New Beginnings and Happy Endings: Psychological Plausibility in Computational Models of Language Acquisition

Luca Onnis and Morten H. Christiansen
Department of Psychology, Cornell University, Ithaca, NY 14853, USA

Abstract

Language acquisition may be one of the most difficult tasks that children face during development. They have to segment words from fluent speech, figure out the meanings of these words, and discover the syntactic constraints for joining them together into meaningful sentences. Over the past couple of decades computational modeling has emerged as a new paradigm for gaining insights into the mechanisms by which children may accomplish these feats. Unfortunately, many of these models use powerful computational formalisms that are likely to be beyond the abilities of developing young children. In this paper, we argue that for computational models to be theoretically viable they must be psychologically plausible. Consequently, the computational principles have to be relatively simple, and ideally empirically attested in the behavior of children. To demonstrate the usefulness of simple computational mechanisms in language acquisition, we present results from a series of corpus analyses involving a simple model for discovering lexical categories using word beginnings and endings.

Introduction

By their third year of life children have already learned a great deal about how words are combined to form complex sentences. This achievement is particularly puzzling for cognitive science for at least three reasons: firstly, whatever learning mechanisms children bring to bear, they are thought to be of simpler computational complexity than adults'; second, children acquire most syntactic knowledge with little or no direct instruction; third, learning the complexities of linguistic structure from mere exposure to streams of sounds seems vastly complex and unattainable.

A particularly hard case that we consider here is the discovery of lexical classes such as nouns and verbs, without which adult linguistic competence cannot be achieved. Indeed the very core of syntactic knowledge is typically characterized by constraints governing the relationship between grammatical categories of words in a sentence. But acquiring this knowledge presents the child with a "chicken-and-egg" problem: the syntactic constraints presuppose the grammatical categories in terms of which they are defined; and the validity of grammatical categories depends on how far they support syntactic constraints. capacity of adult humans. Given the importance of this knowledge in language acquisition much debate has centered on how grammatical category information is bootstrapped from raw input. Even assuming that the categories themselves are innate (e.g. Pinker, 1984), the complex task of assigning lexical items from a specific language to such categories must be learned (e.g., the sound /su/ is a noun in French (*sou*) but a verb in English (*sue*)). Crucially, children still have to map the right sound strings onto the right grammatical categories while determining the specific syntactic relations between these categories in their native language.

In trying to explain the bootstrapping problem the field of language acquisition has recently benefited from a wave in computational modeling. Computational models can be seen as intermediate tools that mediate between a purely "verbal" theory and a purely experimental paradigm (Broeder & Murre, 2003). As a computer implementation of a theory a computational model requires the modeler to make more explicit the assumptions underpinnings their theory. Because it involves an input, a process, and an output, it can also be subjected to experimental manipulations that test different conditions of behavior. As an intermediate between theory and experiment, a model can thus be judged in terms of how well it implements the theory as well as how well it fits the data gathered. Despite advances in computational modeling, many models are still far from being *psychologically plausible*, i.e. they typically assume a level of a) computational power and b) a priori knowledge of the properties of a specific language that is implausible in children. For instance, the Latent Semantic Analysis model of word learning (Landauer & Dumais, 1997) builds lexical knowledge assuming that *all* words in the language are already available. In this paper we argue that it is possible to build more psychologically plausible computational models of language acquisition when two fundamental requisites are met: firstly, the learning mechanisms should be as simple as possible to be realistically implemented in the newly-born brain. Secondly, minimal assumptions should be made about the linguistic input available to the learning mechanism, with the most minimal assumption being that children start constructing a language by perceiving sequences of sounds.

To make a case for psychological plausibility, we start by estimating the usefulness of morphological affixes – prefixes and suffixes – in discovering word classes in English. Subsequently we argue that, even though this source of information is potentially available in the input, children are not spoon-fed with a list of morphological prefixes and suffixes. Despite this, there is evidence that children do pay particular attention to the beginning and end sounds of words. Hence, we argue that a more psychologically plausible mechanism is one that learns to categorize words based on beginning and endings assuming no a priori knowledge of morphology. This is not to discount the role of morphology, which may become very useful at later stages of language development. After assessing the usefulness of word beginnings and endings in English, we test the robustness of our simple model with a language that is similar to English (Dutch), a language that has a richer morphological affixation than English (French) and a language that has different structural properties and does not belong to the Indo-European family (Japanese).

Bootstrapping syntactic categories

There are three sources of information that children could potentially bring to bear on solving the bootstrapping problem: innate knowledge in the form of linguistic universals (e.g. Pinker, 1984); language-external information (e.g. Bowerman, 1973), concerning observed relationships between language and the world; and language-internal information, such as aspects of phonological, prosodic, and distributional patterns that indicate the relation of various parts of language to each other. Though not the only source of information involved in language acquisition, we suggest that language-internal information is fundamental to bootstrapping the child into syntax. Computational models are particularly apt at investigating language-internal information because it is now possible to access large computerized databases of infant-directed speech and quantify the usefulness of given internal properties of a language.

A hypothesis that is gaining ground in the field is that substantial information may be present in the input to the child in the form of probabilistic cues: several studies have already assessed the usefulness of distributional, phonological, and prosodic cues. Distributional cues refer to the distribution of lexical items in the speech stream (e.g. determiners typically precede nouns, but do not follow them, *the car/*car the*; e.g. Monaghan, Chater, & Christiansen, in press; Redington, Chater & Finch, 1998). Phonological cues are also useful: adults are sensitive to the fact that English disyllabic nouns tend to receive initial-syllable (trochaic) stress whereas disyllabic verbs tend to receive final-syllable (iambic) stress and such information is also present in child-directed speech (Monaghan et al. in press). Prosodic information provides cues for word and phrasal/clausal segmentation and may help uncover syntactic structure (e.g. Gleitman & Wanner, 1982).

In this paper, we assess the usefulness of another potential source of information, namely word beginnings and endings. Morphological patterns across words may be informative—e.g., English words that are observed to have both –ed and –s endings are likely to be verbs (Maratsos & Chalkley, 1980). Children may also exploit prefix information, although to our knowledge little work has been done to assess the usefulness of this cue. Our experiments are based on corpus analyses, to indicate the potential information available in the environment for grammatical categorization. A computational system operating optimally will pick up on such signals.

Experiment 1: Testing morphological cues in grammatical categorization

Method

Corpus preparation. A corpus of child-directed speech was derived from the CHILDES database (MacWhinney, 2003). We extracted all the speech by adults to children from all the English corpora in the database, resulting in 5,436,855 words. The CHILDES database provides (with the exception of only a fragment of the database) only orthographic transcriptions of words[1], so we derived phonological and syntactic category for each word from the CELEX database (Baayen, Pipenbrock, & Gulikers, 1995). Words with alternative pronunciations and more than one grammatical class (e.g. *record* can be a verb or a noun), were assigned the most frequent pronunciation and word class for each orthographic form. This contributes noise to the analysis and provides the weakest test of the contribution of these cues towards categorisation. We considered the most frequent 4500 words in the CHILDES database.

Cue derivation. A comprehensive list of English orthographic prefixes and suffixes was compiled, resulting in 248 prefixes and 63 suffixes. Among these, 58 prefixes and 23 suffixes appeared at least once in our corpus. Because some prefixes and suffixes can have more than one phonetic realization (for instance, -ed is pronounced /d/ or /t/), we obtained 62 phonetic prefixes and 37 phonetic suffixes. Each word in the corpus was represented as a vector containing (62+37) 99 units. If the word started and ended with one of the affixes, then its relevant unit in the vector was assigned a 1, otherwise it was 0. At the end of the coding the whole corpus consisted of a list of 54-cue vectors with most cues having value 0 and one or two having value of 1. Importantly, we tested a situation in which the model knows about affixes but knows nothing about lexical categories. The model simply looks for information of these affixes to assign a word category to each word. For instance, -al as an adjectival suffix will apply both to words like *musical, natural*, and to words like *sandal*, *metal*.

To assess the extent to which word prefix and suffix cues resulted in accurate classification, we performed a multivariate linear discriminant analysis dividing words into Nouns, Verbs, or Other. Discriminant analysis provides a classification of items into categories based on a set of independent variables. The chosen classification maximises the correct classification of all members of the predicted groups. Despite its seemingly statistical complexity, discriminant analysis is a simple procedure that can be approximated by simple learning devices such as two-layer "perceptron" neural networks (Murtagh, 1992). In addition, a baseline 'control' condition was established where the

[1] A parsed version of the entire English CHILDES database is now available at http://childes.psy.cmu.edu/data/eng-uk-mor.

lexical category labels for each word were randomly reassigned to a different suffix vector.

Results

When all cues were entered simultaneously, 60.7% of cross-validated words were classified correctly, which was highly significant (Wilk's Lambda = .675, χ^2= 1836.524, p < .001). In particular, 76.9% of nouns, 54.4% of verbs, and 29% of other words were correctly classified using morphological cues. To test against chance levels, a discriminant analysis was run on the baseline condition where the 4500 words were randomly assigned to one of the three categories, (respecting the size of each category). We obtained an overall correct classification of 36.1%, which was not significant (Wilk's Lambda = .967; χ^2=156.232; p=.987). In particular, 49.2% of nouns, 7.8% of verbs, and 34.4% of other words were correctly cross-classified (Figure 1). The baseline classification was also significantly lower than the morphological classification (χ^2=571.518, p<.001). Stepwise analyses were also conducted to assess which cues are most useful in discriminating nouns, verbs, and other classes. In stepwise discriminant function analysis, a model of discrimination is built step-by-step. At each step, all variables are reviewed and evaluated to determine which one will contribute most to the discrimination between groups. That variable will then be included in the model, and the process starts again. Percent results obtained with the stepwise method were very similar or identical to the discriminant analyses reported above. Of the 99 cues entered 20 were most useful in lexical categorization: -ing, -ed, -y, -s, -er/-or, -(o)ry, -ite, -id, -ant, e-, -ite, -ate, un-, -ble, -ive, an-, pre-, out-, bi-, -ine.

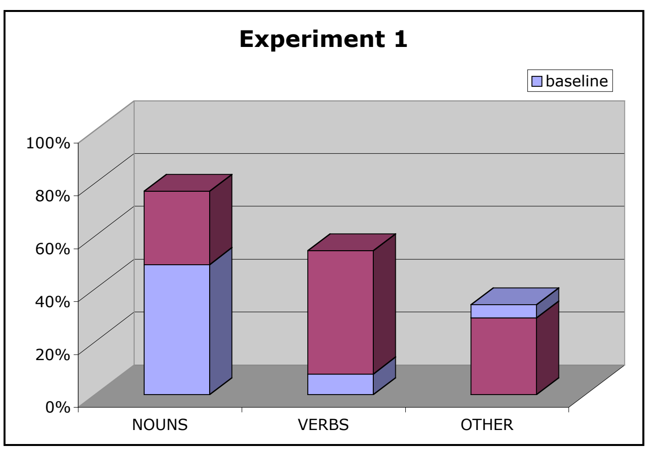

Figure 1. Percent correct classification of English Nouns, Verbs, and Other using affix information.

Experiment 2: A linguistically naïve analysis of word beginnings and endings

Experiment 1 suggests that morphological suffixes are potentially useful cues for discovering lexical categories. However, the method used implies an already sophisticated level of linguistic analysis where suffixes are pre-analyzed units of the lexicon. Thus, one potential objection to these analyses is that children are not spoon-fed a list of relevant morphological suffixes. Another objection is that infants cannot detect suffixes at 20 months (Santelman, Jusczyk & Huber, 2003), which is the period immediately preceding the vocabulary spurt. In our quest for more psychologically plausible learning mechanisms, it seems that a complete morphological system is developed at later stages and may not directly assist in syntactic bootrstrapping. Where does this leave us? Does it mean that the beginnings and endings of words are useless cues? By one year infants will have learned a great deal about the sound structure of their native language (for reviews see Jusczyk, 1997; Pallier, Christophe & Mehler, 1997). Thus, when they face the syntactic bootstrapping problem at the beginning of their second year, they are already well attuned to the phonological regularities of their native language. In particular, infants and children are highly sensitive to word endings (e.g., Slobin, 1973). Recent experimental work in adult word learning also found a primacy and recency facilitation effect: adults repeated the beginning and end of nonwords more accurately than the middle of words (Gupta, in press). Since nonwords are for adults what new words are for children, a reasonable assumption is that whatever sequencing mechanism is responsible for word learning, it displays a learning bias for the beginning and ending of words. We therefore developed a simple procedure that children could plausibly use to discover word-edge cues without prior knowledge of morphology and tested its classification success.

Method

Corpus preparation. The same corpus from Experiment 1 was used.

Cue derivation. We extracted all first and final phonemes from the words in the corpus. By selecting the smallest phonological unit, this procedure makes minimal assumptions about the perceptual and processing capacities of children. Our procedure resulted in 40 beginning and 40 ending phonemes with an attached frequency distribution. A 80-unit (40+40) vector was generated for each word as in Experiment 1. The vectors were entered in a discriminant analysis where the cues were the independent variables and classification for Nouns, Verbs, and Other was estimated as in Experiment 1.

Results

An overall 58.7% of cross-validated words were classified correctly, which was highly significant (Wilk's Lambda=.683, χ^2= 1787.730, p< .001). In particular, 70.5% of nouns, 58.9% of verbs, and 30.6% of other words were correctly classified using the first and last phoneme as word class predictors (Figure 2). As in Experiment 1, a discriminant analysis on the baseline condition yielded an overall correct classification of 38.5%, which was not significant (Wilk's Lambda=.975; χ^2=120.206; p=.723). 48.1% of nouns, 22.7% of verbs, and 32.1% of other words were correctly cross-classified. The baseline classification was also significantly lower than the word-edge classification (χ^2= 385.948, p < .001). Stepwise discriminant analyses revealed that 26 out of 80 word-edge cues were relevant for successful lexical categorization.

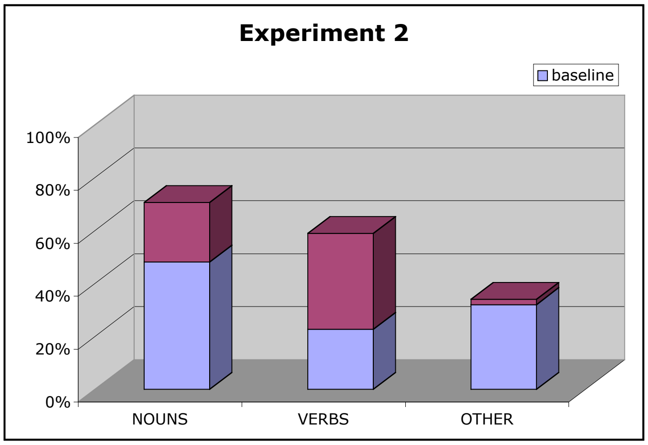

Figure 2. Percent correct classification of English Nouns, Verbs, and Other using first and last phoneme information.

Experiments 1 and 2 have established the potential usefulness of word beginnings and endings in bootstrapping syntactic categories in English. In particular, on the assumption that word beginnings and endings are phonologically salient features and perceptually available to infants in their second year of life, Experiment 2 established that a linguistically naïve learner with no prior knowledge of morphological structure may start bootstrapping English syntactic categories. This is particularly striking given that several sounds are ambiguous (/s/ in English signals the this person singular of a verb as well as the plural of countable nouns), and that several sounds entered as cues do no carry any specific morphological meaning (e.g. beginning /h/ was the 11th cue entered in order of importance in the stepwise analysis, although it does not correspond to any morphological prefix in English). In the following experiments, we assess the robustness of our simple model on different corpora of languages such as Dutch, French, and Japanese.

Experiment 3: Dutch

We begin by extending our simple word-edge procedure to Dutch, a language with structural properties similar to English in many respects (for instance, it is a stress-based language and has a similar morphology).

Method

Corpus preparation. Child-directed speech from the Dutch subcorpus of CHILDES was extracted and the 5000 most frequent words were assigned a phonological representation and a lexical category using the CELEX database. Words belonging to more than one lexical category were assigned the most frequent category.

Cue derivation. Given the good classification results obtained with the naïve procedure in Experiment 2, the same procedure as in Experiments 2 extracted 37 beginning phonemes and 27 ending phonemes. Each word in the corpus was turned into a 64-unit (37+27) vector and entered into a discriminant analysis. The 37+27 beginnings and endings were used as predictors in a three-way lexical category classification (Nouns, Verbs, Other).

Results

An overall 54.0% of cross-validated words were classified correctly (Figure 3), which was highly significant (Wilk's Lambda=.707, χ^2= 1725.088, *p*<.001). In particular, 49.3% of nouns, 76.2% of verbs, and 42.6% of other words were correctly classified using the first and last phoneme as word class predictors. A discriminant analysis on the baseline condition yielded an overall correct classification of 30.0%, which was not significant (Wilk's Lambda=.974; χ^2=128.393; p=.251). In particular, 26% of nouns, 28.9% of verbs, and 41.9% of other words were correctly cross-classified. The baseline classification was also significantly lower than the word-edge classification (χ^2= 547.953, p < .001). Stepwise discriminant analyses revealed that 29 out of the 64 cues were relevant for successful lexical categorization.

Experiment 4: French

For our analyses, French is particularly interesting because of its rich morphological system and because many word endings are highly ambiguous (e.g. the words *fait*=noun,verb, *fais*=verb, *mais*=preposition, *lait*=noun, all end with the same sound).

Method

Corpus preparation. Child-directed speech from the French subcorpus of CHILDES was extracted and its 3000 most frequent words were assigned a phonological representation and a lexical category using the LEXIQUE database (New, Pallier, Ferrand, & Matos, 2001). In case of multiple categories (e.g. *fait*=noun,verb) the most frequent one was assigned as in previous experiments.

Cue derivation. The same procedure extracting the first and last phoneme of each word in the corpus was adopted, resulting in 37 beginnings and 36 endings. Each word was transformed into a 73-unit (37+36) vector, and entered in a discriminant analysis where the 73 cues were used as predictors of a three-way lexical category classification (Nouns, Verbs, Other).

Results

An overall 53.9% of cross-validated words were classified correctly (Figure 3), which was highly significant (Wilk's Lambda= .680, χ^2= 1142.593, *p*<.001). In particular, 52.6% of nouns, 57.8% of verbs, and 49.7% of other words were correctly classified using the first and last phoneme as word class predictors. A discriminant analysis on the baseline condition yielded an overall correct classification of 36.2%, which was not significant (Wilk's Lambda=.949; χ^2=154.192; p=.229). Only 35.7% of nouns, 36.8% of verbs, and 36.3% of other words were correctly cross-classified. The baseline classification was also significantly lower than the word-edge classification (χ^2=405.935, p<.001). Stepwise discriminant analyses revealed that 33 of the 73 cues were relevant for successful lexical categorization.

Experiment 5: Japanese

Our last extension of the simple word-edge procedure applied to a non Indo-European language very dissimilar to English, Dutch, and French. This will allow us to test the potential robustness of our learning procedure across a varied typology of languages.

Method

Corpus preparation. Child-directed speech from the Japanese subcorpus of CHILDES was extracted and the 1000 most frequent words were assigned a phonological representation and a lexical category using the CALLHOME corpus (Canavan & Zipperlen, 1996), with hand-coding for the most frequent 1000 words by a native Japanese speaker. Words belonging to more than one lexical category were assigned the most frequent category.

Cue derivation. The same procedure used in Experiments 2-4 extracted 29 beginning phonemes and 9 ending phonemes. Each word in the corpus was turned into a 38-unit (29+9) vector and entered into a discriminant analysis. As in the previous experiments, the 38 beginnings and endings were used as predictors in a three-way lexical category classification (Nouns, Verbs, Other).

Results

An overall 51.5% of cross-validated words were classified correctly (Figure 3), which was highly significant (Wilk's Lambda=.703, χ^2=345.824, p<.001). In particular, 49% of nouns, 64.1% of verbs, and 44.2% of other words were correctly classified using the first and last phoneme as word class predictors. A discriminant analysis on the baseline condition yielded an overall correct classification of 33.8%, which was not significant (Wilk's Lambda=.934; χ^2=66.410; p=.664). Only 30.4% of nouns, 25% of verbs, and 44.7% of other words correctly cross-classified. The baseline classification was also significantly lower than the word-edge classification (χ^2=64.041, p<.001).

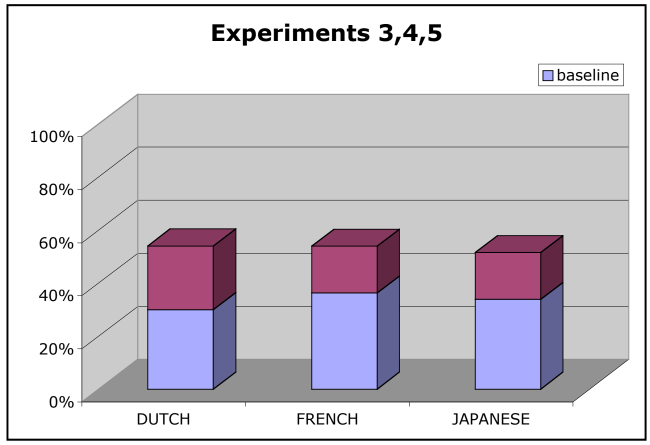

Figure 3. Overall percent correct classification of Nouns, Verbs, and Other using word-edge information in Dutch, French, and Japanese.

General Discussion

In language acquisition a hypothesis is gaining ground that children may exploit various sources of low-level information available in the raw input to start bootstrapping important structural linguistic relations such as discovering lexical categories. Because most sources of information are probabilistic, it is further hypothesized that the child must integrate them together using simple learning mechanisms. Although the potential importance of word beginnings and endings was suggested in the literature (Maratsos & Chalkley, 1980) no empirical study has assessed their usefulness in learning syntactic categories, and we decided to make a quantitative estimate based on corpora of child-directed speech of English, French, Dutch, and Japanese.

In this paper, we also made the theoretical suggestion that for computational models of language acquisition to be theoretically viable they should be psychologically plausible. We have proposed two benchmarks for psychological plausibility. Firstly, the model should be as computationally simple as possible in order to mimick the limited resources available to infants and young children. As a first step toward computational simplicity we have used discriminant analyses, which can be approximated by simple learning devices such as two-layer "perceptron" neural networks. In other simulations (not reported here for reason of space) that we carried out with simple feed-forward neural networks using the same word and ending cues, we obtained similar classification results to those presented here.

The second benchmark for psychological plausibility is that minimal assumptions should be made about the linguistic knowledge and the processing capacity of infants. As a first step, we considered that the bootstrapping problem may be solved not by developing an immediate fine-grained category distinction but rather start with distinguishing those categories that children learn first, namely nouns and verbs. For this reason our analyses involved a coarse distinction between nouns, verbs, and other words where 'other' was a category on its own that would be split into finer-grained categories such as adjectives, determiners, etc. at a later stage. As a second step towards minimal assumptions, after assessing the usefulness of linguistically-defined morphological affixes in Experiment 1, we tested whether the same good categorization results would obtain by a naïve learner that simply focused on the first and last phoneme of a word. This assumption is psychologically plausible because by their second year of life infants develop a striking sensitivity to the sound patterns of their language and also a sensitivity to word endings (Slobin, 1973).

As a 'unit of perception' we chose to focus on the single phoneme, again respecting minimal assumptions about processing capacities of children (the processing window may be limited to one phoneme in very early stages, or other cognitive restrictions may apply). There is also evidence that speakers of "stress-timed" languages such as English and Dutch show greater access to the phoneme (e.g. Cutler, Mehler, Norris, & Segui, 1986). It may be that children are sensitive to other word beginning and ending units larger than the phoneme. For instance, speakers of "syllable-timed" languages (e.g., French, Italian, Spanish, Catalan, & Portuguese) show a processing advantage for the syllable (e.g. Sebastián-Gallés, Dupoux, Segui, & Mehler, 1992), and Japanese adults use the mora as the primary unit of segmentation (Otake, Hatano, Cutler, & Mehler, 1993). In additional analyses not reported here, we obtained good classification results with our model when the first and last syllables were entered as predictors in French and the first and last morae were entered as predictors in Japanese.

In conclusion, our results suggest that simple computational principles can be quite powerful even in isolation. However, a complete account of language acquisition is likely to require a combination of many simple computational principles for the detection and integration of multiple sources of probabilistic information.

Acknowledgments

This research was supported by Human Frontiers Science Program grant RGP0177/2001-B to MHC.

References

Baayen, R.H., Pipenbrock, R. & Gulikers, L. (1995). *The CELEX Lexical Database (CD-ROM)*. Linguistic Data Consortium, University of Pennsylvania, Philadelphia, PA.

Bowerman, M. (1973). Structural relationships in children's utterances: Syntactic or semantic? In T. Moore (Ed.), *Cognitive Development and the Acquisition of Language.* Cambridge, MA: Harvard University Press.

Broeder, P., and Murre, J. (2003). *Models of language acquisition : Inductive and deductive approaches*. Oxford: Oxford University Press.

Canavan, A., & Zipperlen, G. (1996). *CALLHOME Japanese Speech*. Linguistic Data Consortium, University of Pennsylvania.

Cutler, A., Mehler, J., Norris, D., & Segui, J. (1986). The syllable's differing role in the segmentation of French and English. *Journal of Memory and Language*, 25, 385-400.

Gleitman, L., and Wanner, E. (1982). Language acquisition: the state of the art. In Gleitman, L. and E. Wanner. (Eds.) *Language acquisition: The state of the art*. 3-48. New York : Cambridge University Press.

Gupta, P. (in press). Primacy and Recency in Nonword Repetition. *Memory*.

Jusczyk, P.W. (1997). The discovery of spoken language. Cambridge, MA: MIT Press.

Landauer, T. K. and Dumais, S. T. A solution to Plato's problem: The Latent Semantic Analysis theory of acquisition, induction, and representation of knowledge. *Psychological Review*, 1997, 104(2), 211-240.

MacWhinney, B. (2000). *The CHILDES project: Tools for analyzing talk* (3rd ed.). Mahwah, NJ: Lawrence Erlbaum Associates.

Maratsos, M. & Chalkley, M. (1980). The internal language of children's syntax. In K.E. Nelson (Ed.), *Children's language* (Vol. 2). New York: Gardner Press.

Monaghan, P., Chater, N., & Christiansen, M.H. (in press). The differential contribution of phonological and distributional cues in grammatical categorization. *Cognition*.

Murtagh, F. (1992). The multilayer perceptron for discriminant analysis: two examples. In M. Schader (ed.), *Analyzing and Modeling Data and Knowledge*, Springer-Verlag, 305-314, 1992.

New, B., Pallier, C., Ferrand, L., & Matos, R. (2001). Une base de données lexicales du français contemporain sur internet: LEXIQUE. *L'Année Psychologique*, 101, 447-462.

Otake, T., Hatano, G., Cutler, A., & Mehler, J. (1993). Mora or syllable? Speech segmentation in Japanese. *Journal of Memory and Language*, 32, 258-278.

Pallier, C., Christophe, A., & Mehler, J. (1997). Language-specific listening. *Trends in Cognitive Science*, 1(4), 129-132.

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

Redington, M., Chater, N. & Finch, S. (1998). Distributional information: A powerful cue for acquiring syntactic categories. *Cognitive Science*, 22, 425-469.

Santelmann, L., Jusczyk, P., & Huber, M.(2003). Infants Attention to Affixes. In D. Houston, A Seidl, G.Hollich, E. Johnson, & A. Jusczyk (Eds.) *Jusczyk Lab Final Report*.

Sebastián-Gallés, N., Dupoux, E., Segui, J., & Mehler, J. (1992). Contrasting syllabic effects in Catalan and Spanish. *Journal of Memory and Language*, 31, 18-32.

Slobin, D.I. (1973). Cognitive prerequisites for the development of grammar. In C.A. Ferguson & D.I. Slobin (Eds.), *Studies of child language development*. New York: Holt, Reinhart & Winston.