 3.2.1), which is an integrated phrase structure parsing and definite clause logic programming system in which the data structures are typed feature structures [4]. ALE endeavors to parse expressions according to a Head-driven Phrase Structure Grammar (HPSG) which has been designed and implemented in ALE in order to handle a fairly large fragment of Turkish.** HPSG is an integrated theory of natural language syntax and semantics, developed principally by Pollard and Sag [22, 23]. An important aspect of this linguistic theory is the great emphasis placed on mathematical precision and formal rigor, which has played a significant role in its being a predominant formalism in computational linguistics and natural language processing applications. In HPSG, every linguistic object is modeled as a typed feature structure [19, 21].

§ See Carpenter and Penn [4] for detailed discussion of strong typing, feature structures and unification as implemented in the Attribute Logic Engine (ALE).

4 See Kılıçaslan [15] for a semantico-pragmatically oriented grammar of a fragment of Turkish developed within a modified version of the HPSG formalism.

The output of the parsing process is a linguistic structure containing syntactic and semantic information pertaining to the input expression. Of these two types of information, only the latter will be yielded as the ultimate output of the SFG, which is encoded as a semantic frame. As Petrucci [20] points out, perhaps of greatest influence for Artificial Intelligence was Minsky's [18] work that used frame as a cover term for a data-structure as stereotyped situation and the notion frame used in Frame Semantics can be traced back most directly Fillmore's [6, 7, 8] case frames. In general terms, a semantic frame is a conceptual structure that describes a particular type of situation, object or event and the participants and other peripheral entities involved in it.

A semantic frame generated by the SFG is fed to the Query Generator (QG). The duty of the QG is to translate this semantic frame into a database query. In fact, fulfilling this duty amounts to converting the values of the relevant features into database fields. The query created in this way is sent to the Image Database (IDB). The IDB returns a path to the image representing the semantic content of the natural language expression given as input to the system.

4 How to Use the System

As has been touched upon in Section 2, individuals with autism experience difficulties both in thinking using abstract concepts and in using linguistic expressions. As many researchers (e.g. [3]) point out, visualizing verbal expressions improves language comprehension and expression for individuals experiencing mild to severe weakness in comprehension, including those diagnosed with autism. One of the most abstract concepts is that of time. It is our opinion that visualizing three sentences each of which expressing the pre-, mid-, and post-phases of an event will help an individual with autism grasp the temporal development of that event. Consider the following sentences:

- (1) a. Çocuk elmayı yiyecek.
- b. Çocuk elmayı yiyor.
- c. Çocuk elmayı yedi.

When these sentences are given as input to our system, the pictures shown in figure 3 will be generated in the left to right order:

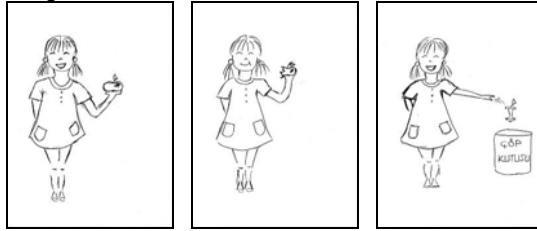


Figure 3. The three phases of an eating event.

As can be gleaned from the work of many researchers (such as [10] and [27, 28]), individuals with autism think in pictures, not words, and, metaphorically speaking, play a video in their mind when reasoning. What our system is meant to do is motivate and assist an autistic person when carrying out a reasoning process corresponding to the depicted states of affairs. That is, pictures generated by the system will replace the sentences describing the situations in question as tools of mental representation. In this way, the autistic individual will be provided with a non-verbal and non-abstract means of thinking. To be more precise, the proposed system is intended to serve the following purposes.

Firstly, the system allows for visualizations of verbal expressions, which will make it easier for the autistic person to comprehend what is meant.

Secondly, it even provides visual descriptions of abstract concepts (such as time), which individuals with autism have considerable difficulties to comprehend.

Thirdly, the autistic person can use the system as a means of communication (or, maybe, also as a tool of reasoning) if it is integrated with, for instance, a tablet PC.

Fourthly, it can also be employed for specific educational purposes. For example, using sequences of pictures like those above, an autistic child can be taught about linguistic encoding of temporal relations in Turkish.

Fifthly, the system can be used as a story teller. Stories are often used to allay an autistic child's fears about a future event or to encourage different behaviors (cf. [11] and [9]). To give an example, the sequence of pictures above can be thought of as a very short story about a child. Admittedly, such stories can be considered too simple. However, this simplicity should rather be viewed as an advantage taking into consideration the fact that children with autism are very reluctant in keeping the track of a sequence of events.

Lastly, even though the emphasis is placed upon autism up to this point, it should be obvious that the proposed system can also assist many other types of disabled people (such as mentally retarded individuals, people

experiencing learning difficulties, people with speech problems and hearing impaired individuals) and even normal people. Evaluating the system from such a broad perspective, another important property of it is worth mentioning. The system is flexible enough to map the same image to all more or less paraphrasable expressions. For example, all those sentences below roughly have the same content and, hence, are assigned the same image, which is shown in figure 4.

- (2) a. Gazete okuyan bir çocuk var.
 b. Gazete okuyan bir çocuk oturuyor.
 c. Gazete çocuk tarafından okunuyor.
 d. Oturan çocuk gazete okuyor.



Figure 4. The image matching the sentence ‘Çocuk gazete okuyor’.

As Green, Dorr and Resnik [12] note, semantic frames effectively “address the paraphrase problem through their slot-and-filler templates, representing frequently occurring, structured experiences” (p. 375). Our system ensures the sameness of the interpretations of paraphrasable sentences by assigning them the same semantic frame. Semantic frames are represented via partial descriptions of feature structures, which are recursively defined feature-value sets. Below is the feature structure which the system will assign to each of the synonymous sentences in (2):

- (3) SYNSEM synsem
 CAT cat
 HEAD verb
 MARKING unmarked
 SUBCAT e_list
 CONT sem_obj
 DET sem_det
 INDEX ind
 FRAME semantic_frame
 ACTOR [1] a_child
 CO_ACTOR a_G525
 GOAL a_G530
 NAME a_read
 PLACE list_atom
 QUALITY list_atom
 QUANTITY list_atom
 THEME [0] a_newspaper
 TIME present

As a notational convention, features are displayed in all caps while types are displayed in lower case. In the structure above the CAT (CATEGORY) feature encodes syntactic information pertaining to the given sentence. The CONT (CONTENT) value constitutes the expression’s contribution to (context-independent) aspects of the semantic interpretation.

5. Conclusion

Many children with autism suffer from speech and language problems. It is widely acknowledged that with the aid of methods of visual education, language barriers will be lowered, and learning and understanding with all senses will be promoted. Autistic children can speak without grasping the meanings of the words they use. They may experience a difficulty in establishing the relation between a word and its referent. For example, an autistic

child hearing the word 'orange' may not be able to apply that word to an actual orange that s/he sees. In just such cases, computer software linking expressions and pictures and/or icons representing the referents of these expressions can come to scene to help speed up and facilitate the education of these children. Of course, all these facts also apply to mentally retarded children who have similar difficulties. Expectedly, our current work and possible improvements added to it in the future will contribute to the education of such children.

It is beyond doubt that the tool presented in this study can be sufficiently improved only if it is employed as an assistive tool in educating autistic children. Observations obtained in this way will certainly show us defects and shortcomings of the tool clearly. To this effect, two relevant centers (Armağan Dönertaş Education, Rehabilitation and Research Center for Disabled Children and Yağmur Çocuklar Psychological Counseling and Special Education Center) have been requested for collaboration to carry out such experimental works. In the near future, the proposed system will undergo a series of tests in the real field of application with intended users. Hopefully, these tests will allow us to improve the system in an incremental manner.

References

1. ACE CENTERS UK, SwitchAccess, <http://ace-centre.hostinguk.com/>
2. BASU A., SARKAR S., CHAKRABORTY K., BHATTACHARYA S., and CHOUDRY M. (2002) Vernacular Education and Communication Tool for the People with Multiple Disabilities. In the Digital Library of the 2nd International Conference on Open Collaborative Design for Sustainable Innovation (On-line), Bangalore, India. Web: <http://www.thinkcycle.org/tc-papers>.
3. BELL N. (2005) The Role of Imagery and Verbal Processing in Language Comprehension. The ASA's 36th National Conference on Autism Spectrum Disorders, Nashville, TN.
4. CARPENTER B. and PENN G. (2001) The Attribute Logic Engine User's Guide, Version 3.2.1. (University of Toronto: www.cs.toronto.edu/~gpenn/ale.html)
5. CRICK SOFTWARE LTD., Clicker5, <http://www.cricksoft.com/uk/products/clicker/>
6. FILLMORE C. J. (1968) The Case for Case. In E. Bach and R. Harms (eds.), *Universals in Linguistic Theory*, 1-88, New York: Holt Rinehart and Winston.
7. FILLMORE C. J. (1982) Frame Semantics. In *Linguistics in the Morning Calm*, 111-137, Seoul: Hanshin.
8. FILLMORE C. J. and ATKINS B. T. S. (1992) Towards a Frame-Based Lexicon: the Semantics of RISK and its Neighbors. In A. Lehrer and E. F. Kittay (eds.), *Frames, Fields and Contrasts*, 75-102, Hillsdale, NJ: Erlbaum.
9. FRANCIS, P. (2004) Techniques to Include Users with Autism in the Design of Assistive Technologies. BSc Thesis. University of Melbourne.
10. GRANDIN, T. (2006) *Thinking In Pictures*. Vintage Press
11. GRAY C. and WHITE, A. L. (2002). *My Social Stories Book*. Jessica Kingsley: PA.
12. GREEN R., DORR B. J., and RESNIK P. (2004) Inducing Frame Semantic Verb Classes from WordNet and LDOCE. In the Proceedings of the 42nd Annual Meeting of the Association for Computational Linguistics, 375 - 382.
13. GRISWOLD, D. E., BARNHILL, G. P., MYLES, B. S., HAGIWARA, T. and SIMPSON, R. L. (2002). Asperger syndrome and academic achievement." *Focus on Autism and Other Developmental Disabilities*, Summer, 17, 2, p.94.
14. KAY M. (1979) Functional Grammar. In Proceedings of the Fifth Annual Meeting of the Berkeley Linguistic Society, pp. 142-158.
15. KILIÇASLAN Y. (1998) A Form-Meaning Interface for Turkish. Ph.D. Dissertation. University of Edinburgh.
16. MAYER-JOHNSON LLC, Boardmaker, <http://www.mayer-johnson.com/>
17. MICROSOFT CORPORATION (2004) History of Microsoft's Commitment to Accessibility (On-line). Web: <http://www.microsoft.com/enable/microsoft/history.aspx>.
18. MINSKY M. (1975) A Framework for Representing Knowledge. In Patrick Henry Winston (ed.), *The Psychology of Computer Vision*, 211-277, New York: McGraw-Hill.
19. MOSHIER D. (1988) Extensions to Unification Grammars for the Description of Programming Languages. Ph.D. Dissertation, University of Michigan, Ann Arbor.
20. PETRUCK M. R. L. (1996) Frame Semantics. In Jef Verschueren, Jan-Ola Östman, Jan Blommaert, and Chris Bulcaen (eds.), *Handbook of Pragmatics*, Philadelphia: John Benjamins.
21. POLLARD C. and MOSHIER D. (1990) Unifying Partial Descriptions of Sets. In Philip P. Hanson (ed.), *Information Language and Cognition*, Volume 1 of Vancouver Studies in Cognitive Science, University of British Columbia Press, Vancouver.

22. POLLARD C. and SAG I. A. (1987) Information-Based Syntax and Semantics, Volume 1: Fundamentals, CSLI Lecture Notes no. 13. Stanford: Center for the Study of Language and Information (distributed by the University of Chicago Press.)
23. POLLARD C. and SAG I. A. (1994) Head-Driven Phrase Structure Grammar. Chicago, London: University of Chicago Press and CSLI Publications.
24. POOLE J. B., SKYMCILVAIN E., JACKSON L., and SINGER Y. (2005). Education for an Information Age: Teaching in the Computerized Classroom, 5th Edition.
25. POWELL, S. (1996), The Use of Computers in Teaching People with Autism, in P. Shattock & P. Linfoot (eds) Autism on the Agenda, papers from NAS Conference, 128-32
26. WILLIAMS C., WRIGHT B., CALLAGHAN G., and COUGHLAN B. (2002), Do children with autism learn to read more readily by computer assisted instruction or traditional book methods? A pilot study, Autism, Vol. 6, No. 1, 71-91, SAGE Publications
27. WILLIAMS. D. (1996) Autism: An Inside-Out Approach. Jessica Kingsley Publishers
28. WILLIAMS. D. (1998) Autism and Sensing: The Unlost Instinct. Jessica Kingsley Publishers
29. WORDS+ INC, EzKeys, <http://www.words-plus.com/website/products/soft/ezkeys.htm>
30. WORLD WIDE WEB CONSORTIUM (2005) Web Content Accessibility Guidelines 2.0 (On-line). <http://www.w3.org/TR/WCAG20/checklist.html>.