Living on the Edge

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# Living on the Edge

## 28 Papers in Honour of Jonathan Kaye

*edited by*
Stefan Ploch

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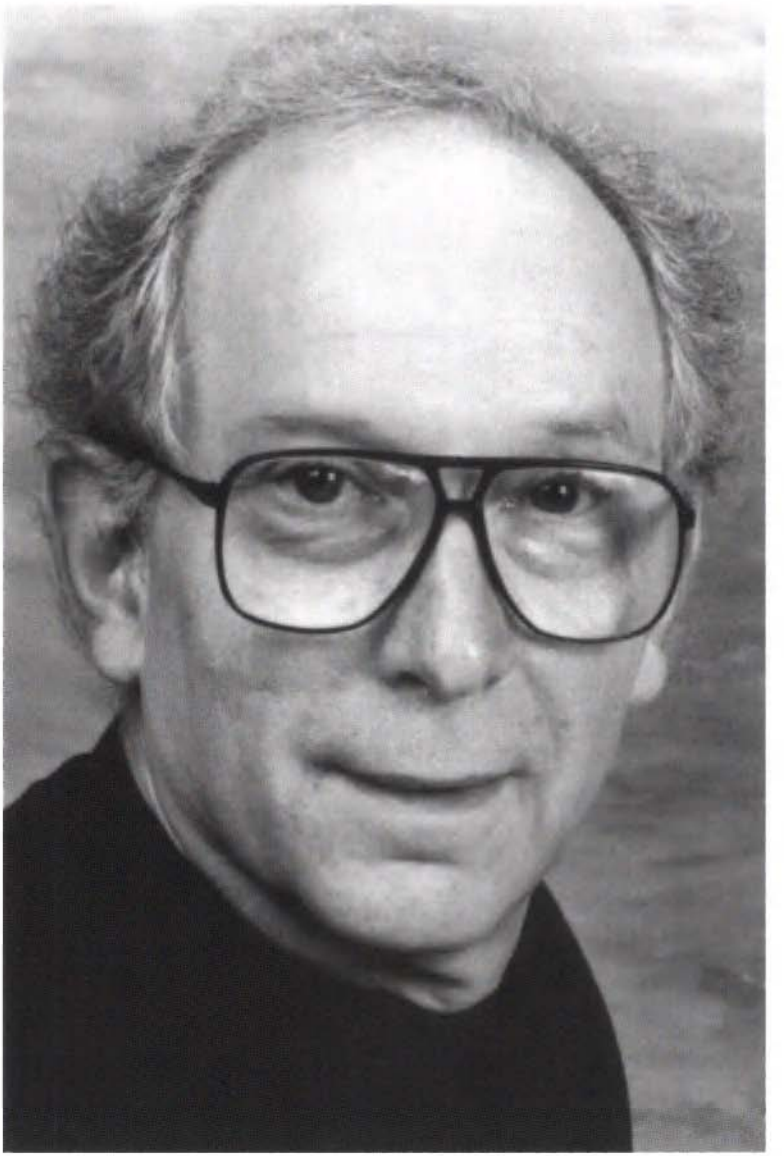

*Jonathan Kaye*
(Picture courtesy Bernard Howard)

# Preface

It took almost five years, I wrote about 250 pages in editorial comments, at least 20 letters and 400 emails, I typeset about 750 pages and collected 50 pages of terms and names for the index. Along the way, there were several people who helped me and who I would therefore like to mention here.

This project was originally conceived in the Postgraduate Common Room of the School of Oriental and African Studies, some time in 1998. The people present were Monik Charette, Margaret Cobb, Sean Jensen, and myself. To all three, I would like to express my gratitude.

After a little while, it became clear that the editors of this Festschrift would be Monik Charette and myself; Monik was involved in writing the original call for papers and in many dealings with potential publishers. For personal reasons, Monik decided in 1999 to withdraw from her editorial role (while remaining one of the contributors) but continued to be an important source of information about Jonathan Kaye and about people who could be of help to me. For all of these reasons, Monik deserves special mention and an extra portion of gratitude.

From 1999 to 2000, Geoff Williams assisted me in proof-reading some of the manuscripts and in composing a number of emails and letters to potential publishers, for which I would like to thank him.

In addition to contributing to this Festschrift, Elan Dresher, Edmund Gussmann, Michael Kenstowicz, Yves-Charles Morin and Glyne Piggott provided information about Jonathan and useful comments about various aspects of typesetting and of orthographical matters. Thank you.

Many thanks also to Elan Dresher, Sean Jensen, and Yves-Charles Morin for offering their personal experiences with Jonathan Kaye (cf. "Testimonials").

Even though it was not necessary in the end, I would like to thank Friedrich Neubarth for his offer to write a perl script for the index.

Another person I wish to mention is Ursula Kleinhenz from Mouton de Gruyter, who showed a great deal of patience and care for this project.

Then, Harry van der Hulst and Nancy Ritter deserve my gratitude for helping me with the arrangement of the articles; Harry was also very supportive as one of the editors of this series (Studies in Generative Grammar).

Of course, I would like to say thank you to all contributors.

Last but not least, I want to express my deep gratitude to John Rennison: he showed me the ropes of typesetting and editing, he explained some of the finer details of Word to me, he helped with the preparation of the summaries of each paper and of the index. He generously assisted me in assembling the entire volume.

Stefan Ploch
Johannesburg, 25 July, 2003

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## 2 Elements: segmental structure and processes



## 3 Structure

### *3.1. Branching onsets*

# Jonathan D. Kaye: Curriculum vitae

Jonathan received his PhD from Columbia University under the supervision of Professor Weinreich. His thesis was on the South American language Desano ("The Desano verb: problems in semantics, syntax and phonology") and was completed after a year of fieldwork in Amazonia.

In 1967 he was offered his first position at the University of Toronto. In 1974 he spent a sabbatical year at McGill University and then joined the Université du Québec à Montréal (UQAM) in 1975. At the University of Toronto he directed the Odawa Language Project, a research project on Eastern Ojibwa. When he joined UQAM he continued to work on Ojibwa, and from 1977 until 1981 he co-directed, with Glyne Piggott, his first PhD student, a research project on Algonquin, the variety of Ojibwa spoken in the province of Quebec. In 1978, he was also invited to give a class at the Linguistics Institute of the University of Illinois.

His interest then shifted to West African languages. From 1981 and until he left Canada in 1988 he had a number of major research grants funded by Canada to work on West African languages. He funded and directed the Projet de recherche en linguistique africaniste. In the mid 1980s Jean Lowenstamm joined him at UQAM and co-directed the project with him. Among the research assistants who have worked in the project are Dominic Sportiche, Hilda Koopman, Isabelle Haik and Laurie Tuller.

He left Montreal and went to the School of Oriental and African Studies (SOAS, University of London) in 1988 to take Firth's Chair.

He left SOAS for China in 1999 to take up a position at the Guangdong University of Foreign Studies. He left China in 2001 to live and work in Spain.

# Jonathan D. Kaye: Testimonials

It is common that the editor of a Festschrift provide some background on the person to be honoured. I have decided, however, to let a number of contributors recount their own experiences with Jonathan Kaye. For me personally, he was the most significant influence on my thinking as a linguist.

## B. Elan Dresher

*Jonathan Kaye as a researcher*

I have known Jonathan Kaye since the early 1970's, when I was studying at McGill University and he was teaching at the University of Toronto. Since then, I have attended many lectures of his in seminars and conferences, I have read and studied his work on a variety of topics, and I have collaborated with him on a project to develop a learning algorithm for the acquisition of stress systems.

In my opinion, Jonathan Kaye is one of the most talented phonologists in the world. His own work is a rare blend of original field work and original theorising. He is thus an uncommonly valuable resource, someone who can give guidance in both the theoretical and practical aspects of research. He has published prolifically on a variety of topics in phonological theory, often bringing original field work to bear on current theoretical issues. He has worked on a wide range of topics in phonological theory, including segmental phonology, syllable theory, stress, and more general considerations such as learnability, abstractness and recoverability. He is also one of the founders of the theory of Government Phonology, a theory which has become widely known and which has been quite influential. He has worked closely on an unusually long list of languages, including native languages of South and North America (Desano and Ojibwa, to name just two), of the Ivory Coast (Vata and others), on Slavic (notably Polish), Semitic (various dialects of Arabic and Ethiopian lan-

guages), Berber, French (Quebec and European), and others. He has also done pioneering and innovative work in computational phonology.

Beyond his own publications and research, Jonathan Kaye has had an important and unique impact on Canadian linguistics through the research projects he founded and headed, and the many students he trained in this country. When he first came to Canada generative grammar was still not very well established in Canada. Jonathan was a passionate and articulate advocate for this approach to linguistics, and did much to further understanding of the theory in Canada. Virtually every senior Canadian trained phonologist now active studied with him, and had him as an advisor. At the University of Toronto, Dr. Kaye headed the Odawa Language Project, which produced linguists such as Glyne Piggott (McGill), Pat Shaw (University of British Columbia), and Keren Rice (Toronto), all of whom remain in the forefront of research on native languages of Canada. Later, at the Université du Québec à Montréal (UQAM), Kaye founded the African Language Project, which included large-scale studies of the Kru languages of the Ivory Coast, and then the languages of Ethiopia and North Africa. This project, which is still running, attracted many good students and research fellows, including Jean Lowenstamm (Paris), Carole Paradis (Laval), Jean-François Prunet (formerly UQAM), Monik Charette (SOAS), and Emmanuel Nikiema (Toronto), to name but a few. At SOAS, he again created an important program, this time with a focus on Government Phonology, and branched into work on phonetics and speech recognition. As is evident from the above, Jonathan Kaye is unusually good at developing interesting research projects and inspiring and guiding students.

Then, he is one of the best speakers and lecturers I have ever seen. He would lecture without notes, even at conferences where talks had to fit into a certain amount of time — 20 minutes, 30 minutes — and he always fit the talk exactly to the time. I on the other hand always read talks — I had to have it all written out. When we gave joint talks on our work, I had to have a text, but Jonathan couldn't work from a written text. Even if the talk was written, he had to deliver it spontaneously. So we worked out a system — I would start and do

the first half my way, and Jonathan would take over in his style. It worked very well — I certainly would not have wanted to follow him.

Collaborating with Jonathan was a great experience, and the work we did then still forms the basis of my current research. I learned from him not to be satisfied with conventional solutions, but to look deeper for principled explanations.

*Jonathan Kaye, the person*

Jonathan was always a very gregarious person — he really liked and needed to be around people — not any people, but people he could have fun with. I think this trait, and his general philosophy about what people are like, contributed to make him such a great field worker.

I once asked him how he was able to live for a year among the Desano in the Amazon. Their whole culture is so different from anything he knew before, how could he relate to people like that? I thought it is hard enough relating to people in our culture, let alone a completely alien one. Jonathan replied that I was thinking about it wrong. He said that in his view, the real differences are not between cultures, but between types of people, and that you find pretty much the same types everywhere. For example, he said, just like in North America there are certain types of people he doesn't get along with — administrators, various officious types. The same was true with the Desano — the religious leaders didn't like him. He said every time one of them passed by him, he (the Desano) shook his head sadly. "According to him," Jonathan told me, "I was totally useless — I didn't know how to plant prayer sticks, I didn't believe in the right things, I was a total failure as a person in his eyes. It's just the same here with priests and rabbis and other such people. But," he went on, "I got along fine with regular people, just like I do here. These people didn't take the religious stuff too seriously — they liked to have a beer and talk about stuff and have a good time."

In every society you find the people you get along with and stay away from the ones you don't. He genuinely believed in the oneness of humanity in this respect, and lived this philosophy. I think that this

is an important insight in these times in particular, when people are talking about "wars between civilisations." The people Jonathan liked were the ones who were not overly impressed by the constructs of culture, religion, or politics that placed barriers — artificial, in his view — between people. For him, the real clash was not between cultures, but between the custodians of official dogmas and those who, like himself, were guided by their own curiosity and creativity.

Jonathan was very good at meeting people. One summer in the early 1980s, he and Jean Lowenstamm kindly agreed to drive down to Providence, Rhode Island, where I had been living, to help me move my stuff back to Montreal. On the way out of town, we stopped at a deli that I used to eat at. I went there frequently, but never met anyone there. After the meal we all went to the washroom. A man was there washing his hands. For some reason, he mumbled a few words to us, not much — excuse me, or he thanked us for holding the door, or maybe we bumped into him because the room was crowded — I don't remember, I hardly heard him. But from this one brief utterance Jonathan detected an accent and asked him, in Portuguese: "Portuguese?" The man was, and suddenly they were great friends, chatting away in Portuguese. It turned out he was the husband of the Portuguese consul in Providence (a city with a large Portuguese population), and by the time we left the washroom Jonathan had a standing invitation to visit the consulate.

This sort of thing happened all the time. On a flight to Spain we sat next to a guy who ended up inviting us (really Jonathan, who did all the talking) to his villa on the Costa del Sol.

Jonathan's approach was always centered on people. We were together at GLOW in Girona in 1986. Jonathan loved Girona — the people, the language, the restaurants. After a few days he seemed to know everyone, and already had a favorite restaurant, bar, etc., as if he'd lived there for years. After the workshop was over, I wanted to go to Barcelona to see the sights there. Jonathan wanted to stay in Girona. He wondered why I wanted to go to Barcelona. I thought it would be self-evident: Barcelona is a famous city with lots of things to see. I liked Girona too, but didn't think it could compete with Barcelona, if we had one or two days to be somewhere.

Jonathan didn't see it like that at all. "What will you do in Barcelona?" he asked, "wander around and look at buildings? There's buildings everywhere. But you don't know anybody in Barcelona. Here in Girona we know people, we can go to places we know, be with people we know. That's a much better way to spend two days."

Jonathan had a great sense of humour, and one could go on about it at length, but I'll finish with one story. We had a stop-over at Heathrow airport once, about four hours between planes. We were in a restricted waiting area, and you had to go through security to get into it. We each had a satchel, and had to put them on the belt to pass through the X-ray machine. There wasn't much to do there, so we decided to go in to London. We left the area, but after walking a few minutes we calculated that we wouldn't really have time, so we returned to the waiting area. We had to go through security again, so we again put our satchels through the machine. After a few minutes we again got bored and decided to go out to look for food. We walked around but couldn't find anything, so we again returned to the waiting area, and lined up again to go through security. I went first and put my bag through the machine. Jonathan was behind me, and as he put his satchel down on the belt, he said to the security guard, "Those little hamsters must be getting really fried by now." On the other side of security I collected my bag, but Jonathan was not behind me. I looked back and saw him taking everything out of his satchel onto the table for the unamused security guard. "Aw, come on," Jonathan said, as the guard asked him to empty his pockets. After that we decided to stay in the area until it was time to board our flight.

**Sean Jensen**

There are two aspects of Jonathan Kaye's philosophy of science which we should like to highlight here. They do not come across as forcefully in his published work as they do in workshop, classroom and conference hall. These two facets are perhaps what sets Jonathan Kaye's ideas about linguistics apart from most others.

The first *modus operandi* is his insistence, rightly, that *everything* that a theory allows to exist, *must* exist in "the real world". If it seems to be that such predicted things do not exit, that is a serious problem for the theory. A series of lectures for advanced students at the School of Oriental and African Studies (SOAS) in the mid 1990s, and a number of workshops, also at SOAS, spawned a flurry of working papers and research threads investigating the predictive content of Government Phonology, and comparing and contrasting these results with an equally exacting analysis of the predictive content of leading theories from elsewhere (Lexical Phonology and Optimality Theory, principally, as well as the University College of London dialect of Government Phonology).

The second *modus operandi* Jonathan Kaye refers to in lectures as the "Thunderdome", citing the eponymous film as the most important in linguistics. In the Thunderdome, two combatants enter, but only one can come out. For Jonathan Kaye, as for many of us, the only meaningful way to destroy a bad theory is to put it in the Thunderdome with a better theory. One theory predicts X, the other theory predicts not-X; in the Thunderdome, empirical observation provides the "facts" (exactly one of X or not-X). The theory which gets it wrong is obliterated, and the other theory emerges from the Thunderdome, temporarily triumphant, until another, better theory comes along and defeats it in the Thunderdome.

The Thunderdome, thus transported to the world of science, and the insistence on the inescapability of logical consequences of a theory, will be immediately familiar to anyone acquainted with the ideas of Karl Popper (which should, of course, be everyone). Jonathan always professed a polite distance between himself and Popper — perhaps due to the staggering amount of misinformation and almost willful misunderstanding of Popper's work in the vast secondary literature — although his working practice is actually the epitome of Popperian methodology.

**Yves-Charles Morin**

I might be interesting to mention that Jonathan was always very keen in using the local vernacular, wherever he was.

When in Toronto, he practiced "Canadian raising", with the result that he spoke English with a Manhattan accent plus Canadian raising.

In Quebec, he practiced Quebec diphthongisation, with the result that he spoke French with a Manhattan accent plus Canadian raising plus Quebec diphthongisation.

He recently sent me an e-mail from Barcelona, written in Catalan (claiming he no longer knew French — I suppose he no longer knew English, or else he wouldn't have used a language I can only read with a dictionary).

I presume that in Barcelona he speaks Catalan with a Manhattan accent plus Canadian raising plus Quebec diphthongisation!!

I really wonder how it went with his Chinese?

# Jonathan D. Kaye: Publications

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Kaye, J.D., (Translated into Chinese by Ma Qiuwu) "A fresh look at Putonghua onset-rime pairs", Manuscript.

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# Instead of an introduction

Cassimjee and Kisseberth (p. 203) present a basic description and analysis of the tonal system of the Eerati dialect of Emakhuwa (northern Mozambique), positing a number of constraints to account for both the Eerati and other Emakhuwa tone systems.

Charette (p. 465) reanalyses the p-licensing of empty nuclei in French in contexts where they precede a p-licensed pseudo-empty nucleus. She concludes that a proper governor deploys its full governing potential in governing an empty position, but not in governing a pseudo-empty position.

Cobb (p. 223) accounts for the relationship of "height" to "ATR"-harmony in the vowel harmony processes of Yoruba and Natal Portuguese with a modified version of head licensing, combined with the Complexity Constraint.

Cristófaro-Silva (p. 243) analyses the palatalisation of the alveolar stops /t, d/ in various dialects of Brazilian Portuguese as the spreading of the element *I* regulated by constraints on spreading within licensed domains.

Cyran (p. 303) reviews the evidence for the "branching onset" and the "two onset" analysis of polish clusters like [kl, br, tr] and concludes that there is no compelling evidence for the former structure, even though no detailed analysis using the second structure is yet available.

Denwood (p. 543) explores the potential of a four-position template, as previously proposed for Chinese, for the description of Khalkha Mongolian, and concludes that it accounts for the attested consonant clusters.

Dresher (p. 7) argues for a "treasure hunt" model of language acquisition with innate *cues* for the setting of individual parameters within

Universal Grammar and contrasts this with other current acquisition models.

Goh (p. 563) traces the history of the diminutive retroflex suffix [ər] in Beijing Mandarin from an independent word [ər] 'child' or 'smallness' and argues that this suffix is not analytic, but rather still a minimal phonological word in the present-day language.

Guerssel (p. 581) proposes that the failure of ablaut in Classical Arabic verbs containing a guttural as their second or third consonant is not the result of a phonological process, but rather is dictated by the principles of non-concatenative morphology

Gussmann (p. 321) considers the evidence supporting the existence of branching onsets in Modern Icelandic and draws the conclusion that only obstruents followed by /r/ and perhaps /v/ might constitute branching onsets.

Heo (p. 481) discusses two cases in which a domain-final empty nucleus that is expected to be p-licensed in Korean resists being licensed and accounts for them with the necessity or optionality of licensing the preceding consonant.

van der Hulst (p. 75) argues for a distinction between two independent areas of phonology: lexical and postlexical. The former applies to units that are stored or processed in the lexicon (up to the maximal domain that the lexicon provides) and the latter to units constructed in the syntax.

Kenstowicz, Abu-Mansour and Törkenczy (p. 259) review the analysis of voicing in a large number of languages and reanalyse Hungarian voicing with a phonetically motivated revised Laryngeal Licensing Constraint "The feature [voice] is licensed in contexts of salient release."

Kim (p. 497) considers the distributional constraints on consonants before a licensed domain-final empty nucleus in Korean and accounts for them with the limited licensing potential of licensed empty nuclei, which results in "unreleasing".

Lowenstamm (p. 339) analyses *muta cum liquidā* consonant sequences as contour segments and thereby accounts for syllable structure paradoxes in a wide range of languages. He argues that such sequences therefore do not constitutes an argument for branching onsets.

Morin (p. 385) summarises the literature of the various types of French *liaison* and goes on to propose a new solution for one subclass, whereby the prenominal liaison consonants [t, z, n, r] and [g] are "status prefixes" on the following (vowel-initial) noun.

Nikièma (p. 365) argues for word-initial empty-headed syllables, which he terms "defective syllables", to account for both the distribution of /il/ vs. /lo/ variants of the masculine definite article and *radoppiamento* in Italian.

Piggott (p. 401) examines the syllable structure of Selayarese (and other "Prince" languages) and proposes that the coda position (and phonological features found in that position) are licensed by general principles of phonology rather than by a following non-coda position.

Ploch (p. 149) charges a range of current phonological theories with "unscientificness" as a result of the over-application of Occam's razor and non-arbitrariness. He argues that Popper's criterion of testability will both restore the scientific status of phonology and make the two former principles derivable and therefore superfluous.

Rennison and Neubarth (p. 95) present a comprehensive overview of a new CV-type theory of Government Phonology, in which the CV syllable (termed "syll") is the only constituent type, and all governing and licensing relations are established at the syll level.

Rice (p. 427) adduces evidence from Ahtna (Athapaskan) for claiming that there are two distinct types of word-final consonant (codas vs. onsets) and, in one variety, two types of empty nucleus (which respectively license or fail to license marked laryngeal features).

Ritter (p. 29) combines innate principles of Universal Grammar with general cognitive functions in a head/dependent model of language acquisition. This she demonstrates with the order in which syllable structure and prosodic structure are acquired by children.

Rowicka (p. 511) analyses the "trapped" (i.e. interconsonantal) [r] of Polish, claiming that it can function as syllabic in phonotactic patterns, while at the same time being metrically "weightless". In this way she accounts for previously problematic consonant clusters.

Scheer (p. 283) correlates the absence of stops at certain places of articulation with classic spirantisation processes like Grimm's law, and relates both phenomena to the presence or absence of a glottal friction feature in the phonological representations of the consonants concerned.

Vergnaud (p. 599) demonstrates that the correspondence between metrical grids and beats is inherent in the formal definition of the metrical grid. His formal account involves a model of metrical structure which relies upon the notion of "occurrences" of units.

Williams (p. 55) takes up the issue of the class of languages generated by the theory of Government Phonology and shows that the Projection Principle and the Uniformity Principle largely goals of formal restrictiveness and explanatory adequacy at the same time.

Shohei Yoshida (p. 527) describes the range of phonetic variants of the "syllabic nasal" of Japanese and interprets it within Government Phonology as a sequence of an onset and a nucleus with a floating nasal element, thus accounting for both its vocalic and consonantal realisations.

Yuko Yoshida (p. 449) shows how the filling of final nuclei in Japanese borrowings from Chinese with an epenthetic U-element (producing /N/, the so-called "moraic nasal"), in fact echoes a licensing constraint of Ancient Chinese.

# Meno's paradox and the acquisition of grammar*

B. Elan Dresher

> From our point of view as English speakers, a language such as Chinese might seem totally different from our own. In fact, these two languages as well as all other human languages are nearly identical. The differences that seem all important to us are relatively minor. (Jonathan Kaye 1989: 54).

## 1 Plato's problem and Meno's paradox

In Plato's dialogue *The Meno*, Meno doubts that one can investigate what one does not know. Which of the things you do not know, he asks, will you propose as the object of your search? Even if you stumble across it, how will you know it is the thing you did not know? Socrates replies that there is a way out of this paradox: we can investigate what we do not know because, at some level, we already know everything; what we call learning is but recollection. He goes on to demonstrate the truth of this astonishing claim by showing that an ignorant slave boy actually knows the Pythagorean theorem, even though the boy does not know that he knows it, and in fact does not seem to know it until Socrates leads him through a series of questions about it. The implication is that Meno's paradox would indeed make learning impossible, unless we assume that we have knowledge from some source other than experience in this life.

More recently, Noam Chomsky has observed that the problem of how we come to know things remains with us. He has named this *Plato's problem* (Chomsky 1988: 4). In the words of Bertrand Russell (Russell 1948: 5), the problem is this: "How comes it that human beings, whose contacts with the world are brief and personal and limited, are able to know as much as they do know?" As Chomsky has shown over the years, this problem arises sharply in the case of language. For it can be shown that everybody is like Meno's slave boy, in that they know many things about their native language that they

don't know they know; moreover, these are things they were never taught; nor does it appear that they could have had any other experience, in this life, that could suffice to account for their knowledge.

## 2 Some examples of Plato's problem in language

To give a brief example (Chomsky 1975: 30-35): every native speaker of English knows how to form yes/no questions. Given a declarative sentence like (1a), the corresponding question is (1b); similarly, the corresponding question to (2a) is (2b):

(1) a. *The boy is tall.*
b. *Is the boy tall?*

(2) a. *Mary has been swimming.*
b. *Has Mary been swimming?*

It is clear that every speaker of English can do this for any declarative sentence, so this ability is not just a matter of memorising a long list of questions. Rather, every speaker of English must have at some point acquired a general rule for creating such questions. Some aspects of this rule must be based on experience, since not every language forms questions in the same way. We might imagine a child, on the basis of being exposed to simple questions of the sort mentioned earlier, (unconsciously) formulating a rule such as the following: to form a yes/no question, move the first auxiliary verb of the corresponding declarative to the front of the sentence. (This formulation presupposes that the learner has figured out what auxiliary verbs are.)

The rule we have given, though, is not exactly correct. When we consider a more complex example, we see that we do not always move the first auxiliary verb to the front. Consider (3a). Applying our rule, we would move the first auxiliary verb *was* to the front, deriving the incorrect question (3b). This is of course totally ill-formed. What every speaker of English knows is that the correct question in this case is (3c). That is, one has to skip the first auxiliary verb *was*,

which is in a subordinate clause *who was in the room*, and pick out the auxiliary verb of the main clause, which is *is*, and move that to the front. So the rule is that we must move the first auxiliary verb of the main clause to the front, not the first auxiliary verb in the sentence.

(3) a. *The man who was in the room is tall.*
b. **Was the man who in the room is tall?*
c. *Is the man who was in the room tall?*

If children learn this rule by observation, through hypothesis formation or trial and error, we might expect to find a learning sequence such as the following: on the basis of simple sentences, children arrive at the simple rule, "Move the first auxiliary verb to the front." Later on, when they start producing more complex sentences with subordinate clauses, we expect them to make mistakes, where they move the wrong verb to the front. Observations of children, and experiments designed to test how they in fact deal with such cases, reveal, to the contrary, that children never make such mistakes. They make all sorts of other mistakes, but they never try to move a verb from a subordinate clause rather than a main clause (Crain and Nakayama 1987). It follows, then, that children never entertain what appears to be the simplest hypothesis. Rather, they appear to know from the outset that rules of grammar that move elements around are sensitive to clause structure.

Here, then, is an example of Plato's problem, and Chomsky proposes a version of Plato's solution: the knowledge that rules of grammar are sensitive to structure is not gained in this lifetime, but sometime before, and is a part of our genetic inheritance. Supporting this idea is the further observation that the principle of sensitivity to structure appears to be universal, true of every human language.

Such cases are not limited to syntax, but arise in all aspects of language acquisition. Consider how one learns the meaning of words. In *Word and Object* (1960: 29–54), W.V.O. Quine made up a story about field linguists studying a completely unfamiliar language. They observe that a native says *gavagai* when a rabbit runs past, and guess that *gavagai* means 'rabbit'. But Quine observes that there are many

other possibilities. *Gavagai* could be a whole sentence, such as 'Lo, there goes a rabbit!'. And even if the linguists are able to learn enough of the language to determine that *gavagai* is a word, not a sentence, Quine points out that it will still not be certain that *gavagai* means 'rabbit'. For it might mean 'temporal rabbit stages'; or 'all and sundry undetached rabbit parts'; or it might refer to 'that single though discontinuous portion of the spatio-temporal world that consists of rabbits'; or 'rabbithood'; or 'a momentary leporiform image'; and so on. Quine observes that all these possible meanings, and infinitely many more, are very hard to distinguish from each other and from plain 'rabbit', in all kinds of tests and situations — i.e., most things which are true of 'rabbit' are true of 'undetached rabbit parts'. So if we ask a native speaker, "Is this [pointing to something] an example of *gavagai*?" the answer will be "yes" or "no" (or as Quine suggests, *evet* or *yok*) whether *gavagai* means 'rabbit' or some other of the above candidate interpretations.

Now, it is interesting to notice that linguists or travellers do not in actual practice encounter the *gavagai* problem when learning an unknown language; nor do children, since they arrive at the same meanings of words as their parents, siblings, and other members of the same speech community. How can this be? It must be the case that everybody draws similar conclusions about what a word means, and what a likely meaning is. That is, the odds are that *gavagai* means 'rabbit' and not 'a momentary leporiform image'.

As with syntax, children do make many mistakes in the course of learning what words mean. For example, they may overgeneralise or undergeneralise the meanings of words. They might, for example, suppose that the word *dog* applies also to horses and other such animals. But again, the misgeneralisations children actually make are very limited in comparison with the ones it is possible to make. For example, when a dog enters the room and someone says "Dog," no child supposes that *dog* means 'animal viewed from the front', or 'animal that has just entered a room'. Again, it appears that learners are constrained to entertain only a small subset of the conceivable hypotheses.

The *gavagai* problem does arise, however, when we try to decode the meanings of the vocalisations of other species. For example,

Cheney and Seyfarth (1990), after much observation of vervet monkeys, are unable to decide if their leopard call means 'Behold! a leopard!', or 'Run into the trees!', or a range of other possibilities. It is unlikely that the language of vervet monkeys is so much more complex than our own; vervet monkeys do not do well at learning English yes/no questions, for example. But lacking the appropriate built-in constraints, we are at a loss to arrive at the correct answer, which must be obvious to any vervet monkey.

Acquisition of phonology, the sound system of a language, is also not just a question of memorising sounds, but involves learning patterns. Consider how words are stressed in English, for example. English stress, though complex and subject to numerous exceptions and special cases, follows certain patterns that we have come to know at some unconscious level. The reality of these patterns is made manifest when we borrow into the language a word that does not observe them. For example, the Russian word *bábushka* is more usually pronounced by English speakers as *babúshka*. Similarly, the capital of Finland, *Hélsinki*, is frequently pronounced *Helsínki* in English. The shift in stress brings these words into conformity with English stress patterns.

If stress patterns of languages all involved simple generalisations, we could think that it would suffice to learn them from experience. But some extremely complex generalisations are quite common cross-linguistically, whereas myriad others of lesser or comparable complexity that one could imagine do not occur. For example, here is the rule for assigning main stress in Passamaquoddy, an Algonquian language spoken in Maine and New Brunswick (Stowell 1979, based on data from Philip LeSourd):

(4) a. If the penultimate syllable of a word has a full vowel, stress it.
b. Otherwise, if the antepenultimate syllable has a full vowel, stress it.

c. Otherwise (if neither the penult nor antepenult has a full vowel), stress whichever one of these two syllables is separated by an even number of syllables from the last preceding syllable that has a full vowel, or — if there is no full vowel — from the beginning of the word.

This type of stress system is not at all rare; many languages have rules that are similar, with minor variations. As before, we seem led to the conclusion that the learner is constrained to look for particular types of patterns.

The idea that language learners must be benefiting from innate direction of some kind is supported further when we consider under what conditions language learners (here we are talking about small children) must master these complex and subtle linguistic generalisations. Unlike linguists, who can bring to bear on these questions all sorts of evidence, children must learn the rules of their language from exposure to whatever examples come their way, without any explicit discussion of what the rules are, or any systematic ordering of examples. Imagine trying to learn how to play chess by observing other people play, where nobody tells you explicitly what the rules are for moving a knight or for taking a pawn en passant; suppose moreover that some small percentage of moves you observed are actually illegal, but unnoticed, hence unremarked, and that many games are broken off or left incomplete for a variety of reasons, usually unstated; suppose also that grown-ups let you make many illegal moves without correcting you, because you are little and don't know better; and now suppose that the game you are learning is not chess but one that is many times more difficult. How much more difficult? Recall that a few years ago a computer beat the highest ranked chess player in history; but no computer can speak a language in a way that can even be compared to the most inarticulate human speaker, nor are there any prospects of creating such a program in the foreseeable future.

## 3 Parameters in Universal Grammar

The above remarks, then, are intended to persuade you that Plato's problem arises with great force in the acquisition of language: people know things about their language that seem to go beyond their experience. It follows, then, that their knowledge of these things does not come from experience, but from their own minds. Following Chomsky, let us call these innate cognitive principles, whatever they are, *Universal Grammar*. What these principles are is an open question that is still far from solved; but the hypothesis that there is a Universal Grammar is, so far, the only hypothesis that offers any hope of solving Plato's problem in the domain of language.

Assuming that grammar is universal, though, presents us with a new problem, and that is to explain why languages are not all the same. The most striking way in which languages differ, of course, is in how sounds are paired with meaning to form words. A tree is denoted by the word *tree* in English, but by *arbre* in French and by *baum* in German. This is the phenomenon called the *arbitrariness of the sign* by de Saussure; that is, there is no inherent connection between the meaning of a word and its sound. It follows that the words of each language have to be learned by experience. Fortunately, Plato's problem does not arise here: English children have lots of opportunities to observe that the word for tree is *tree*.

Apart from vocabulary, there are other sources of cross-language variation that must be accounted for. For example, in some languages a verb precedes its object, while in others the verb follows its object. In some languages, like Italian, a subject is optional, whereas in others, like English, it is obligatory, even if has no semantic role, such as in the sentence *It's raining*. In Passamaquoddy, the rules of stress assignment distinguish between full vowels and reduced vowels; in other languages, similar distinctions are drawn between long vowels and short vowels, or between open syllables and closed syllables. These cross-language differences have the flavour of being variations on a theme. To account for such variation, Chomsky (1981b) has proposed that the principles of Universal Grammar are not rigidly fixed, but allow for parametric variation. These parameters are like open variables in a formula, whose value is to be set on the basis of

experience. The possible values of a parameter are limited and given in advance, like choices on a menu that allows very limited substitutions. On this view, then, language acquisition is reduced to setting parameters to their appropriate values.

## 4 Parameter setting

Parameter setting is a much more manageable learning problem than open-ended induction, or hypothesis formation and testing. Most research into Universal Grammar has quite appropriately concentrated on trying to figure out what the principles and parameters are. There is not much we can say about the learning problem until we know what it is that has to be learned. Nevertheless, a small subfield devoted to parameter setting has arisen in the last fifteen years which has begun to consider different models of how learners might go about setting parameters. The problem has turned out to be deceptively difficult, much more than one might have thought.

On the face of it, parameter setting would appear to be a simple matter. Suppose there is a principle of Universal Grammar that says that in each language the subject of a sentence may either precede or follow the verb — the learner must decide which it is. In English, the subject precedes the verb, as in the sentence *John kicked the ball.* So one might think that a learner just has to hear a few simple sentences like this to know how to set this parameter. But it's not that simple. The parameter fixes what we could call the canonical, or basic, word order of a sentence; however, in many languages the basic order can be disturbed by other rules that move elements around. English has constructions in which the subject follows the verb, as in *Hello, said Peter to his friend.* Further, in order to set the parameter correctly, we have to know what the subject and object in any given sentence are, but it is not obvious that a learner always knows this. In an imperative sentence like *Watch yourself!* there is no overt subject; from the meaning, a language learner might mistakenly conclude that the subject is *yourself,* which follows the verb.

Cases of this kind occur in other languages. In French, for example, the object follows the verb, as in *Paul voit la table.* But when the

object is a pronoun, it appears before the verb: *Paul la voit.* The explanation for this, as we understand it, lies in the fact that French pronouns are clitics, and clitics have special positions that are not the canonical ones. However, a learner might not know that, and be misled by this example.

In Dutch and German, it can be shown that the verb follows its object in the basic word order. However, this basic order can be observed mainly in subordinate clauses. In main clauses, the basic order is disturbed by a principle that requires the verb to occur in second position in the sentence.

Jonathan Kaye and I worked on a computational model for learning how to assign stress to words. We found that the relation between a parameter and what it does is rather indirect, due to the fact that there are many parameters, and they interact in complex ways. For example, in English main stress is tied to the right edge of the word. But that doesn't mean that stress is always on the last syllable, as in *chandelíer.* It could be on the penultimate syllable, as in *Manitóba,* or even on the first syllable, as in *Cánada.* How can *Cánada* be an example of stress on the right? In English, stress is assigned not to individual syllables, but to groupings of syllables called *feet.* An English foot is a *trochee,* consisting of a stressed syllable followed by an optional unstressed syllable. Other languages have other kinds of feet, depending on how the foot parameter is set. But then why are words like *Cánada* and *álgebra* stressed on the third to last syllable and not on the second to last? That is due to another parameter to the effect that the last syllable may be ignored in assigning stress. Why, then, are some words stressed on the second to last syllable, like *aróma* and *agénda*? That is due to their different syllable structures. In English, syllables with long vowels or closed by a consonant are considered to be *heavy,* like full vowels in Passamaquoddy, and heavy syllables tend to attract stress. A heavy syllable can be a foot by itself. Thus, words that have a heavy penultimate syllable have stress on that syllable, as in *aróma, Helsínki, babúshka*; words with a light penult have stress on the antepenult, as in *Cánada, álgebra.*

The point of all this is that the stress patterns of any language are the result of a number of interacting parameters. This interaction

makes the relationship between a parameter and its effects non-transparent. Some surprising consequences follow from this fact.

The first one is that learners who have some incorrectly set parameters might know that something is wrong, but might not know which parameter is the source of the problem. Suppose, for example, that a learner of English mistakenly thinks that objects must precede the verb. The learner observes the sentence *John kicked the ball.* According to the learner's developing grammar, that should have been *John the ball kicked.* So the learner realises that something is wrong with the grammar: one or more parameters are set to the wrong values. But which ones? It could be the parameter that says whether the object should precede or follow the verb. But it could be something else entirely. Maybe English is like Dutch in requiring the verb to move to second position. Maybe that's the parameter that has to be adjusted, and not the word order parameter. This is known as the *credit problem*: a learner cannot reliably assign credit or blame to individual parameters when something is wrong.

There is a second way in which parameters can pose problems to a learner, somewhat reminiscent of Meno's paradox. When we talk about specific parameters, we presumably know exactly what they do, and we assume that learners ought to know what they do, also. But it is not obvious that this is the case, and indeed, it looks quite certain that this cannot always be the case. For some parameters are stated in terms of abstract entities and theory-internal concepts which the learner may not initially be able to identify. For example, the theory of stress is couched in terms of concepts such as heavy syllables, heads, feet, and so on. In syntax, various parameters have been posited that refer specifically to anaphors, or to functional projections of various types. These entities do not come labelled as such in the input, but must themselves be constructed by the learner. So, to echo Meno, how can learners determine if main stress falls on the first or last foot if they don't know what a foot is, or how to identify one? How can learners set parameters that control where anaphors can appear when they don't know which parts of the data represent anaphors? And if they happen to stumble across an anaphor, how will they know that that's what it is? This can be called the *epistemological problem.*

## 5 Some parameter setting learning models

To summarise, to get out of Meno's paradox and to solve Plato's problem, we posited a theory of Universal Grammar with a set of open parameters. By doing so, we limit the role of experience to parameter setting. But now we have found that the same problems arise even in this limited domain. How do we solve them? Different learning algorithms have taken radically different tacks in trying to deal with the credit problem and the epistemological problem.

### *5.1. A cue-based learner (Dresher and Kaye 1990)*

Our proposal is to put even more into the mind: not only the principles and parameters of Universal Grammar are innate, but learners must be born with some kind of a road map that guides them in setting the parameters. Some ingredients of this road map are as follows.

First, Universal Grammar associates every parameter with a *cue*, something in the data that signals the learner how that parameter is to be set. The cue might be a pattern that the learner must look for, or simply the presence of some element in a particular context.

Second, parameter setting proceeds in a (partial) order set by Universal Grammar: this ordering specifies a learning path (Lightfoot 1989). The setting of a parameter later on the learning path depends on the results of earlier ones.

Hence, cues can become increasingly abstract and grammar internal the further along the learning path they are. For example, in learning stress patterns, we suppose that children are able to recognise relative stress levels, and can tell if words with different types of syllables have the same stress patterns or different patterns. Such a developmental stage may have representations as in Figure 1. In these simple representations of English stress contours, each syllable is represented by *S*, and the height of the column of *x*'s indicates the relative perceived stress level of each syllable.

| a. *América* | b. *Mànitóba* | c. *agénda* | |
|---|---|---|---|
| x | x | x | Line 2 |
| x | x x | x | Line 1 |
| x x x x | x x x x | x x x | Line 0 |
| S S S S | S S S S | S S S | Syllables |
| A me ri ca | Ma ni to: ba | a gen da | |

Figure 1. Representations of English stress contours before setting metrical parameters

As learners acquire more of the system, their representations become more sophisticated, and they are able to build on what they have already learned to set more parameters, eventually acquiring the representations in Figure 2.

| a. *América* | b. *Mànitóba* | c. *agénda* | |
|---|---|---|---|
| x | x | x | Line 2 |
| (x) | (x x) | (x) | Line 1 |
| x (x x) <x> | (x x) (x) <x> | x (x) <x> | Line 0 |
| L L L L | L L H L | L H L | Syllables |
| A me ri ca | Ma ni to: ba | a gen da | |

Figure 2. Acquired representations

In these representations, the undifferentiated *S* has been replaced by *L*, which indicates a light syllable, and *H*, which stands for a heavy syllable. Scanning from right to left, syllables have been grouped into binary left-headed (trochaic) feet, and final syllables are marked as extrametrical (<x>).

As an example, consider (a), the word *America*. The learner has found that the word consists of four light syllables. On line 0, metrical structure is constructed as follows: start at the right end of the word, and skip the last syllable. Then group the preceding two syllables into a foot. Since there is only one light syllable left over, it does not get put into a foot. In (b), *Manitoba*, we skip the last syllable. Since the second to last syllable is heavy, we do not group it with the preceding syllable but it makes a foot by itself. The two light syllables of *Mani* are grouped into a second foot.

An *x* on line 1 indicates a stress, which is the head of a foot. Since English feet have their heads on the left, in (a) the *x* goes on the second syllable. In (b) there are two feet, (Ma ni) and (to:), and they are grouped together on line 1. Which foot is stronger? In English, main stress goes on the rightmost foot, so on line 2 we put an *x* over the third syllable in *Manitoba* — this is the main stress in the word.

In the learning model proposed by Dresher and Kaye (1990), the representations of Figure 1 are transformed gradually into those of Figure 2, as learners set the metrical parameters that generate these representations. In this learning algorithm, called YOUPIE and modelled on a computer in PROLOG, the learner puts these representations together in the order given in (5). In (6) I list what each parameter is, and what cues the learner looks for to set these parameters.

(5) Order in which parameters must be set

| | |
|---|---|
| 1. Syllable Quantity: | Establishes whether feet are quantity insensitive (default, henceforth "QI") or quantity sensitive ("QS") (and type of QS). |
| 2. Extrametricality: | Establishes edge of domain; can only exclude it at this point. |
| 3. Foot size: | If QI, only bounded feet available; if QS, unbounded is default. |
| 4. Main stress: | Depends on correct settings of all the above. |
| 5a. Headedness: | Sometimes depends on having set main stress. |
| 5b. Directionality: | Cannot be determined apart from headedness. |
| 6. Destressing: | Determined by comparing stresses predicted by above parameter settings with actual stresses. |

(6) Parameters and cues

1. Syllable Quantity
   a. Parameter: The language {does not/does} distinguish between light and heavy syllables (a heavy syllable may not be a dependent in a foot).
   b. Cue: Words of *n* syllables, conflicting stress contours, indicates QS.
2. Extrametricality
   a. Parameters: A syllable on the {right/left} {is not/is} extrametrical.
   b. Cue: Stress on a peripheral syllable rules out extrametricality on that side.
3. Bounded constituent construction
   a. Parameter: Line 0 constituents are bounded.
   b. Cue: The presence of a stressed non-edge *L* indicates bounded constituents.
4. Main stress
   a. Parameter: Project the {left/right}-most element of the line 1 constituent.
   b. Cue: Scan a constituent-sized window at the edge of a word. Main stress should consistently appear in either the left or right window.
5. Headedness and directionality of feet
   a. Parameters: {Left/right}-headed feet are constructed from the {left/right}.
   b. Cue: Scanning from the {left/right}, a light syllable {following/preceding} any other syllable must be unstressed.
   c. Example: Scanning from the left, if for all (*X L*), *L* is unstressed, then direction = Left, Headedness = Left. If for all (*L X*) *L* is unstressed, then headedness = Right.

6. Destressing (conflates a number of separate parameters)
   a. Parameters: {Various types of} feet are destressed in {various situations}.
   b. Main Cue: The absence of stress on a foot.
   c. Example: The lack of stress on the first syllable of *agénda*, with intermediate acquired foot structure (à)(gén)<da>, shows that this foot is destressed (further cues reveal the conditions under which this occurs).

Space does not allow us to go through all of these parameters and cues in detail, but we can look at at the first one to get some sense of how this works.

The first parameter the learner tries to set is syllable quantity: does the language treat all syllables the same with respect to stress, or is there a distinction between heavy and light syllables? If all syllables are equal, then we say that the stress system is *quantity insensitive*, or QI. If the quantity or weight of a syllable is important, then the stress system is *quantity sensitive*, or QS.

How can a learner set this parameter? Even if you don't know anything about the stress system, you can still keep track of how many syllables words have and where stresses fall. In a language in which syllables are all treated equally, then every word of *n* syllables should be stressed in the same way. But if stress is quantity sensitive, then heavy syllables will not be treated the same as light syllables, and words of the same length can have different stress patterns. So we propose that this is the cue for quantity sensitivity: if you find conflicting stress patterns in words of the same length, you have QS; if you do not find this, you stick with QI, which we assume is the default setting. English is QS, because words of the same length are not all stressed the same way, as we have seen.

Once this parameter has been determined, the learner can use information about syllable quantity to set further parameters, and proceeding in this way, can arrive at the final representations in Figure 2. See Dresher and Kaye 1990 and Dresher 1999 for a detailed description of the cues and parameters assumed here, as well as the order in which they are set.

This approach has something of a Piagetian flavour, with later stages depending on and building on what was acquired in earlier stages; but whereas Piaget supposed that later stages are literally invented out of earlier ones, without being innately specified — a position that creates a seemingly intractable mystery (see Piattelli-Palmarini 1980) — in the view sketched here the whole sequence is innately specified .

If this approach is correct, there is no parameter-independent learning algorithm.

### *5.2. The Triggering Learning Algorithm (Gibson and Wexler 1994)*

A different approach is taken by Gibson and Wexler (1994: 409–410), who characterise what they call the Triggering Learning Algorithm (TLA) as follows:

(7) Triggering Learning Algorithm (Gibson and Wexler 1994)

> "Given an initial set of values for *n* binary-valued parameters, the learner attempts to syntactically analyze an incoming sentence *S*. If *S* can be successfully analyzed, then the learner's hypothesis regarding the target grammar is left unchanged. If, however, the learner cannot analyze *S*, then the learner uniformly selects a parameter *P* (with probability 1/*n* for each parameter), changes the value associated with *P*, and tries to reprocess *S* using the new parameter value. If analysis is now possible, then the parameter value change is adopted. Otherwise, the original parameter value is retained."

We can illustrate how this learning algorithm is supposed to work by looking at the diagram in Figure 3, where each square represents a setting of two syntactic parameters. The first parameter determines whether the head of Spec X′ is initial (value 1) or final (0). In this case, the head is the verb (*V*) and its specifier is the subject (*S*). The second parameter encodes whether the head of a complement is initial or final, here exemplified by the relation between a verb and its object (*O*). These two parameters define a space with four states.

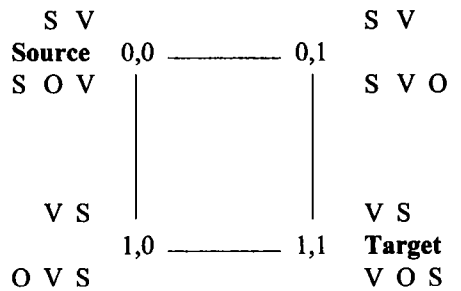



Figure 3. Parameter space (Spec-Head f/i, Comp-Head f/i): final = 0, initial = 1

Assume now that the target language is VOS (1,1), and that the learner's current hypothesis is SOV (0,0). Suppose the learner hears a sentence of the form *V O S*. This sentence is not parsable by the learner, who now determines that the current state is not correct. Even though there is only one setting of parameters that corresponds to *V O S*, it would take a change of both parameters for the learner to reach it. This is not allowed by the Triggering Learning Algorithm, which makes available only the two neighbouring spaces. Neither space yields the target *V O S*. Therefore, the learner cannot move. Thus, the sentence *V O S* is not a *trigger* to a learner at (0,0). Fortunately, in this case there is another type of sentence from the target that the learner will eventually hear, namely *V S*. *V S* is a trigger to a learner at (0,0), since there is a neighbouring space which parses it, namely (1,0). So the learner moves to there. From there, a further presentation of *V O S*, which is a trigger to a learner at (1,0), will take the learner to the target.

A learner following the Triggering Learning Algorithm does not know what any parameter does, it simply tries to match input forms by moving to a parameter space that can parse a given input form. The Triggering Learning Algorithm runs into a number of serious problems:

1. The Triggering Learning Algorithm cannot handle parameters in subset relations.
2. The learner can fall into incorrect grammars from which it cannot escape.

3. Or the learner can thrash around indefinitely, repeatedly revisiting the same incorrect grammars.
4. Learning follows a sequence dictated by accidents of input data; there is no notion of development toward greater complexity.
5. The learner will be unable to match the input perfectly at early stages of acquisition, so the learning process cannot get off the ground.

To see how the Triggering Learning Algorithm would apply to more than three parameters, I generated a set of schematic languages using six metrical parameters. There were thus $2^6$ (64) languages. Each language was assigned four two-syllable words, eight three-syllable words, sixteen four-syllable words, and ten five-syllable words. Thus, each language has 38 words. Four pairs of languages are extensionally equivalent: their surface stress patterns are identical, though their grammars assign different structures. Since a learner would have no evidence to decide which grammar is correct, these languages are excluded as target grammars from the following discussion. An analysis of how the Triggering Learning Algorithm would apply to the remaining 56 languages yields the results in Table 1.

Table 1. 64-state Triggering Learning Algorithm, 6 metrical parameters (56 target states tested)

| Number | | Problem states | | |
|---|---|---|---|---|
| of targets | Safe states | Local maxima | Cul-de-sacs | Dangerous states |
| 2 | 16 | 4 | 8 | 36 |
| 2 | 40 | 13 | 9 | 2 |
| 2 | 42 | 3 | 1 | 18 |
| 2 | 48 | 1 | 11 | 4 |
| 2 | 48 | 1 | 1 | 14 |
| 2 | 48 | 0 | 6 | 10 |
| 2 | 52 | 12 | 0 | 0 |
| 6 | 55 | 9 | 0 | 0 |
| 8 | 55 | 6 | 0 | 3 |
| 2 | 56 | 2 | 0 | 6 |
| 26 | 64 | 0 | 0 | 0 |

In this table, *local maxima* are states (excluding the target itself) from which the learner cannot exit, and *cul-de-sacs* are states that do not connect to the target, though exit is possible to one or more dead-end states. A learner who arrives at any of these states is guaranteed to fail to reach the target. A *dangerous* state is a state that connects to a local maximum or cul-de-sac, as well as to the target. Although a learner in a dangerous state has a chance of reaching the target, success is not guaranteed. In terms of the goal of a learning theory for language, all of these states are *problem* states. *Safe* states are states that do not connect to any problem states; assuming that each triggered transition from a safe state has some probability greater than zero, arrival at the target is guaranteed in the limit. We find that 26 languages have Triggering Learning Algorithms with no problem states, whereas 30 languages have between 8 and 48 problem states. In other words, even though there are no subset relations in the data set, and all languages have the same number of words, nearly one half of the languages cannot be guaranteed to be learnable by the Triggering Learning Algorithm.

### *5.3. A genetic algorithm (Clark and Roberts 1993)*

A different type of learning algorithm was proposed by Robin Clark, and applied in Clark and Roberts (1993) in connection with the loss of V2 in French. On this model, parameter setting proceeds by way of a genetic algorithm that enacts a Darwinian competition of survival of the fittest. A learner simultaneously considers a number of competing hypotheses. Each candidate hypothesis is exposed to input which it attempts to parse. At the end of a round of parsing, the learner assesses how well each candidate did. The candidates are ranked according to their relative fitness. The fittest go on to reproduce candidates in the next generation, the least fit die out. Through successive iterations of this procedure, the candidate set presumably becomes increasingly fit, and converges toward the correct grammar.

There are three main problems with this model:

1. It requires an accurate fitness measure, but none has been proposed.
2. Any such measure requires that the learning space be *smooth*, i.e., that closeness in surface resemblance reflects closeness in parameter space; but this assumption is incorrect.
3. As with the Triggering Learning Algorithm, the developmental sequence is dictated by the input forms encountered.

To get some idea of the problems facing this model, consider Table 2.

Table 2. Effects of parameter settings: Selkup (number and percent correct)

| | Parameters | | Words | | Syllables | | Main stress | |
|---|---|---|---|---|---|---|---|---|
| | of 10 | in % | of 8 | in % | of 20 | in % | of 8 | in % |
| a. | 4 | 40 | 2 | 25 | 7 | 35 | 3 | 37.5 |
| b. | 6 | 60 | 1 | 12.5 | 7 | 35 | 5 | 62.5 |
| c. | 7 | 70 | 4 | 50 | 12 | 60 | 4 | 50 |
| d. | 8 | 80 | 5 | 62.5 | 14 | 70 | 5 | 62.5 |
| e. | 9 | 90 | 5 | 62.5 | 14 | 70 | 5 | 62.5 |
| f. | 9 | 90 | 3 | 37.5 | 10 | 50 | 3 | 37.5 |

I simulated a genetic algorithm attempting to learn ten metrical parameters for Selkup (Halle and Clements 1983: 189). The chart shows a sample of the results. In the first column are listed the number of parameters correct. This gives an indication of how close the grammar is to the target. In the other columns I listed a number of possible surface indicators that one might try to use to show goodness-of-fit: number of words correctly stressed (there were eight words in the test), number of syllables correctly stressed, and number of main stresses on the correct syllable. Though the grammars get progressively closer to the target as we proceed down the columns, no single surface measure reflects a monotonic improvement. This is illustrated most dramatically by grammar (f), which has only one parameter wrong and yet does worse than grammar (c), with three parameters wrong, and not much better than grammars (a) or (b). A more systematic simulation of 64 grammars using six metrical parameters confirms the general unreliability of surface measures as keys to the goodness of the grammar. In other words, closeness in extensional

space (i.e., the surface data) is unreliably correlated with closeness in intensional space (i.e., the grammar).

## Conclusion

Steven Crain (1991) has compared language acquisition to a scavenger hunt: learners are given a list of things to get — a green sock, an old muffler, a banjo — and they run around looking for these things, and collect them as they find them. But if the scenario I have sketched is correct, language acquisition is not a scavenger hunt but a treasure hunt. In a treasure hunt, you have to find a sequence of numbered clues in order, where one clue leads you to the next. Clue #15, for example, might tell you to look for #16 using information you collected at #11 and #14. If you accidentally stumble on this clue before you have reached the earlier ones, it may well be meaningless or misleading to you. Like Meno's slave boy, we gradually construct the solution to the puzzle that is our native language by proceeding systematically, answering a series of questions put by our own inner Socrates.

## Note

* I am very happy to dedicate this article to Jonathan Kaye: I learned so much from him, and had so much fun working with him on the problems discussed here. This research was partially supported by grants from the Social Sciences and Humanities Research Council of Canada. An expanded version of the material in section 5 can be found in Dresher (1999).

# On the logical order of development in acquiring prosodic structure

Nancy A. Ritter

## Introduction

Following the spirit of Kaye, Lowenstamm, and Vergnaud's (1990) seminal work, in which they utilise established syntactic principles of Universal Grammar to address issues in phonology, the purpose of this article is to support this claim and to advocate the idea of a strong parallelism between the syntactic and phonological components by claiming that a single set of innate, universal principles exists which applies to both these components (and perhaps others) of the language faculty.[1] Going further, however, the point of this article is to also demonstrate that, in addition, there are more general cognitive functions of the mind that also play a role in the language faculty. Together, these innate principles and general cognitive functions comprise a cognitive-based, computational system of language. In the latter part of the article, emphasis is put on the construction of this cognitive system and how its construction is realised or naturally embodied in the order of acquisition of syllabic shapes.

In the approach proposed in this article, it is assumed that there is an innate predisposition to human language. With respect to phonology, one aspect of such predisposition could be understood to be the ability to attend to sounds found in natural language and to disregard other bodily noises, such as burps, sneezes, snaps *et alia*, as irrelevant. However, the approach advocated here also assumes that cognitive processes govern the language faculty by imposing a design on the elements (such as sounds) found in each component of language, in terms of an organisational system. This system is based on formal relationships, such as head/dependent, that are found to occur between component elements, and these relationships, in turn, depend

upon cognitive notions, such as salience and dominance. Such systematic organisation is crucial in the design and form of language.

Other components of the brain also rely upon having an organisational system. For example, organisation is a crucial factor in the visual component in that fragmented visual input requires assembly into some coherent whole, which is then categorised. Such cognitive notions of organisation, precedence, dominance, etc., can be claimed to take on specific instantiations in different components of the brain and within the language faculty itself. For example, the notion of locality, in relating and grouping objects in an organised system, is formulated differently in syntax (in terms of adjacency/subjacency) than in phonology, most likely due to the nature of the objects being related. However, the core notion of there being a minimal distance between related objects (whether the relation is movement, spreading, etc.) underlies the innate principle of locality found in both components of the language faculty. If cognitive concepts are claimed to underlie the functions of the different components of the mind, then it is not far-fetched to claim that these concepts reign over Universal Grammar as well, leading to a unified set of innate principles, which, however, may take on different forms or be formulated slightly differently in keeping with the function of the specific domains of each sub-component of Universal Grammar. Therefore, it is proposed in this article that a synthesis of the two notions of predisposition and cognitive processing, is deemed necessary for language.

Following this line of thinking, along with the claim that these cognitive processes are understood in terms of a computational system, this article will explore the clear relationship between a formal system and its various structural layers on the one hand, and the phases usually distinguished in the acquisition of prosodic structure, on the other hand. As acquisition essentially involves a change in behaviour from one system to another, I claim that such changes are motivated by the expansion of the dynamics of the computational system. The progress that a child makes is understood in terms of discrete developments in the way in which the formal system expands. Every structural layer is claimed to correspond to a noticeable development in the production of prosodic syllabic structure. In other words, the child is actively involved in constructing phonological

grammars. The evidence used is documented data taken from children's utterances observed at different stages of their development. The purpose here is to try to understand the developmental stages of syllable structure in terms of a formal model. In evaluating any type of model, one should satisfactorily be able to relate structural layers or structural developments in the model to the observed stages of acquisitional growth.

Lastly, the model presented here relies on, and incorporates, findings from acquisitional research which has been done from three distinct perspectives, namely, cognition, perception, and production. This approach is in contrast to previous models of acquisition which have tended to ascribe acquisition to only one of these areas, e.g., production-based models of acquisition (for a brief overview of the relation of perception to production in theoretical models, cf. Vihman 1996: 46–47).

The article is organised as follows. In section 1, the interaction between the two approaches of predetermination and cognition, as they relate to child language acquisition, is discussed. In section 2, a model in which cognitive principles are claimed to drive fundamental licensing relationships between objects, is set forth. This model, Head-Driven Phonology (van der Hulst and Ritter 1998, 1999a, 2000a,b, in prep.), claims that head/dependent relations, in the form of licensing relations, are the mechanisms that underlie the phonological computational component. In section 3, the logic of the order of acquisition of prosodic structure is addressed in terms of the Head-Driven Phonology framework. Section 4 discusses the effect that the child's recognition of the onset as an independent organisational unit has on the growth of phonological complexity.

## 1 Two approaches to the child language acquisition process

This section focuses on two approaches that try to explain the language acquisition process in children. The first claims that there is an innate component of the brain known as Universal Grammar, which is wired in such a way as to predispose the child to natural human language. The second approach aims more at discovering the learn-

ing processes of children from a more general cognitive capacity. Researchers in this area have taken into account information-processing skills, organisational principles of categorising, and varied learning strategies used by the child, such as paying attention to beginnings or ends of items, boundary markers, stress, etc. In this article, I propose that both approaches are necessary in explaining the acquisition of phonological structure. In fact, this model attempts to incorporate, in a cohesive manner, findings and conclusions of studies focusing on the acquisition process, which have been contributed from the areas of cognition, perception, and production.

The cognitive disposition toward categorising and organising chaotic information is specifically instantiated in the component of the brain that is predisposed to language. Such cognitive methods target and recognise salient information and organise other information, in turn, in relation to the predominantly targeted essential category (similar to Lakoff's 1987 proposal of *center-periphery schemas*). The claim here then is that the child's mind is actively involved in constructing a phonological grammar (*contra* Jakobson 1968 *et alia*, and Stampe 1973 *et alia* who basically maintain that phonological acquisition is predetermined). Moreover, given that the proposed approach appeals to the notion of the child organising chaotic input into some principled orderly schema, I disagree with the claims, advocated by Stampe (1973) and many current-day proponents of Optimality Theory (cf. C. Levelt, Schiller, and W. Levelt 1999/2000), that the basis for production of a word is a stored representation of the accurate adult form of that word. Smith's (1973) findings and conclusions that child language is a result of realisation rules operating upon adult representations assume that the child's perception is complete and accurate from birth.

As later researchers have pointed out, this approach, however, is unable to readily account for the individual variations in the types of "errors" that children make. Ingram (1974 *et sequentia*) has argued that the concept of having an adult form plus certain phonological processes to yield a child's form is inadequate given real-life evidence (cf. Menn 1978 and Waterson 1981 for different proposals regarding the same issue). He, instead, proposes that "children actively operate on adult forms to establish their own phonological represen-

tations of these words" (Ingram 1986: 233). According to Ingram (1989), the child's phonological representation of a word occurs at a level (the organisational level) which intervenes between the perceived adult representation and the child's phonetic output. This intervening level does not operate on its own as an autonomous system, however. Rather, Ingram, in the spirit of Jakobson, contributes a great deal of importance to the adult form and to the pressure and influence that the adult form asserts in order for the child's representation to conform more closely to the adult form. Thus for Ingram, adult forms seem to be the basis for children establishing and storing their own form or representation of a word in their lexicon. Such approaches seem to suggest that the child is fully cognisant of the adult form in the child's initial state and that the child attempts various ways in which to achieve such forms to yield the final state.

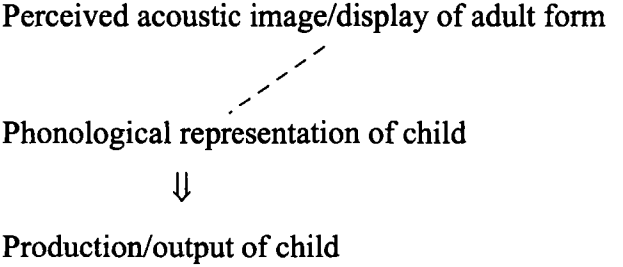
While Ingram's proposal may be a correct assessment for the acquisition of segments and phonological contrasts that take place during the linguistic stage of acquisition, between the ages of 1;6 and 4;0, it is claimed in this article that for the acquisition of prosodic structure, which can be seen to arise at earlier stages such as the prelinguistic (0 to 1;0) or transition stages of acquisition, a different process prevails, which I set forth in the following sections. The acquisition of prosodic categories is to be considered a separate process from the acquisition of segmental contrasts and, in fact, is claimed to be a pre-requisite for the acquisition of phonological contrasts, thus logically preceding the latter.

Despite the fact that much of the literature on child language acquisition has focused on the acquisition of segments (for instance, Jakobson's (1968) work has been to present a model which shows how children build up their phonological inventory through a process of acquiring contrasts in phonemes), others, however, such as Moskowitz (1970, 1973) and Peters (1983) have considered higher prosodic units (such as phrases, words, syllables) to be the primary objects of recognition in children and the more essential building blocks in the acquisition process. Only recently, though, has a thorough investigation been conducted, which focuses solely on the acquisition of syllable structure (cf. Fikkert 1994). I agree with these

latter researchers in their claims about the primacy of prosodic structure in language acquisition.

However, I wish to go a step further in considering prosodic development as the rudimentary construction of the computational system of language. I suggest that in the acquisition of prosodic structure, rather than claiming that the adult forms are the input to a child's establishing a certain structural representation, it is the interaction between Universal Grammar principles and cognitive perceptual and organisational principles that results in the child creating and producing representations of certain structural shapes and types. The child is guided by the cognitive disposition toward categorising and organising chaotic input into some principled orderly schema. Therefore, it is not the adult form itself that directly causes or has impact on the child's representational form but, rather, the building and creation of the child's linguistic computational system that has a direct effect on the output produced by the child. The claim, furthermore, is that specific phonological knowledge linked to the spoken modality is not innate, but, rather, constructed (cf. sign languages). In spoken language, then, the stages of production of prosodic development in some way mirror the construction of the child's computational system of natural language. In other words, the development of CV combinations and complications on this schema are tangible evidence of the way in which the child's phonological computational system is being built and designed. Example (1) illustrates a proposal for the child's lexical representation, which is the basis for his/her production. As emphasised above, the phonological representation of the child is not a stored representation of the accurate adult form.

(1) Lexical representation



In the representation above, the acoustic image of the perceived adult form is claimed to be initially stored as a holistic unit, i.e., a gestalt. (At this point it is unclear to me how much, if any, phonetic detail is stored initially). This stored information is associated with the child's own phonological representation of the adult form; however, this holistic stored unit does not influence the child's phonological representation. It exists separately in the child's short-term memory. Evidence for this claim comes from the observation that a child may, initially, accurately produce the adult form of a word, which would generally be acquired later in the development of the syllabic structure (i.e., when a child first produces a form such as *bus* with the presence of the final [s] consonant), but after a few occurrences, the child reverts to producing the word with a simpler CV structure (such as [bə]). This can be explained by the claim that before the child has constructed his/her own phonological representation for the word in question, the child is able to resort to its memory bank for production. There is no phonological representation of this piece of memory; thus, it is not part of the cognitive understanding of the child (the child's competence) and is predicted to be unstable in its occurrence. However, after the child's own cognitive form or mental representation of the word has been established, the child relies on that input for its production system. In this model, then, the child's phonetic form is not attempting to realise a phonological representation of the adult form since the adult form is not the direct input to the child's production system but is only stored information which becomes loosely associated with the child's phonological representation.

As the child's mind engages in identifying, categorising, organising, and constructing a computational system for language, a child's phonological representation of a word will reflect the acquisition of the discrete development of the way in which the computational system expands itself. A phonological representation is made by the child based on his/her competence of the system at the moment, and this representation leads to the child's output. The child's production and competence are thus very close in this model, as opposed to model's where competence reflects the adult form. As the child's computational system develops, his/her phonological representation will reflect more and more structural complexities, such as the pres-

ence of codas, the absence of onsets, the complexity of codas and onsets.

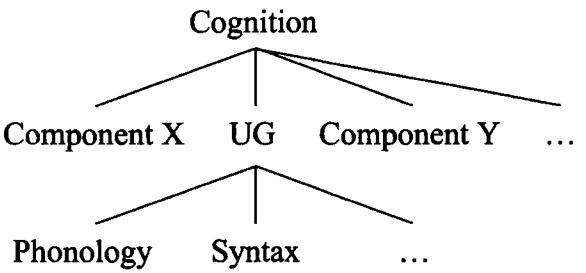
As the child's computational system grows further and matures (and thus the child's competence matures), the child is also then further able to analyse the stored adult form (perhaps in terms of finer phonetic detail). Only at this later stage does the child continue to readjust his/her phonological representation of a word to include more segmental information that closely resembles the adult form. This is the stage at which the adult form curries more impact and influence on the child's phonological representation. The development of the structure of words, then, is claimed here to mirror the piecing-together process of the development of the phonological computational system. This development stems from reliance on innate principles of Universal Grammar and cognitive organisational tasks of the mind, rather than on direct access to the adult form and processes which try to realise that form. The particular sounds of the child's language, however, are acquired (i.e., filled-in) later in a manner which relies more heavily on direct access to the adult form of a word.

Lastly, it should be noted that this model does not give prominence to the notion of the "syllable" as a phonological reality in the prosodic hierarchy in the same way as other phonologists have. Rather, the CV unit is regarded as a syncretised whole in which the components are of unequal status and consonant initiality is regarded as a phonetic dependency on the more salient and prominent vocalic unit that is the target of production. Differing cognitive modes of deliberate conscious processes, and automatic, routine processes (phenic *versus* cryptic, cf. Campbell 1986) are also claimed to play a crucial role in the development of the child's prosodic system leading to consonantal complexities and marked structures.

### *1.1. Cognition reigns over Universal Grammar*

The cognitive disposition toward categorising and organising chaotic information is manifested in specific ways in the component (Universal Grammar) of the brain that is predisposed to language:

(2)




Cognitive abilities target and recognise salient information and organise other information in relation to the predominantly essential category of each component of the mind. What is innate in the child is the ability to recognise the mode or cues in each component that subsume the predominantly essential category of each specific component. With respect to the language component, the concept of "Universal Grammar" has been used to serve two functions. One function of Universal Grammar is to account for the infant's innate ability or predisposition to perceive certain cues or categories from birth (e.g., thematic roles such as Agent). In other words, to recognise the salient aspects which comprise language *per se*. The other function of Universal Grammar entails principles which allow the child competence in a certain grammatical form, for example, that (s)he has never experienced through input. These principles are formulated in terms of language specifics. However, if one abstracts away from the specifics involved in a number of these principles, certain overall, general types of cognitive principles may be seen to underlie many, if not all, of the principles of Universal Grammar. X-bar theory, which could be claimed to be an innate structure in Universal Grammar, can be understood as a basic cognitive method of organising information in terms of head/dependent relations and hierarchical structure, in accordance with the *part-whole* schematic functioning of the mind as proposed by Lakoff (1987). This notion of there being universal cognitive principles that pertain to language plays a crucial role in the acquisition of phonological structure.

In the area of syntax, for example, many linguists claim that the predicate-argument division is a fundamental relationship that children utilise as an analytic necessity (Braine 1976) or a useful tool (Maratsos and Chalkley 1980) in the acquisition of syntactic struc-

tures. The concept of bootstrapping semantic/cognitive categories onto their syntactic realisations, implies that fundamental, or innate, cognitive notions are mapped onto certain corresponding structures (albeit, by means of affixation, structural position, etc.). In the predicate-argument case, essentially, the predicate acts as a head of a syntactic structure and the argument as its dependent. This hypothesis that children can identify and make use of the notion of a predicate in syntactic acquisition has a correlate in phonological acquisition. In phonology, this notion of there being a head/dependent relationship exists as well with the vocalic unit or nucleus being the head or core and the consonantal onset its dependent.[2]

When one abstracts away from the specific domain-related objects and instead focuses on the roles that these objects play, it appears evident that the cognitive notion of an asymmetrical head/dependent relation exists at the core of universal grammar. This concept can be formulated as a unique principle of Universal Grammar, namely the principle of head/dependency. Secondly, the structure of this relation is such that the components of the relation combine in a binary fashion. Thus there is a principle of binarity that is also claimed to be an innate principle of Universal Grammar. In a model developed by van der Hulst and Ritter (1998) called Head-Driven Phonology, which expands and elaborates upon insights of Government Phonology and Dependency Phonology, it is these two principles which have been isolated as the core principles of Universal Grammar. The combination of these two principles operating in conjunction with one another is claimed in this theory to underlie the mechanisms used in providing an explanatory computational system of phonological occurrences.

## 2 Theoretical assumptions of the model

In the Head-Driven Phonology model, these two principles, set forth in (3) below, are realised in terms of licensing relations which ensure that each and every object that is phonologically relevant is licensed. These licensing relations then are to be considered the constructs for the phonological computational system.

(3) Core principles of universal grammar
   1. *Head/Dependency Principle* — the notion of saliency is translated into the notion of a head (the dominant object or focal point).
   2. *Binarity Principle* — organises these heads and the material around them in a binary grouping fashion.

The licensing relations, which are in some sense the mechanisms behind the computational system, come in three varieties as outlined in (4) below:

(4) Licensing relations
   1. *Structural licensing* — creates hierarchical prosodic structure.
   2. *Paradigmatic licensing* — determines the segmental selection as a result of the possibility of contrasts allowed in a certain position (based on the position's status as a head or dependent within the structure); this leads to the notions that:
      a. heads are the site of maximal contrast, and,
      b. dependents are the site of neutralisation and absence of contrast (with the greatest lack of contrast being "emptiness" or a phonetically null phonological segment).
   3. *Syntagmatic-content licensing* — the content of a position as head has some bearing on the content of its adjacent dependent position (e.g., in assimilation/dissimilation cases and head-to-head relationships such as harmony).

These last two relational mechanisms, i.e., (4-2) and (4-3), pertain to licensing the content within structural positions rather than the structural positions themselves.

As each of these types of relations is built and subsequently becomes an automatic process, the phonological system is slowly created. A discussion of the logic of development of the acquisition of prosodic structure, couched in terms of the Head-Driven Phonology framework mentioned above, is given below in section 3.

## 3 The logic behind the acquisition of prosodic structure

### *3.1. Vocalic saliency*

As mentioned in section 2, two crucial cognitive concepts, namely "recognition of saliency" and categorisation, are manifested in Universal Grammar in the form of two principles: Head/Dependency and Binarity. In the first, the notion of saliency is translated into the notion of a head. The second principle subscribes to organising these heads and the material around them in a binary grouping fashion. With respect to spoken language, given the input of spoken utterances surrounding the child, the child (due to the innate ability to recognise human language sounds *versus* non-language sounds) selectively focuses on the parts of the utterance which are highly salient. This attention to saliency runs along acoustic parameters where infants pay attention to stress, fundamental frequency and pitch.[3] Thus, these more salient features in the signal point to the vowel being the head or core unit. I term this "vocalic saliency".

In a word of more than one syllable, the focus would more likely be on the most salient vowel, i.e., the stressed vowel (cf. Pyé 1980 regarding the importance of stress as a perceptual determinant). Cues such as intensity and duration of stressed vowels can account for this (cf. Waterson 1987 who posits rhythm as a possible acoustic cue of saliency). In some instances, though, an infant's attention to beginnings or ends of words, as well as memory limitations, may be factors in the infant's conscious selection of the head or core vocalic unit. Peters (1983) likens the salience of ends and beginnings of words to remembering initial and final items in a series. Whichever notion of saliency the infant attends to, the infant recognises and thus consciously selects the head of an utterance in this way. In terms of the production correlate at this point, sounds made in the first two pre-linguistic stages (0 to 20 weeks), the second of which (cooing and laughter) is considered a major landmark, are predominantly vocalic (cf. Campbell 1986).

This conscious selection of the head and awareness that this head is vocalic (in terms of aperture and sonority) falls under the paradigmatic licensing relation (4-2) (in terms of the Head-Driven Phonol-

ogy model cited above). Based on the child's recognition of a head, the child associates the vocalic category with this position. Thus, the child becomes aware that vocalic-type elements are contained within the head. It is this licensing relation of a position (i.e., the head) with its content (i.e., vocalic) that is claimed to operate first.

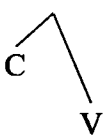
### *3.2. CV stage*

The next stage of acquisition demonstrates the effect of consonant/vowel sequencing. This stage arises from the infant's perception and conscious awareness that a vowel is something preceded by closure and from the infant then adopting a general strategy for production. Evidence seems to point to the fact that infants quickly move to producing consonant/vowel sequences in stage three of vocal play (16 to 30 weeks), in landmark stage four of reduplicated babbling (25 to 50 weeks), and subsequently in the expressive jargon stage of stage five.[4] Irwin and Wong's (1983) investigation of twenty children aged 16 to 18 months showed a vowel/consonant ratio in the children's speech of 49/51 as opposed to a ratio of 39/61 in adults. In fact, from an acoustic perspective, according to Bertoncini and Mehler (1981), the continuous speech signal is analysed by the infant into segments that target peaks in the speech wave. The segmentation generally contains both consonantal and vocalic information; however, the contrastive parts are not claimed by these researchers to be specifically analysed as distinct units by the infant. Rather, the sound chunk that is segmentised is regarded by the infant as a holistic unit in which the temporal organisation of phonetic events is not seen as the exponent of two underlying or discrete units. In other words, this CV unit is a constituent but not in the sense of a unit that has any phonological realisation in the prosodic hierarchy as some have claimed that the syllable might. In a similar spirit, Peters (1983) considers that the syllable is initially unanalysed and equatable with the word.

Since infants attend to acoustic peaks in the sound wave (indicating attention to vowels and vocalic prominence), there seems to be no awareness that the consonant has a prominent role at this point.

Rather, it seems that the consonant serves as a type of boundary marker where the infant becomes aware of the internal phonetic dynamic of "closure" as signalling the onset of the more prominent vocalic aperture. This awareness paves the way for the later cognitive/phonological notions of "onset" and "nucleus". Such a distinction in boundary/prominence also leads to the assumption that the ordering of these two units (C/V) is phonetically predictable and non-contrastive. Since infants recognise that stricture always precedes a vowel, there is no need for them to encode a sequential order to these two objects. The fact that it is phonetically predictable that consonantal stricture will precede vocalic aperture implies the notion of plane segregation. This logical implication was first mentioned by McCarthy (1989) with respect to the concatenation of consonants and vowels in Semitic languages. The implication here then is that these two objects (C — the manifestation of stricture, and V — the manifestation of aperture) reside on different planes or tiers. This notion is illustrated in (5):

(5)

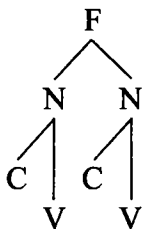



In terms of the Head-Driven Phonology framework and of constructing a computational system, the observation that a head/vocalic unit takes a dependent object that is maximally contrastive (in terms of stricture) with it, reflects a stage in the development of the computational system. This form of a head/dependent relation is a manifestation of the establishment of a second type of licensing relation, a syntagmatic-content licensing relation, in which a head may determine the content of its dependent (4-3)[5]. In this syntagmatic licensing relation, the content of the head, which is vocalic, requires that the content of the object preceding it contain stricture. The strict enforcement of this particular licensing relation explains the possibility of having strict CV language types. More relaxed versions of this relationship allow for onsetless syllables.

### *3.3. Reduplication phase — CVCV form*

The next stage in the development of prosodic structure is seen in the reduplicative CVCV form. In effect, this phase in acquisition reflects the binary grouping of vocalic units into feet:

(6)




This CVCV stage of acquisition is evidence of the infant subsuming the third type of head/dependent licensing relation discussed above in (4-1) namely, structural licensing. As noted in section 2, structural licensing is responsible for creating hierarchical prosodic structure.

According to acquisition data, the dependent member of the foot (F) in (6) is a copy of the head. At this point, it is assumed that the head of the foot is on the left and that the dependent is on the right, although there is no evidence to bear out the position of the head nucleus from the data alone, except that since saliency correlates with word edges or stress, one of these may be the deciding factor. Reduplication will result in forms like [baba] 'rock-rock' (Jonah, 12 months), [mama] 'mommy' (Leslie, 11 months, Sarah, 11 months), [kaka] 'quack-quack' (Timmy, 10 months), [bebe] 'bébé' French (Carole, 11 months), [wawa] Japanese 'doggie' (Emi, 14 months).[6] This copying phenomenon of reduplication is seen to follow, in the model proposed here, from the claim that dependents are the site for neutralisations and lack of contrasts.

### *3.4. Emergence of subsequent canonical forms — CVC, CVV, V, VC*

The following phase manifests the emergence of subsequent canonical forms such as:

(7) The emergence of subsequent canonical forms — CVC, CVV, VC

CVC: [pux] 'pus(jə)' 'cat' Dutch (Thomas 15 months), [tsis] 'shoes' (Will 12 months), [bap] 'Birne' 'pear' German (Hans 14 months), [hap] 'schaap' 'sheep' Dutch (Jarmo, 1;7,15), [pap] 'aap' 'monkey' Dutch (Leonie, 1;9,15)

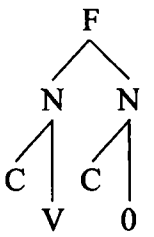
CVV: [ʔai] 'hi' (Jonathan 15 months), [hai] 'hi' (Jessie 15 months), [baibai] 'bye' bye (Sarah 11 months), [daʊ] 'down' (Alice 16 months)

VC [o:t(o)] 'auto' Dutch (Thomas 15 months) and (Jarmo 1;6,13), [ap] 'aap' 'monkey' Dutch (Jarmo 1;7,15)

Each of these word-types does not necessarily appear in equal number of occurrences in the speech of individual children (CVC occurring more frequently than VC, for example). This observation of children's individual differences in the frequency of production of one prosodic shape over another reflects the individual's differences in choosing which type of licensing relation is expanding in his/her computational system.[7]

For instance, given the cognitive development of an internal binary foot structure, the next thing that can occur is expansion of the paradigmatic licensing relation to the dependent. Recall that the dependent is the site of neutralisation, which, when strictly enforced, results in the dependent housing the most neutral or weak possibility lacking all contrasts, i.e., emptiness. When this occurs, the child acquires the concept that a phonological unit may be present, yet be phonetically empty. The form CVC is just such an instance of this, with branching at the foot level, as in (6) above, but now with the final (dependent) vowel not phonetically produced. Thus the representation may be $CV_1CV_2$, where $V_2 = 0$, which is resultantly produced as CVC on the surface.

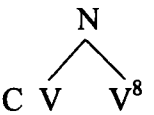
(8)




*Birne* 'pear', German

With respect to the CVV syllable form, this syllable type emerges as the result of the expansion of the structural licensing relation to the nucleus. Expansion of this type of licensing relation is recognised as branching of the nucleus into two vocalic components. Since branching at the foot level has already been exhausted by yielding two sister nuclei, the next lower level (i.e., the head nucleus) is the only possible site remaining that can be recognised as a site for branching.

(9)




Interestingly, though, initially there seems to be a constraint against allowing both branching at the foot level and at the nucleic head level to occur simultaneously, thus disallowing structures such as CVVCV from being produced. This suggests that expansion of the structural licensing relation, and perhaps any licensing relation in general, focuses on the more recent expansion (a kind of narrow scope phenomenon), without incorporating previous expansions as well to yield a more global, wide scope process. As each separate function of the computational system develops, there is a realistic counterpart that emerges in the guise of distinct syllabic forms. Once the entire system is in place, and "saturated" in the Fregean sense, then these separate functions can be conjoined to yield multi-syllabic forms.

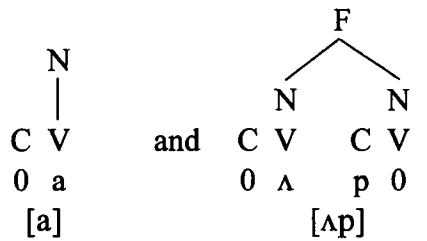
The next syllabic forms to emerge are the V and VC forms. These forms do not occur with the initial closure of a consonantal object. This suggests that the development of such forms results from the child's cognitive realisation that 1. stricture may not be the only

boundary marker before the prominent vocalic head, and 2. silence can also serve as an initial boundary marker. This realisation leads to the relaxing of the strict obligatory syntagmatic-content licensing relation, which requires stricture to precede aperture. In order to perceive that stricture can be optional, the child must, by implication, conceive stricture to be an independent entity at this point. An entity which can be present or not, thus yielding an alternation between CV and V type forms. In viewing the emergence of stricture as a separate phonological concept at this point, one can more readily understand why V is not the first syllable to emerge in a child's speech, and, moreover, why V emerges after what seem to be more complex syllable shapes, such as CVC and CVV. Also, in line with this reasoning, it is more readily comprehensible to see why, given an adult input which is vowel-initial (such as Dutch *aap* 'monkey'), a child would be more likely to first produce the word by adding an extraneous onset consonant preceding the vowel ([pap]) and only later produce the correct VC form.

Up until this point in the child's competence, consonantal material appearing before the vowel is perhaps merely regarded as some beginning point or transitional epiphenomemon. However, once there is awareness that there can be a separation between this initial consonantal material and the vowel, the vowel is then free to emerge on its own. The question arises as to whether the child cognitively retains the concept of their being an initial (boundary type) object, let's call it "onset", directly preceding the vowel. If so, then the child will understand that this object can either contain a set of member elements or be empty of any elements (as discussed above with respect to the vowel/nucleus). The phenomenon of being empty of any elements translates into phonetic silence or phonetic uninterpretability. Given this line of reasoning, the canonical VC shape could then be said to be a variant of the reduplicative binary foot form but with the addition of newly acquired information, namely the non-obligatoriness of consonantal stricture in the onset and the paradigmatic licensing of an "empty segment" in both the onset and final nucleus (the dependent nucleus of the branching foot). In other words, the weaker dependent positions, such as onset of the nucleus, and dependent nucleus of the foot, will be licensed to remain inaudible. Thus the rep-

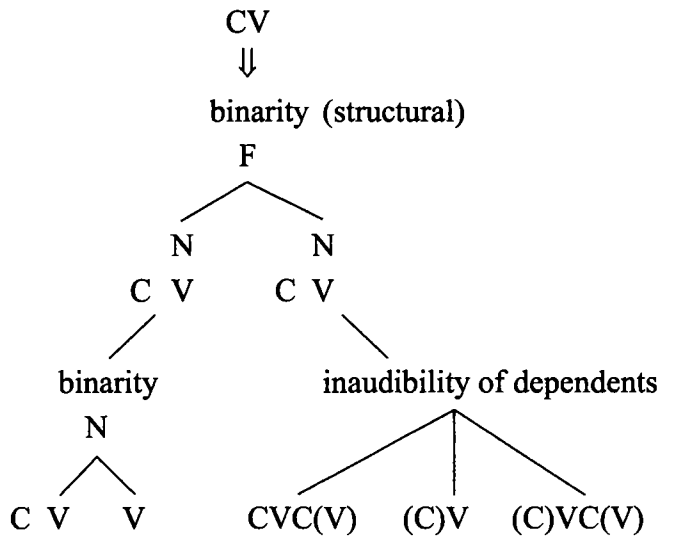
resentations of surface forms such as V and VC would be as in (10), respectively:[9]

(10)




Example (11) below summarises by illustration the development of prosodic structure as outlined above:

(11)




## 4 Onsets coming of age

Correlative with the observation that syllable shapes tend to become differentiated, is the fact that the ratio difference between consonants and vowels tends to increase with age during the acquisition period: from a ratio of 51 consonants: 49 vowels in children 1.5 years old to a ratio of 60 consonants: 40 vowels in 3.0 year old speech (Irwin and Wong 1983). I suggest that the emergence of this higher ratio of con-

sonants points to the claim that the child becomes consciously aware of the onset plane as an autonomous dimension within which the three types of head/dependent licensing relations can operate. In this way, the notion "onset" (formerly a signaller of word boundaries) is recognised by the child as an independent organisational unit.

As stated in section 3.4 above, there comes a point in the child's acquisition where the child is able to make a distinction between the consonantal material preceding a vowel and the vowel itself. Yet, the question then arises as to what triggers this deliberate consciousness in the child in recognising that consonants are no longer predictable appendages to vocalic material, but, rather are distinctive in themselves. An explanation in terms of this model may be that since the paradigmatic licensing relation becomes exhausted with respect to licensing nucleic heads to vocalic material (by first recognising the salience of vocalic aperture, then incrementally recognising the importance of distinctive cues in terms of vocalic contrasts and later segmental emptiness), this licensing mechanism expands to the next dimension, i.e., the consonantal plane. In so doing, consonantal differences in terms of varying degrees of stricture are now recognised and licensed as a part of the child's phonological representation of a word.

(12) O
|
C
$\alpha$

A cognitive link emerges between the category onset, as a phonological constituent, and the prosodic/acoustic cues associated with that category. This recognition (as with vocalic recognition) entails a child's perception of salient acoustic cues, such as voice onset time and bursts. The claim here is that what has been referred to as enhancement, and sharpening or fine tuning (Aslin and Pisoni 1980) in the process of perceiving discriminable speech sounds correlates with the expansion of paradigmatic licensing with respect to the phonological concept of "onset". Onset is a category, an organisational unit, which serves initially as a boundary marker preceding the