ACQUIRING PHONOLOGY[*]

Paula Fikkert

1. Introduction

Child language data have usually been considered as external evidence for linguistic theory, but they have never had much influence on phonological theory. Yet, the central goal of linguistics is to understand what knowledge of language entails and *how it is acquired.* Recently, Chomsky (2004) stressed that in order to understand what constitutes syntactic knowledge it is important to gain insight into how a lexicon is built up during acquisition, and what lexical representations look like. This also holds for phonology: insight into the development of both phonological representations and the phonological system should be of immanent importance to understanding phonological knowledge, at least on the assumption that there is *continuity* between child phonology and adult phonology. Continuity supposes that child and adult languages can only vary in limited ways. Under the strong continuity hypothesis child language can only differ from adult language in ways that adult languages can differ from each other (Pinker 1984). In a weaker definition, continuity refers to the systematicity with which children gradually build up a phonological system (Jakobson 1941/1968). Most present-day theories assume continuity. In the nativist view of Optimality Theory, for example, child phonology has the same substance as adult phonology: a set of universal markedness constraints on outputs and computational principles to determine optimal input-output mappings (faithfulness constraints and correspondence relations) (Prince & Smolensky 1993, Tesar & Smolensky 1998). As continuity implies a direct relationship between adult and child language, the study of child phonology is important for understanding phonology.

Over the years many studies have provided insight into the acquisition of phonology. Why then has the study of phonological acquisition not been more central

[*] Many thanks to Suzanne van der Feest, René Kager, Annemarie Kerkhoff, Paul de Lacy, Bruce Moren, Joe Pater, Jessica Rett, Tania Zamuner, and especially Claartje Levelt for very useful comments. This research is part of the project 'Changing Lexical Representations in the Mental Lexicon' supported by NWO.

to phonological theory? In my view this is due to a number of factors. First, phonological theories changed every decade, changing with it the focus of acquisition studies. In the seventies, children were supposed to acquire morpheme structure conditions and the active phonological rules that relate underlying forms to surface forms. In the eighties, the focus was on phonological representations that children had to acquire. In the nineties, child phonology was about defining the (ordering of the) constraints that characterize children's productions (for an overview see Fikkert 2000; Kager *et al*. 2004).[1]

The lack of sophisticated and thorough analyses of longitudinal databases and complementary experiments where databases do not provide enough information is another factor that has prevented child language data from speaking to a larger audience. Moreover, most studies investigate only one particular phenomenon in a set of child language data, such as cluster reduction (e.g., Ohala 1996, Jongstra 2003) or consonant harmony (e.g., Vihman 1978, Goad 1997, Pater & Werle 2003). Rarely do studies view such phenomena in the light of the whole developing phonological system.[2] A more complete picture of how language acquisition proceeds requires a strong foundation of databases, along with in-depth studies of them. Presently, these are few in number. However, times may be changing, as currently a lot of effort is being put in making phonetically transcribed data publicly available through *Phon*, a new database format in *Childes* (http://childes.psy.cmu.edu/phon/) (Rose 2003, Rose & MacWhinney 2004).

In this chapter I will present an overview of what I regard as the main themes in phonological acquisition. In section 2, I present a brief overview of the short history of the field. Section 3 discusses how phonological acquisition is viewed in Optimality Theory. The focus of these analyses lies on production data (but see e.g. Jusczyk *et al.* 2002, Davidson *et al*. 2004, Pater 2004). Section 4 focuses on developments in the field of child speech perception. Patterns in infant perception often show great similarity to patterns in production; they just appear much earlier. As developmental patterns in infant speech perception demonstrate acquisition of knowledge about the sound system of the mother language, the implicit assumption

---

[1] Today, another challenge for child language researchers is to link results from child production and perception. Although it has long been an issue whether children use the same representation for perception and production (Menn & Matthei 1992, Boersma 1998), perception and production studies have typically been studied in isolation.

[2] Smith (1973) is one of the remarkable exceptions.

often is that when similar developmental patterns show up in production data they merely reflect performance factors, rather than the acquisition of phonology.

Speech perception has not played a dominant role in formal theories of phonology and phonological acquisition, but this is currently changing (e.g. Broe & Pierrehumbert 2000, Hume & Johnson 2001). The growing interest in the role of phonology in perception comes from at least two tendencies. One is the current tendency to relate markedness to phonetic grounding both in perception and production (Hayes, Kirchner & Steriade 2004, Davis, McNeilage & Matyear 2002). The second tendency is the renewed focus on phonological representations – which mediate between perception and production – where the central question is how much detail is stored. This is discussed in section 5.

Interestingly, the main findings from the fields of production and perception seem largely incompatible and differ with respect to the answer to questions concerning continuity, like 'When does the acquisition of phonology start?' and 'Can acquisition of phonology proceed without a lexicon?' Section 6 will conclude with the suggestion that we should aim at reconciling the findings for perception and production in a coalition model in which both abstract and detailed representations play a role. It is hypothesized that the nature of acquisition changes in the course of development, particularly when a lexicon is installed and lexical representations appear. The focus may shift from auditory-driven sound classification to lexicon-driven abstract phonology.

Let me end this introduction by remarking that despite the surge of new research on acquisition of phonology, it is striking that a web search for 'acquisition of phonology' delivers more hits that refer to learnability than to data-driven acquisition studies. There is still regrettably little collaboration across the two domains. In this chapter I will not refer to formal learnability issues, as this is dealt with in chapter 24. The reader is invited to help bridge the gap between the two domains.

2. Child phonology research: Production

Child phonology traditionally studies patterns in child language production data. These data have revealed three simple facts that have to be accounted for. First, children do not speak like adults. Second, children's speech often differs in a systematic fashion from that of adults. Third, child language develops gradually towards the target language.[3] It has proven difficult to explain these simple facts.

Markedness has always played a key role in accounting for acquisition patterns. Researchers usually find that children start out producing relatively simple and unmarked phonological patterns, which become more marked in the course of development. Traditionally, markedness has been related to typology: what is common in languages of the world is unmarked and acquired early. In this view, typology relates to acquisition in much the same way as phylogeny to ontogeny (Jakobson 1941/1968).

However, markedness constraints seem to come in different flavors. Some researchers assume innate and universal markedness constraints; others argue that markedness constraints are grounded in perception and articulation. These grounded constraints could be universal. Yet others view markedness constraints as generalizations over a lexicon (Beckman & Edwards 2000, Pierrehumbert 2003, Fikkert & Levelt 2004). Thus, much of the diversity in the field of acquisition of phonology today stems from different opinions on the origin of markedness constraints. The study of the acquisition of phonology promises to offer a great deal of insight into this issue.

This is of course only true on the assumption that children's productions reflect phonological competence rather than limited performance abilities. It is often assumed that children store the correct form of words on the basis of so-called *fish*-phenomena (Berko & Brown 1960), where the child pronounces the word *fish* as [fɪs] instead of [fɪʃ], but at the same time rejects his own pronunciation when uttered by an adult (see Smith 1973, for an elaborate discussion). An alternative view is that representations are acquired as part of the grammar; hence, knowledge of representations may not be presupposed (Dresher 2004b, Fikkert & Levelt 2004).

If performance limitations are reflected in the phonology, for instance as constraints on perception and articulation, the distinction between competence and performance is meaningless. This is an area of much controversy in the field: to what extent does production reflect linguistic competence rather than mere performance

[3] U-shaped patterns of development have been reported. Yet, these patterns often indicate a change or reorganization of a system, rather than loss or regression of it (Werker, Hall & Fais 2004).

limitations? Linguists have usually assumed that production reflects competence, whereas psycholinguists often assume that perception reflects competence, while in production competence is obscured by performance limitations. In this section we assume that production data reflect the child's phonological competence.

Relatively theory-independently, one could say that in order to acquire a language's phonology children need to acquire (a) the segmental inventory of that language, (b) phonological processes, (c) restrictions on phonotactics, word prosodic structure and larger prosodic units that define the adult grammar. In addition, children need to build a lexicon in which phonological representations of words are stored. The following sections focus on the first three aspects of phonological acquisition. Section 5 discusses phonological representations in the mental lexicon.

2.1 Acquiring phonological contrasts

The study of acquiring an abstract phonology is often claimed to have started with Jakobson (1941/1968), who argued that children gradually build up a (universal) system of contrast. Contrasts that are typologically frequent are high up in the hierarchy and acquired early, and vice versa. In this view, acquisition is the unfolding of a pre-existing feature hierarchy, presumably based on positive evidence in the input (see Dresher 2004a for an excellent overview and a modern reinterpretation). This view has been widely criticized because child language shows more variation than expected based on a universal feature hierarchy (Kiparsky & Menn 1977, Macken & Ferguson 1983);[4] it has turned out to be impossible to find such a hierarchy. Children acquiring different languages have different systems of contrasts, and differences sometimes even exist among children acquiring the same language. However, researchers have not refrained from exploring the acquisition of contrasts.

There have essentially been two methods for investigating the construction of a system of contrast by children. The first one (Rice & Avery 1995, Brown & Matthews 1997) focused on contrasts and processes appearing in *child* language. These researchers assumed that processes in child language should largely follow from children's feature representations. Brown & Matthews (1997) argue that building up a system of contrast coincides with the acquisition of lexical

[4] Moreover, the theory also seemed hard to falsify (see Kiparsky & Menn 1977).

representations. Early words are underrepresented (or un(der)specified), as not all contrasts have been acquired.[5]

The second way of viewing the acquisition of contrasts assumed that features that play a role in *adult* phonological processes are acquired early, as the phonological activity of features is a cue for children to pay attention to those features (Dresher 2004a, b, Fikkert & Freitas 2004b). Dresher (2004a) proposes the *Continuous Dichotomy Hypothesis* (Dresher 2004a, Dresher, Piggott & Rice 1994, Jakobson & Halle 1956). Under this hypothesis, all sounds are assumed to be variants of a single phoneme at the initial stage of acquisition. An initial binary distinction (dichotomy) is made using one of the universal distinctive features (see also Fikkert 1994). This process continues until all distinctive sounds have been differentiated. The crucial question is how to determine what is contrastive, because an initial failure in setting up the system of contrast has far-reaching consequences. Dresher proposes that phonological processes play a key role. He furthermore assumes that only contrastive features can be represented, and hence, be phonologically active. Redundant features are not specified. If the system of contrast is built on the basis of active phonological features, redundancy follows immediately. In this view, children must use systematic variation in the input to build up their system. A current theme in the (child) phonology literature is how the child determines which segments are contrastive in his or her language. Views vary from one extreme where a lot of innate phonological structure is assumed to the other extreme position assuming that alll contrasts fall out from statistical learning based on input speech (e.g., Maye *et al.* 2002).

In the views summarized above, child language differs from adult language in the sense that a child's phonological system is immature, and does not allow all contrasts that the adult language exhibits, but it is not fundamentally different.

2.2 Processes in child phonology

The majority of studies in acquisition of phonology has focused on processes in child language (Ingram 1974). Let us take the well-known and frequently discussed case of consonant harmony:

---

[5] Brown & Matthews (1997) argue that development in perception involves the reduction of the number of contrasts (via "pruning"), whereas in production, it must expand.

(1) Examples of consonant harmony

a. English (data from Pater 1997)

dog			[□□□]	Trevor 1;4.19~2;3.17
big			[□□□]	Trevor 1;9.21~1;10.9

b. Dutch (data from Levelt 1994)

sop	*suds*	/□□□/	[□□□]	Robin 1;10.7
tafel	*table*	/□□□□□□/	[□□□□□]	Robin 1;10.7

c. French (data from Rose 2000)

chapeau	*hat*	/□□□□□/	[□□□□□]	Clara
gâteau	*cake*	/□□□□□/	[□□□□□]	Clara

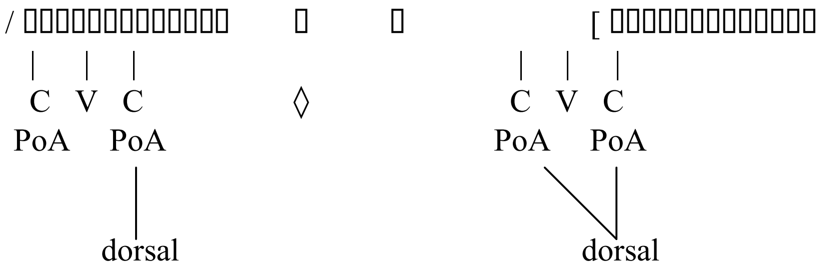
Most child-language phonologists have explained the differences between adult targets and children's produced forms in terms of different phonological systems for adults and children. This is true for early generative studies on phonological acquisition (Smith 1973), as well as current studies on acquisition in Optimality Theory (see papers in Kager *et al.* 2004). Consider for instance Smith's analysis of the phonological system of his son Amahl. On the assumption that input representations are essentially adult-like, Smith was able to describe the complete data set with less than thirty ordered *realization* rules. Smith described consonant harmony forms with a single rule: "Alveolar and palato-alveolar consonants harmonize to the point of articulation of a following consonant; obligatorily if that consonant is velar, optionally if it is labial". As a result Amahl produces *duck* as [□□□]. Later in development, he produces the word as [□□□]: the rule is cast out. In general, development is taken to involve rule reordering, rule simplification or rule loss. Ultimately, however, all rules should be disposed of to ensure that all words are produced in an adult-like fashion. In other words, the system of realization rules, so carefully constructed during acquisition, has to be unlearned at later stages of development. This raises the question 'Where is (adult) phonology?' In fact, the whole system of realization rules is child-specific, despite the fact that they were argued to reflect universal tendencies.

Kiparsky & Menn (1977) argued that the acquisition process is more complex and must have at least two types of rules. One set of rules, *invented* rules, exists to simplify adult target forms in such a way that they can be produced by children. Although many of these rules are common in child phonology, they may also be specific to individual children. These rules are similar in nature to Smith's realization rules. The second set of rules is the set that also exists in the adult phonology. These rules need to be learned on the basis of positive input data. Children start out assuming that inputs they hear corresponds to underlying representations. As input forms are often too 'difficult' to produce, either due to articulatory limitations or to processing problems, children invent – sometimes quite idiosyncratic – strategies to deal with these words. As children become more competent language users, they can do without the simplification rules. As a result the invented, child-specific, rules gradually disappear. However, as children learn more words, and also more related words, they may discover (morpho)-phonological processes that account for alternations: the adult phonological rule system. This may lead children to restructure the underlying forms to more abstract representations.

In other words, there are two types of largely unrelated developments. First, the invented rules appear and gradually disappear. They do not affect phonological representations or the final-state phonological system. Second, adult phonological rules appear and cause restructuring of phonological representations. To my knowledge there are very few acquisition studies that have investigated the acquisition of adult phonological rules and their effects on phonological representations (a point already made ten years ago by Macken 1995, see also Bernhardt & Stemberger 1998). The general assumption seems to be that alternating forms are acquired late, when children are, phonology-wise, fairly competent speakers (Hayes 2004, Kerkhoff 2004).

The importance of phonological representations was emphasized in the eighties, when non-linear phonology dominated the field. Child language data formed additional evidence for the new linguistic tools of non-linear representations, which could elegantly account for processes typical for acquisition like consonant harmony. In consonant harmony, coronals – considered unspecified for place of articulation – are often targets of feature spreading (Stemberger & Stoel-Gammon 1991). The process can be depicted as in (2):

(2) Consonant harmony: a non-linear account



Yet, despite the elegant descriptions the non-linear rules too ultimately had to be abandoned by children in order to master adult-like phonological competence. In this sense, child phonology was still concerned with child-specific rules, bearing little to the question of phonological knowledge. However, there is one important difference between this and earlier rule-based approaches: the option that children could have underdeveloped phonological representations was considered, as argued by for instance Menn (1983). We will return to this issue in section 5.

2.3 The acquisition of prosodic structure: syllable structure and stress

Prosodic structure is principally different from segmental structure: whereas the latter largely consist of arbitrary segmental information that needs to be stored, prosodic structure, particularly syllable structure, is usually predictable from the string of segments and not used contrastively. In this sense, prosodic structure is not part of lexical representations, but is generated by grammatical 'rules'.[6]

The earliest work on prosodic structure stems from the seventies, and was mainly concerned with the question of what the basic unit of acquisition was (Ferguson & Farwell 1975, Menn 1978). It became clear that segments are not acquired in isolation, but need a word to surface. Moreover, the position in the word mattered: some contrasts appeared in onset position earlier than in coda position, and vice versa. According to Moskowitz (1973) the first unit acquired in English is the syllable, but others argued for a larger unit, i.e. the word (Menn 1971, Ferguson & Farwell 1975). This line of research led to the establishment of more or less fixed word templates (see for instance Waterson 1971, Macken 1979 and Vihman 1996). These word templates constrained word forms that children produced and formed the

[6] The term 'rules' is used loosely here to refer to either syllabification and stress rules, prosodic parameters, or prosodic constraints. I.e. the grammatical rules posit prosodic structure that is not part of the underlying phonological representation, but is part of the output structure.

basis of children’s phonological representations. A well-known case is the [labial-dental] template described by Macken (1979), which her Spanish subject Si strictly adhered to by deleting syllables that do not conform to this pattern, as in (3ad), and by applying a kind of ‘consonant harmony’ prior to the deletion of the initial unstressed syllable in (3bc):

(3) Si’s labial-dental word templates (Macken 1979)

a.	zapato	*shoe*	[□□□□□□]	1;8.7
b.	manzana	*apple*	[□□□□□]	1;9
c.	Fernando	name	[□□□□]	1;9
d.	elefante	*elephant*	[□□□□], [pantI]	1;9

With regard to the development of syllable structure, Moskowitz observed that early words in English child language all consisted of CV syllables, but stated that beyond the primary acquisition of the (CV), there was no unique and specific pattern, or predictable order of acquisition of syllable types. For example, Hildegard expanded her syllable repertoire with a CVC syllable (Leopold 1939–49), whereas Joan first had CV and VC syllables, before producing CVC syllables (Velten 1943). The first pattern is widely attested (Fikkert 1994, Levelt *et al*. 1999/2000). The second pattern is reported for German child language (Grijzenhout & Joppen-Hellwig 2002).

(4) Syllable structure of children’ first words

a. CV > CVC (data from the Dutch child Jarmo)

klaar	*ready*	/□□□□/	[□□], [□□]	1;4.18
poes	*cat*	/□□□/	[□□]	1;5.2
poes	*cat*	/□□□/	[□□□]	1;7.29

b. CV > VC (data from the German child Naomi)

Bal	*ball*	/□□□/	[□□]	1;2~1;5.01
Milch	*milk*	/□□□□/	[□□]	1;2
ab	*off*	/□□/	[□□$^{□}$]	1;4.26

For a long time the study of acquisition of syllable structure kept repeating the following findings: children (i) start with CV syllables, (ii) reduce consonant clusters, and (iii) often delete final consonants. Fikkert's (1994) extensive longitudinal analysis of syllable structure based on data of twelve children also found these same facts for the initial stages. She showed furthermore that the developmental patterns showed relatively little variation among the children.

The developments could be nicely captured in a principles and parameters framework, in which marked parameter-settings have to be acquired. Dutch has a fairly complex syllable structure, allowing for both initial and final clusters, as well as vowel length contrasts; in other words, all syllable parameters have the marked setting. In this respect, Dutch is a good test case for investigating learning paths in acquisition. Variation in learning paths is essentially limited to the following cases. First, whereas most Dutch children have onset clusters consisting of an obstruent followed by a sonorant first, some children acquire /s/-obstruent clusters earlier. Children who correctly produce /s/-obstruent clusters also have final consonant clusters (Fikkert & Freitas 2004a). Second, while some children produce final clusters before they produce initial (obstruent-sonorant) clusters, others have the reverse order (Levelt *et al.* 1999/2000, Levelt & Van de Vijver 2004). As the patterns in acquisition show less variation than expected on the basis of typology, Levelt & Van de Vijver (2004) hypothesized that development is guided by the frequency of syllable types in the target language. In terms of decreasing frequency, stressed syllable types in Dutch have the following rank order: CV > CVC > V > CCVC/CVCC. Where frequencies are similar, children's choice of syllable type expansion varies.

However, frequency is not all that matters. The choice for /s/-obstruent vs. obstruent-sonorant clusters cannot be explained on the basis of frequency.[7] The former type of cluster is far less frequent in Dutch than the latter. Yet, some Dutch children start with the least frequent pattern. The same distribution is found in adult European Portuguese. Strikingly, /s/-obstruent clusters are produced months before obstruent-liquid clusters by the Portuguese children studied by Freitas (1997). Fikkert & Freitas (2004a) claim that other factors may interact with local phenomena, such as the acquisition of extraprosodic positions elsewhere and the saliency of morphological marking.

[7] Levelt *et al*. (1999/2000) and Levelt & van de Vijver (2004) left syllables with /s/-obstruent clusters out of consideration.

Kirk & Demuth (2003) claim that English children acquire coda clusters before onset clusters; in other words, they do not show the same variation as Dutch children. The time has come for thorough cross-linguistic investigations, combining the knowledge about the acquisition of syllable structure in various languages, such as English, Hungarian (Fee 1996), European Portuguese (Freitas 1997, Vigário *et al*. 2003), Spanish (Kehoe & Lleo 2003), German (Grijzenhout & Joppen-Hellwig 2002, Kehoe & Lleo 2003), Japanese (Ota 2003), French (Wauquier-Gravelines & Suet-Bouret 2004), and Greek (Kappa 2002) to discover which factors are involved in explaining development.

Cross-linguistic investigation shows that it is not always easy to compare languages. For their study, Levelt *et al.* (1999/2000) examined all stressed syllables produced by children, which were mostly word-initial, as this is the predominant stress pattern in Dutch. However, in French, stressed syllables are invariably final, and in Portuguese stressed syllables occur either in final or prefinal position (Fikkert *et al*. 2004). Since position in the word influences the structure of syllables, this introduces an extra variable in the investigation of cross-linguistic syllabic development. It is clear that other factors than universal syllable markedness and frequency must be considered.

Similar issues arise when looking at word prosodic patterns. Prosodic word forms in child language have been studied in a variety of languages. At first, these forms were described as more or less fixed templates, which in English, for instance, is a trochaic template. Subsequent work provided a more formal account of these templates, in terms of parameter settings (Fikkert 1994). Moreover, development was formalized as the change of one or more parameter settings from the default to the marked value, thereby assuming continuity from children's early grammars to the final state grammar. Markedness played a key role in the principles and parameter framework: in the initial state all parameters have the default or unmarked value. In the course of development, parameters are changed to their marked setting if the input data provide positive evidence for that setting. Prosodic templates defined by parameter settings constrain possible output patterns.

A robust finding in the literature is that children acquiring Germanic languages predominantly produce words that are monosyllabic or disyllabic trochees, whereas children acquiring Romance languages seem to produce very few monosyllabic words. Moreover, children acquiring Germanic languages produce disyllabic words with a trochaic foot, truncating target ‘iambic’ words. Some typical examples from English are given in (5):

(5) Typical early word truncations in English (from Pater 1997)

banana	[□□□□]	Trevor 0;11.10~1;6.8
gorilla	[□□□□□□□	Trevor 1;11.12
spaghetti	[□□□□]	Trevor 1;4.7~1;9.2
guitar	[□□]	Trevor 1;1.19~1;6.17

Children acquiring Romance languages, on the other hand, produce both trochaic and iambic word patterns (Hochberg 1988a, b, Santos 2001, 2003, Vigário *et al.* 2003). In those languages word stress seems not as reliable a cue for metrical structure as in Germanic languages, as stress can vary depending on morphology. Cross-linguistic research into factors that determine the prosodic shape of early words is very important for our understanding of phonological acquisition. Optimality theory offers the possibility to investigate the interaction of different grammatical constraints, making it possible to integrate segmental, prosodic and morphological preferences.

3. Phonological acquisition in Optimality theory

Formal phonological approaches to acquisition are currently captured in constraint-based theories. Constraint-based theories like Optimality Theory, henceforth OT (Prince & Smolensky 1993, papers in Kager *et al.* 2004), are fundamentally different in nature from rule-based theories, as, for example, proposed in Chomsky & Halle’s (1968) Sound Patterns of English (SPE) (see chapter 5). In SPE, the output is constructed by step-by-step application of rules; in OT, the output is chosen from a range of options by means of output constraints and constraints on input-output relations. The focus on *output* is in sharp contrast to earlier theories, particularly to non-linear phonology, which aimed at providing the most elegant and economic descriptions of *input* representations. A great deal of explanatory power was assumed to come from restrictions on input representations, especially through underspecification of predictable and non-contrastive information (e.g., Jakobson &

Halle 1956, Chomsky & Halle 1968, Lahiri & Marslen-Wilson 1991, Steriade 1995; see Dresher 2004a for an implementation of abstract underspecified phonological representations in OT). In contrast, OT places no restrictions on inputs – all explanation is due to constraints on output form and the input-output relation. It is (often tacitly) assumed that input forms to children and adults are identical. However, as noted above, children's output forms differ from adult output forms.

Another assumption is that child and adult phonology are made up of the same ingredients. In the 'classical' view of OT, a grammar consists of a set of ordered innate constraints. There are two sets of constraints: Markedness constraints, which aim at minimizing the degree of markedness in output forms and Faithfulness constraints, which aim at faithfully producing the input structure.[8] Markedness and Faithfulness constraints are often in conflict, and hence, constraints are violated, although the grammar keeps violations to the minimum number needed. As inputs and constraints are assumed to be the same for children and adults, output differences must be due to differences in the ranking of the constraints.

At the onset of acquisition Markedness constraints outrank Faithfulness constraints (M >> F) (Smolensky 1996, Gnanadesikan 2004, and others, but see Hale & Reiss 1998). Consequently, children's phonological grammars usually deliver more 'unmarked' outputs than adult grammars. Development entails constraint re-ranking, i.e. the demotion of some markedness constraints, which results in output forms that are more marked and at the same time often more faithful to the adult target forms. Learning is error-driven: the detection of mismatches between children's own productions and target forms will trigger changes in the grammar. Once low-ranked, the influence of formerly high-ranked constraints is reduced to a minimum, but their presence can still be felt in cases of The Emergence of The Unmarked (TETU) phenomena (McCarthy & Prince 1994, Pater 1997, Gnanadesikan 2004, Fikkert *et al.* 2005a). Another consequence of this view is that each phonological system that occurs during the course of acquisition is a possible phonological system of a natural human language (cf. Levelt & Van der Vijver 2004).

However, the innateness of constraints is not an essential property of OT; constraints could also emerge in the course of acquisition. For example, in Boersma

---

[8] There are also other types of constraints that play a role when morphology is at stake, such as Output-Output constraints, which aim at paradigm uniformity (Benua 1997). We will not discuss these here, as this has hardly ever been topic of investigation in acquisition of phonology.

(1998), Hayes (1999) and Hayes *et al.* (2004) constraints are constructed by mechanisms that refer to articulatory and acoustic factors. That is, phonological constraints are grounded in either acoustics or articulation. What is easy to produce or perceive is likely to show up earlier in child language than what is more difficult to produce or perceive (see also Waterson 1971). Boersma, Escudero and Hayes (2004) propose an acquisition model which starts with non-lexically driven distributional learning of phonological categories, based on acoustic properties. Once phonological categories have emerged, faithfulness to phonologicalcategories starts playing a role and interacts with articulatory constraints that are created when the child learns the gestures to produce the phonological categories. In other words, they assume a perception grammar that links the acoustic signal to phonological categories and ultimately to stored phonological representations, and a production grammar that mediates between stored phonological representations and output forms. In such a view markedness is driven by phonetics rather than phonology. How the linking between the different levels of representation takes place remains to be investigated.

Constraints can also emerge as generalizations over the lexicon (Beckman & Edwards 2000, Pierrehumbert 2003, Fikkert & Levelt 2004). According to Beckman & Edwards (2000) and Pierrehumbert (2003) acquisition is guided by frequencies in the target lexicon. In general, it seems hard to distinguish between frequency and 'universal' markedness as often both conspire towards the same patterns (Zamuner 2003, Zamuner *et al.* 2004). Fikkert & Levelt (2004), however, argue that constraints are generalizations over children's own lexicons. The relation between the make-up of a child's lexicon and frequency in the target language is not 1:1, even though frequent items are more likely to appear in children's lexicons early.

Fikkert & Levelt (2004) investigated the acquisition of place of articulation features in detail. They found that at early stages of acquisition, words consisted of consonants and vowels that shared place of articulation features, where the vowel features are dominant (following Lahiri & Evers 1991, Levelt 1994; for a similar, although not identical view see MacNeilage & Davis 2000, Davis *et al.* 2002, Vihman 1992). At subsequent stages, first the vowel could be specified independently from the consonants, and later, the consonants in a word could also have different places of articulation. At this stage, a pattern emerged in which specific places of articulation were preferred in specific prosodic positions. That is, Dutch children preferred labials in word-initial position, while they tended to avoid words beginning with dorsals, which is reminiscent of the word templates in (3). At this stage, dorsal-initial words like *koek* [kuk] 'cookie' were produced with an initial coronal, i.e. as [tuk], even if they were produced correctly at an earlier stage.

Another important finding was that children were initially very faithful to the place of articulation make-up of target words (see also Vihman *et al*. 1994), and that 'incorrect' renditions only occurred at a later stage. The unfaithfully produced words often resulted in labial-initial child's productions, where the adult target was labial-final, as for instance in *zeep* /zep/ 'soap' produced as [fep] (Levelt 1994). In addition, unfaithfulness often affected target dorsal-initial target words, such as the *koek* example mentioned above. For those reasons Fikkert & Levelt (2004) argue that children's early lexicons give rise to emerging markedness constraints in the children's grammars: children make generalizations over their own production lexicons. If a child's lexicon contains many labial-initial words, the child may generalize that labial is designated to word-initial position, leading to emerging constraints in the grammar. Because coronals can freely appear in all positions, it is assumed that coronal is underspecified, i.e. the default place of articulation in Dutch. In this view, then, development takes place both in the grammar and in the underlying representations: features first have scope over the whole word, but become part of segments in the course of development.

Future work will undoubtedly focus more on the nature of Markedness constraints and where they come from, as they play a dominant role in (the acquisition of) phonology. Another issue that deserves more attention is how children manage to construct phonological categories and phonological representations from the continuous speech stream, because the nature of the input representation is of consequence for the interpretation of Faithfulness constraints.

4. Child speech perception and word recognition

In the seventies and eighties researchers assumed that children pick up salient parts of the input first (e.g., Ferguson & Garnica 1975, Waterson 1971, 1981, 1987), and initially have global representations of words that become more detailed under pressure of the increasing lexicon. Changes in the lexical representations served an efficient organization of the lexicon. Today, most researchers of infant and child language perception assume that children have fairly detailed phonetic representations from a very early stage. By simply listening to language, infants acquire sophisticated information about what sounds and sound patterns occur in the language and which of those patterns are frequent (e.g., Maye *et al.* 2002).

Current research in child language perception has contributed two insights that have consequences for the understanding of phonological acquisition. First, children already know a lot about the sound patterns of their language before they speak their first word. Ever since the ground-breaking work of Eimas and colleagues (1971) we know that infants are good in speech perception and the categorization of sounds. Another important break-through was the discovery that, while speech perception may start out as 'universal', it becomes language-specific in the course of the first year of life (Werker & Tees 1984), when infants are able to distinguish between sounds, prosodic and phonotactic structures that are specific to their native language from those that are foreign (for overviews see Jusczyk 1997, 1998, Kuhl 2000, Gerken 2002). Children must be able to deduce this knowledge on the basis of distributional properties of the input, as they do not yet have a lexicon.

When at around 7.5 months of age word learning begins, children prefer to listen to 'words' that they have been familiarized with over 'words' that are minimally different (e.g. *feet* vs. *zeet*) suggesting that they have stored detailed representations of the 'words' they hear (Jusczyk & Aslin 1995). This study did show that 7.5 month old infants are able to recognize word forms – a prerequisite for word learning – but not that they have learned words, i.e. sound-meaning combinations.

There is also evidence from early word perception showing that children do not always use phonetic detail (Werker *et al*. 2002). Werker and colleagues showed that fourteen month old English children could not distinguish newly learned (non)words that contrast minimally, such as *bin* and *din*. However, they are able to distinguish the pair in a pure discrimination task. These results are accounted for by assuming that discrimination of newly learned words is such a demanding task that phonetic detail is temporarily not accessible. In a subsequent study Fennell & Werker (2004) showed that pair *ball-doll*, i.e. words known to the children, could be distinguished in the same task. However, an alternative view is that phonological representations of stored words contain less detail than the phonetic representation of unanalyzed words of the prelexical child (Pater *et al*. 2004).

Fikkert *et al*. (2005b) investigated this possibility, replicating the experimental set-up of Werker and colleagues with Dutch fourteen month old infants. Based on the results that children’s early words only have one place of articulation, determined by the vowel (see section 3), and assuming coronal underspecification, different responses were predicted for items containing front unrounded, i.e. underspecified vowels, such as [I] in *bin-din*, and specified back rounded vowels, such as [▯] in *bon-don.* This prediction was borne out. The pair *bin-din* could not be distinguished, replicating the findings of Werker and colleagues. However, the Dutch children had no problems distinguishing the pair *bon-don*. Both sets of (non)words contrast ‘b’ and ‘d’, the difference being that in *bin-din* the vowel is underspecified, while in *bon-don* the vowel has a place feature specification. The presence of a specified feature in children’s phonological representations is crucial for detecting mispronunciations: a perceived coronal sound [d], in *don* for *bon*, mismatches with a labial/dorsal place of articulation in the phonological representation of *bon*. On the other hand, mismatches are not detected if the phonological representation is not specified for that feature: whatever place feature is perceived, it will never form a mismatch. This study thus suggests that the same stored phonological representations are used for both perception and production.

Research investigating the relation of perception and production is important in order to gain insight into the nature of phonological representations in the mental lexicon. Although input representations are not the focus in OT, it remains puzzling how they are acquired and what they look like exactly in different stages of the acquisition process.

5. Phonological representations in the mental lexicon

Menn (1978) has argued for a two-lexicon model: one for perception, and another for production, which contains “just the information required to keep the child’s output words distinct from one another” (Menn & Matthei 1992: 218). For a variety of reasons researchers have assumed that early (stored) words are holistic or un(der)specified. Children may have a preference for certain fixed word templates (e.g., Menn 1978, Waterson 1987, Macken 1979, Vihman *et al.* 1994, MacNeilage &

Davis 2000, Davis *et al.* 2002). Another reason is that children's early vocabularies are so small, that there is no need to specify all phonological detail in the lexicon (e.g., Ferguson & Garnica 1975, Fischer *et al.* 2004). Yet another reason is that certain processes could be readily accounted for by assuming underspecification, as we saw in (2). Finally, contrasts that are not yet produced by children are considered absent in children's phonological representations. If children's phonological representations are not adult-like, the continuity hypothesis can in principle still be maintained, but the burden of explanation for how children arrive at an adult-like competence is now not only put onto children's developing phonologies, but also onto developing phonological representations in the mental lexicon.

Of course, child phonology is not only about developing representations. Often children's perception clearly indicate that they perceive differences between words, which nevertheless can be mapped onto the same output form (e.g. Jongstra 2003 for the perception and production of clusters). The fact that children's mapping of inputs to outputs is systematic strongly suggest that they have an abstract phonological system. Moreover, different children may use different mappings for the same targets, suggesting that it is not a matter of ease of articulation alone. It is a challenge to distinguish cases in which children systematically alter input forms that they have stored in an adult-like way from cases where children's representations arguably differ from adult representations.

In 'classical' OT there are no restrictions on input forms or underlying representations, *only* output forms may be constrained. The question how phonological representations of words are stored in the mental lexicon is underresearched in OT. Acquisition studies in 'classical' OT tacitly assume that during the whole acquisition process the underlying phonological representation of words is essentially 'adult-like'. Hence, the reason why children do not produce words like adults do is solely due to differences in the child's phonology. This is a direct consequence of the principle of 'Richness of the Base' (McCarthy & Prince 1994, Dinnsen *et al.* 2001) and 'Lexicon Optimization', stating respectively that, in principle, any input is possible, but input forms that match the output form are preferred and will be the ones stored in the lexicon. In the OT literature on acquisition one finds however very little discussion on the exact shape of stored phonological development, nor on their development (but see Pater 2004).[9]

Incidentally, although there are many differences between current approaches focusing on production and those focusing on perception, what they share is the assumption that stored representations are fairly detailed. If the (developing) lexicon is indeed relevant to, or even crucial for understanding phonological acquisition, then lexical phonological representations should be reassessed. By careful investigation of the evidence from both child language perception and production, we may come closer to an understanding of early phonological representations.

6. Summary and directions for future research

Why do children produce words differently from adults? There are several possible explanations. Children may have perceived differently from adults, they may have stored them differently, they may have a different phonological system which causes divergent patterns, they may lack sufficient processing skills to remember and encode a phonological string in such a way that the output mimics the target, or children may simply lack the articulatory skills necessary to produce the words in an adult-like fashion. Child-language phonologists have mostly been concerned with two of these explanations: child-specific phonological systems or child-specific storage of phonological representations, where the first has been most prominent. I believe, however, that a phonological system and a (phonological) lexicon develop in tandem.

One challenge is to understand the relationship between perception and production. The evidence from both fields seems contradictory. Infant speech perception research suggests that segmental inventories and knowledge about phonotactic and prosodic structure is largely acquired in the absence of a lexicon. In fact, it needs to be acquired before lexical learning can even start, as it guides word segmentation. Research into child production has argued that children gradually build up a system of phonological contrasts, phonotactics and prosodic structure. One way to solve this conflict is to assume that children construct phonetic categories that play a role in the target language on the basis of statistical and distributional properties in

[9] The assumption of fixed input forms is important for learnability models of acquisition. A change in underlying representations in the course of development can have dramatic consequences for the constraint ranking, in particularly for the interpretation of faithfulness constraints.

the input. For storage of words in the mental lexicon, these phonetic categories receive a phonological interpretation, in terms of active or contrastive phonological features.

Another important question that is discussed in this chapter is in what ways children's phonological systems and phonological representations differ from those of adults. Do children follow patterns of (universal) markedness, starting out with unmarked structures that become more marked (and more faithful) on the basis of simple positive evidence? Or do markedness constraints emerge from generalizations based on the 'analysis' of either the input lexicon or children's own lexicons, which, in turn, may affect their output forms? Within phonology an important research question is where markedness constraints come from and it is likely that answers will be found in the study of phonological acquisition. Careful analysis of both perception and production data may help to understand how children manage the complex task of acquiring phonology.

Suggested literature for further reading:

Boersma, Paul & Clara C. Levelt (2004). 'Optimality theory and phonological acquisition'. *Annual Review of Language Acquisition* 3: 1–50.
Fikkert, Paula (2000). 'Acquisition of Phonology'. In L. Cheng & R. Sybesma (Eds.), *The First* Glot International *State-of-the-Article Book. The Latest in Linguistics.* Studies in Generative Grammar 48. Berlin/New York: Mouton de Gruyter. 221–250.
Gerken, LouAnn (2002). 'Early sensitivity to linguistic form'. *Annual Review of Language Acquisition* 2: 1–36.
Kager, Rene, Joe Pater & Wim Zonneveld (2004). *Constraints in phonological acquisition*. Cambridge: Cambridge University Press.
Vihman, Marilyn (1996). *Phonological development. The origins of language in the child*. Oxford: Blackwell.

Bibliography

Beckman, Mary E. & Jan Edwards (2000). 'The ontogeny of phonological categories and the primacy of lexical learning in linguistic development'. *Child Development,* 71, 240–249.

Benua, Laura (1997). *Transderivational identity: Phonological relations between words.* Ph. D. Dissertation, University of Massachusetts, Amherst.

Berko, Jean & Roger Brown (1960). 'Psycholinguistic Research Methods'. In: P. Mussen (ed.), *Handbook of Research Methods in Child Development*. New York: Wiley.

Bernhardt, Barbara & Joe Stemberger (1998). *Handbook of phonological development: from the perspective of constraint-based non-linear phonology.* San Diego: Academic Press.

Boersma, Paul (1998). *Functional phonology. Formalizing the interactions between articulatory and perceptual drives.* Doctoral dissertation, University of Amsterdam. The Hague: Holland Academic Graphics.

Boersma, Paul, Paola Escudero & Rachel Hayes (2003). 'Learning abstract phonological from auditory phonetic categories: An integrated model for the acquisition of language-specific sound categories'. In: *Proceedings of the 15th International Congress of Phonetic Sciences*. Barcelona, August 3-9, 2003. Pp. 1013–1016.

Boersma, Paul & Clara C. Levelt (2004). 'Optimality theory and phonological acquisition'. *Annual Review of Language Acquisition*, 3, 1–50.

Broe, Michael B. & Janet B. Pierrehumbert (2000) (eds.), *Acquisition and the lexicon*. Proceedings of the Conference on Laboratory Phonology 5. Cambridge MA Cambridge University Press.

Brown, Cynthia & John Mattews (1997). 'The role of features geometry in the development of phonological contrasts'. In S.J. Hannahs & M. Young-Scholten (eds.), *Focus on phonological acquisition.* Amsterdam: John Benjamins. Pp. 67–112.

Chomksy, Noam (2004). Key note lecture, GLOW 2004. Thessaloniki, Greece.

Chomsky, Noam & Morris Halle (1968). *The sound pattern of English*. New York: Harper & Row.

Davidson, Lisa, Peter W. Jusczyk & Paul Smolensky (2004). 'The initial and final states: theoretical implications and experimental explorations of Richness of the Base'. In: R. Kager, J. Pater & W. Zonneveld (eds). *Constraints in phonological acquisition*. Cambridge: CUP. Pp. 321–368.

Davis, Barbara L, Peter F. MacNeilage & Christine L. Matyear (2002). 'Acquisition of serial complexity in speech production: A comparison of phonetic and phonological approaches to first word production'. *Phonetica*, 59, 75–109.

Dinnsen, Daniel A., Kathleen M. O'Connor and Judith Gierut (2001). 'The puzzle-puddle-pickle problem and the Duke-of York gambit in acquisition'. *Journal of Linguistics*, 37, 503–525.

Dresher, B. Elan (2004a). 'On the acquisition of phonological contrasts'. In: J. van Kampen & S. Baauw (eds.), *Proceedings of GALA 2003*. Volume 1. Utrecht: LOT. Pp. 27–46.

Dresher, B. Elan (2004b). 'On the acquisition of phonological representations'. In: *Proceedings of the first workshop on psycho-computational models of human Language Acquisition*. http://www.colag.cs.hunter.cuny.edu/psychocomp. Pp. 41–49.

Dresher, B. Elan, Glynn Piggott & Keren Rice (1994). 'Contrast in phonology: Overview'. In: C. Dyck (ed.), *Toronto Working Papers in Linguistics* 13/1. Toronto: Department of Linguistics. Pp. iii–xvii.

Eimas, Peter D., E. R. Siqueland, Peter W. Jusczyk & J. Vigorito (1971). 'Speech perception in infants'. *Science*, 171, 303–306.

Fee, E. Jane (1996). 'Syllable structure and minimal words'. In: B. Bernhardt, J. Gilbert & D. Ingram (eds.), *Proceedings of the UBC International Conference on Phonological Development.* Somerville, MA: Cascadilla Press. Pp. 85–98.

Fennell, Christopher & Janet F. Werker (2004). 'Early word learners' ability to access phonetic detail in well-known words'. *Language and Speech*, 46, 245–264.

Ferguson, Charles A. & Carol Farwell (1975). 'Words and sounds in early language acquisition'. *Language*, 51, 419–439.

Ferguson, Charles. A. & O. K. Garnica (1975). 'Theories of phonological development'. In: E. H. Lenneberg & E. Lenneberg (eds.), *Foundations of language development*. Volume 1. New York: Academic Press. Pp. 153–180.

Ferguson, Charles. A., Lise Menn & Carol Stoel-Gammon (eds.) (1992), *Phonological development. Models, Research, Implications.* Maryland: York Press.

Fikkert, Paula (1994). *On the acquisition of prosodic structure*. Doctoral dissertation 6, Holland Institute of Generative Linguistics (HIL), Leiden University. The Hague: Holland Academic Graphics.

Fikkert, Paula (2000). 'Acquisition of Phonology'. In L. Cheng & R. Sybesma (eds.), *The First* Glot International *State-of-the-Article Book. The Latest in Linguistics.* Pp. 221–250.

Fikkert, Paula & Maria João Freitas (2004a). 'The role of language-specific phonotactics in the acquisition of onset clusters'. In: L. Cornips & J. Doetjes (eds.), *Linguistics in the Netherlands 2004.* Amsterdam: John Benjamins. Pp. 58–68.

Fikkert, Paula & Maria João Freitas (2004b). 'Allophony and allomorphy cue phonological development: Evidence from the European Portuguese vowel system'. Ms. Radboud University of Nijmegen and University of Lissabon. Submitted to *Journal of Catalan Linguistics*.

Fikkert, Paula, Maria João Freitas, Janet Grijzenhout, Clara C. Levelt & Sophie Wauquier-Gravelines (2004). 'Syllabic Markedness, Segmental Markedness, Rhythm and Acquisition'. Talk presented at GLOW 2004, 18 April 2004, Thessaloniki, Greece.

Fikkert, Paula & Clara C. Levelt (2004). 'How does place fall into place? The lexicon and emergent constraints in the developing phonological grammar'. Ms. Radboud University of Nijmegen & Leiden University.

Fikkert, Paula, Marieke van Heugten, Philo Offermans &Tania S. Zamuner (2005a). 'Rhymes as a Window into Grammar'. To appear in the *BUCLD 29: Proceedings of the 27th annual Boston University Conference on Language Development.* Somerville, MA: Cascadilla Press.

Fikkert, Paula, Clara Levelt & Tania S. Zamuner (2005b). 'Perception through production?' Ms. Radboud University of Nijmegen & Leiden University.

Fischer, Cynthia, Barbara A. Church & Kyle E. Chambers (2004). 'Learning to identify spoken words'. In: D. G. Hall & S. R. Waxman (eds.), *Weaving a lexicon.* Cambridge, MA: The MIT Press. Pp. 3–40.

Freitas, Maria João (1997). *Aquisição da Estrutura Silábica do Português Europeu.* Univeristy of Lisbon, doctoral dissertation.

Gerken, LouAnn (2002). 'Early sensitivity to linguistics form'. *Annual Review of Language Acquisition*, 2, 1–36.

Gnandesikan, Amalia (2004). 'Markedness and faithfulness constraints in child phonology'. In R. Kager, J. Pater & W. Zonneveld (eds.), *Constraints in phonological acquisition*. Cambridge: Cambridge University Press. Pp. 73–108. [ROA-67].

Goad, Heather (1997). 'Consonant harmony in child language: an optimality theoretic account'. In: S. J. Hannahs & M. Young-Scholten (eds.), *Focus on phonological acquisition*. Amsterdam: Benjamins. Pp. 113–142.

Grijzenhout, Janet & Sandra Joppen-Hellwig (2002). 'The lack of onsets in German child phonology'. In: I. Lasser (ed.), *The Process of Language Acquisition (Proceedings of GALA'99)*. Frankfurt am Main: Peter Lang Verlag. Pp. 319–339.

Hayes, Bruce (1999). 'Phonetically-driven phonology: the role of OptimalityTheory and inductive grounding'. In: M. Darnell, E. Moravscik, M. Noonan, F. Newmeyer & K. Wheatly (eds.), *Functionalism and formalism in linguistics, Vol. I: General Papers.* Amsterdam: Benjamins. Pp. 243–285.

Hayes, Bruce (2004). ‘Phonological acquisition in Optimality Theory: the early stages’. In R. Kager, J. Pater & W. Zonneveld (eds.). *Constraints in phonological acquisition*. Cambridge: CUP. Pp. 158–203.

Hayes, Bruce, Robert Kirchner & Donca Steriade (2004) (eds.), *Phonetically-Based Phonology*. Cambridge MA: Cambridge University Press.

Hale, Mark & Charles Reiss (1998). ‘Formal and empirical arguments concerning phonological acquisition’. *Linguistic Inquiry*, 29, 656–683.

Hochberg, Judith G. (1988a). ‘First steps in the acquisition of Spanish stress’. *Journal of Child Language*, 15, 273–292.

Hochberg, Judith G. (1988b). ‘Learning Spanish stress: developmental and theoretical perspectives’. *Language*, 64, 638–706.

Hume, Elizabeth & Keith Johnson (2001) (eds.), *The role of speech perception in phonology*. San Diego: Academic Press.

Ingram, David (1974). ‘Phonological rules in young children’. *Journal of Child Language*, 1, 49–64.

Jakobson, Roman (1941/1968). *Child language, aphasia and phonological universals*. The Hague & Paris: Mouton.

Jakobson, Roman & Morris Halle (1956). *Fundamentals of Language*. The Hague: Mouton.

Jongstra, Wenckje (2003). *Variation in reduction strategies in Dutch word-initial consonant clusters*. Ph.D. Dissertation, University of Toronto.

Jusczyk, Peter (1997). *The discovery of spoken language*. MIT Press, Cambridge 1997.

Jusczyk, Peter (1998). ‘Constraining the search for structure in the input’. *Lingua*, 106, 197–218.

Jusczyk, Peter & Richard N. Aslin (1995). ‘Infants’ detection of sound patterns of words in fluent speech’. *Cognitive Psychology*, 29, 1–23.

Jusczyk, Peter, Paul Smolensky, Theresa Allocco (2002). ‘How English-learning infants respond to Markedness and Faithfulness constraints’. *Language Acquisition* 10, 31–73.

Kager, Rene, Joe Pater & Wim Zonneveld (2004). *Constraints in phonological acquisition*. Cambridge: CUP.

Kappa, Iona (2002). ‘On the acquisition of syllabic structure in Greek’. *Journal of Greek Linguistics*, 3, 1–52.

Kehoe, Margaret & Conxita Lleó (2003). 'The Acquisition of Syllable Types in Monolingual and Bilingual German and Spanish Children'. In: B. Beachley, A. Brown & F. Conlin, (eds.), *BUCLD 27: Proceedings of the 27th annual Boston University Conference on Language Development.* Somerville, MA: Cascadilla Press. Pp. 402–413.

Kerkhoff, Annemarie (2004). 'Acquisition of voicing alternations'. In: S. Baauw & J. van Kampen (eds.), *Proceedings of GALA 2003*, Volume 2, LOT, Utrecht. Pp. 269–280.

Kiparsky, Paul & Lise Menn (1977). 'On the acquisition of phonology'. In: J. MacNamara (ed.), *Language and thought*. New York: Academic Press. Pp. 47–78.

Kirk, Cecilia & Katherine Demuth (2003). 'Onset/Coda Asymmetries in the Acquisition of Clusters'. In: B. Beachley, A. Brown & F. Conlin, (eds.), *BUCLD 27: Proceedings of the 27th annual Boston University Conference on Language Development.* Somerville, MA: Cascadilla Press. Pp. 437–448.

Kuhl, Patricia K. (2000). 'A new view of language acquisition'. *PNAS*, 97, 11850–11857.

Lahiri, Aditi & Vincent Evers (1991). 'Palatalization and Coronality'. In: C. Paradis & J. Prunet (eds.), *The special status of coronals: Internal and external evidence*. (Phonology and Phonetics 2.), San Diego, California: Academic Press. Pp. 79–100.

Lahiri, Aditi & Willam Marslen-Wilson (1991). 'The mental representation of lexical form: a phonological approach to the recognition lexicon'. *Cognition*, 38, 245–294.

Leopold, Wilhelm F. (1939–49). *Speech development of a bilingual child. A linguist's record.* (4 volumes: 1939, 1947, 1949, 1949) Evanston: Northwestern University Press.

Levelt, Clara C. (1994). *On the acquisition of a place*. Doctoral Dissertation 8, Holland Institute of Generative Linguistics (HIL), Leiden University. The Hague: Holland Academic Graphics.

Levelt, Clara, Niels Schiller & Willem Levelt (1999/2000). 'The acquisition of syllable types'. *Language Acquisition*, 8, 237–264.

Levelt, Clara C. & Ruben van de Vijver (2004). 'Syllable types in cross-linguistic and developmental grammars'. In: R. Kager, J. Pater & W. Zonneveld (eds.), *Constraints in phonological acquisition*. Cambridge: Cambridge University Press. Pp. 204–218.

Macken, Marlys (1979). 'Developmental reorganization of phonology: A hierarchy of basic units of acquisition'. *Lingua*, 49, 11–49.

Macken, Marlys (1995). 'Phonological acquisition'. In: J. A. Goldsmith (ed.), *The handbook of phonological theory*. Cambridge, MA: Blackwell. Pp. 671–696.

Macken, Marlys & Charles A. Ferguson (1983). 'Cognitive aspects of phonological development: Model, evidence and issues'. In K. Nelson (ed.), *Children's Language*. Volume 4. Hillsdale, N.J.: Lawrence Erlbaum. Pp. 255–282.

MacNeilage, Peter F. & Barbara L. Davis (2000). 'Origin of the internal structure of word forms'. *Science*, 288, 527–531.

Maye, Jessica, Janet Werker & LouAnn Gerken (2002). 'Infant sensitivity to distributional information can affect phonetic discrimination'. *Cognition*, 82, 1001–111.

McCarthy, John & Alan Prince (1994). 'The emergence of the unmarked: Optimality n prosodic morphology'. *Norteastern Linguistic Society*, 24, 333–379.

Menn, Lise (1971). 'Phonological rules in beginning speech'. *Lingua*, 26, 225–241.

Menn, Lise (1978). 'Phonological units in beginning speech'. In A. Bell & J. B. Hooper (eds.), *Syllables and Segments*. New York: Elsevier-North Holland. Pp. 157–172.

Menn, Lise (1983). 'Development of articulatory, phonetic, and phonological capabilities'. In: B. Butterworth (ed.), *Language production, 2* London: Academic Press. Pp. 3–50.

Menn, Lise & Edward Matthei (1992). 'The "two-lexicon" account in child phonology. Looking back, looking ahead'. In: C.A. Ferguson, L. Menn & C. Stoel-Gammon (eds.), *Phonological development. Models, Research, Implications.* Maryland: York Press. Pp. 211–247.

Moskowitz, Arlene J. (1973). 'The acquisition of phonology and syntax: A preliminary study'. In: J. Hintikka *et al*. (eds.), *Approaches to natural language : proceedings of the 1970 Stanford Workshop on Grammar and Semantics*. Dordrecht : Reidel Publ. Pp. 48–84.

Ohala, Diane (1996). *Cluster reduction and constraints in acquisition.* Doctoral disseration, University of Arizona.

Ota, Mitsuhiko (2003). *The Development of Prosodic Structure in Early Words.Continuity, divergence and change*. Amsterdam: Benjamins.

Pater, Joe (1997). 'Minimal violation and phonological development'. *Language Acquisition*, 6, 201–253.

Pater, Joe (2004). 'Bridging the gap between perception and production with minimally violable constraints'. In R. Kager, J. Pater & W. Zonneveld (eds.), *Constraints in phonological acquisition*. Cambridge: Cambridge University Press. Pp. 219–244.

Pater, Joe, Christine Stager & Janet Werker (2004). ‘The perceptual acquisition of phonological contrast’. *Language*, 80, 384–402.

Pater, Joe & Adam Werle (2003). ‘Direction of Assimilation in Child Consonant Harmony’. *Canadian Journal of Linguistics*, 48 (3/4), 385–408.

Pierrehumbert, Janet B. (2003). ‘Phonetic diversity, statistical learning, and acquisition of phonology’. *Language and Speech*, 46, 115–154.

Prince, Alan & Paul Smolensky (1993). ‘Optimality Theory: constraint interaction in generative grammar’. Ms. University of Rutgers & University of Colorado at Boulder.

Pinker, Steven (1984). *Language learnability and language development.* Cambridge M.A.: Harvard University Press.

Rice, Keren & Peter Avery (1995). ‘Variability in a deterministic model of language acquisition: A theory of segmental acquisition’. In: J. Archibald (ed.), *Phonological acquisition and phonological theory.* Hillsdale N.J.: Lawrence Erlbaum. Pp. 23–42.

Rose, Yvan (2000). *Headedness and Prosodic Licensing in the L1 Acquisition of Phonology*. Ph.D. Dissertation. McGill University.

Rose, Yvan (2003). ‘ChildPhon: A Database Solution for the Study of Child Phonology’. In: B. Beachley, A. Brown & F. Conlin, (eds.), *BUCLD 27: Proceedings of the 27th annual Boston University Conference on Language Development.* Somerville, MA: Cascadilla Press. Pp. 674–685.

Rose, Yvan & Brian MacWhinney (2004). ‘Towards a solution for the sharing of phonological data’. Paper presented at the BUCLD 2004, Boston.

Santos, Raquel (2001). *A aquisição do acento primário no português brasileiro*. PhD Dissertation. Campinas: UNICAMP.

Santos, Raquel (2003). ‘Bootstrapping in the acquisition of word stresss in Brazilian Portuguese’. *Journal of Portuguese Linguistics*, 2, 93–114.

Smith, Neil V. (1973). *The acquisition of phonology: A case study*. London: Cambridge University Press.

Smolensky, Paul (1996). ‘The initial state and ‘Richness of the base’ in Optimality Theory’. Technical Report JHU-CogSci-96-4, Johns Hopkins University (ROA 154).

Stemberger, Joe P. & Caroll Stoel-Gammon (1991). ‘The underspecification of coronals: Evidence from language acquisition and performance errors’. In: C. Paradis & J.-F. Prunet (eds.), *Phonetics and phonology: Vol 2. The special status of coronals*. San Diego, CA: Academic Press. Pp. 181–199.

Steriade, Donka (1995). 'Underspecification and markedness'. In: J. A. Goldsmith (ed.), *The handbook of phonological theory.* Cambridge, Mass.: Blackwell. Pp. 114–174.

Tesar, Bruce & Paul Smolensky (1998). 'Learnability in Optimality Theory'. *Linguistic Inquiry*, 29, 229–268.

Velten, H. (1943). 'The growth of phonemic and lexical patterns in infant speech'. *Language*, 19, 281–292.

Vigário, Marina, Sónia Frota, & Maria João Freitas (2003), 'From Signal to Grammar: Rhythm and the Acquisition of Syllable Structure'. In: B. Beachley, A. Brown & F. Conlin, (eds.), *BUCLD 27: Proceedings of the 27th annual Boston University Conference on Language Development.* Somerville, MA: Cascadilla Press. Pp. 809–821.

Vihman, Marilyn (1978). 'Consonant harmony: its scope and function in child language'. In: J. H. Greenberg (ed.), *Universals of human language, Vol. 2: Phonology*. Stanford: Stanford University Press. Pp. 281–334.

Vihman, Marily (1992). 'Early syllables and the construction of phonology'. In: C.A. Ferguson, L. Menn & C. Stoel-Gammon (eds.), *Phonological development. Models, Research, Implications.* Maryland: York Press. Pp. 393–422.

Vihman, Marilyn (1996). *Phonological development. The origins of language in the child*. Oxford: Blackwell.

Vihman, Marilyn, Shelley L. Velleman & Lorraine McCune (1994). 'How abstract is child phonology? Towards an intergration of linguistic and psychological approaches'. In M. Yavas (ed.), *First and second language phonology.* San Diego: Singular Publishing Group. Pp. 9–44.

Waterson, Natalie (1971). 'Child phonology: a prosodic view'. *Journal of Linguistics*, 7, 179–211.

Waterson, Natalie (1981). 'A tentative developmental model of phonological representation'. In: T. Myers, J. Laver & J Anderson (eds.), *The cognitive representation of speech*. Amsterdam: The North-Holland Publishing Company. Pp. 323–334.

Waterson, Natalie (1987). *Prosodic phonology: the theory and its application to language acquisition and speech processing*. Newcastle upon Tyne: Grevatt & Grevatt.

Wauquier-Gravelines Sophie & Déborah Suet-Bouret (2004). 'Acquisition des attaques syllabiques et 'palatal patterns'. Pourquoi yod?'. Paper presented at Colloque du Réseau « Phonologie »- 3 juin 2004-Orléans.

Werker, Janet F., Chris Fennell, K. Corcoran & C. L. Stager (2002). 'Age and vocabulary size influences on the phonological representation of newly learned words in infants aged 14 to 20 months'. *Infancy*, 3, 1–30.

Werker, Janet F. & R. C. Tees (1984). 'Cross-language speech perception: Evidence for perceptual reorganization during the first year of life'. *Infant Behavior and Development*, 7, 49–63.

Werker, Janet F., D. Geoffrey Hall & Laurel Fais (2004). 'Reconstruing U-shaped functions'. *Journal of Cognition and Development*, 5, 147–151.

Zamuner, Tania S. (2003). *Input-based phonological acquisition*. New York: Routledge.

Zamuner, Tania S., LouAnn Gerken, Michael Hammond (2004). 'Phonotactic probabilities in young children's speech production'. *Journal of Child Language*, 31, 515–536.