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CONSONANT HARMONY IN THE SCOPE OF LANGUAGE DEVELOPMENT

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ABSTRACT

Consonant Harmony is one of the most intriguing and studied phenomena in language acquisition. It is defined as long distance consonant-consonant assimilation, i.e. through an intervening vowel (e.g. /soʊp/ 'soap' → [pop]). Generally, Consonant Harmony is considered to be a simplification strategy helping the child to deal with the task of language development. However, there is no consensus regarding what motivates its use. Previous proposals include: (a) segmental motivation, i.e. replacing "difficult" with "easy" consonants; (b) phonotactic motivation, i.e. avoiding certain consonantal sequences (or disharmonic sequences in general); and (c) prosodic motivation, i.e. simplifying the segmental complexity of the utterance in order to enhance the acquisition of new prosodic structures.

The present study investigates the motivation behind Consonant Harmony using longitudinal data from two children acquiring Hebrew. The analysis suggests that Consonant Harmony may have multiple sources and it cannot be treated as a single distinct phenomenon, at least for the child subjects in this study. From a phonological point of view, Consonant Harmony may serve to replace unacquired segments and simplify the articulation of difficult sequences and complex structures.

From a general perspective in which speech is viewed as "data processing", Consonant Harmony may be related to the representational system and to speech planning processes; the long term use of certain harmonized words suggests that Consonant Harmony can be a lexical phenomenon stemming from underdeveloped representational system. The existence of many isolated cases of Consonant Harmony with no apparent motivation and the relative rareness of clear consonant-consonant assimilations question the idea that the children operate a grammatical rule of Consonant Harmony and support the hypothesis that the Consonant Harmony stems from speech planning errors. In addition, it is found that Consonant Harmony often occurs on the first use of a target word, even if the structure and content of the word are not expected to be difficult for the child. This finding can be attributed to either poor representation of the target word or to faulty planning.

In addition, the present study analyzes the properties of Consonant Harmony as normally performed in studies of the topic. The interaction of Consonant Harmony with stress and the directionality of assimilation support to some extent the hypothesis that Consonant Harmony is influenced by prosodic development. The tendency of one child to prefer sonorant targets suggest that Consonant Harmony can also be motivated by segmental factors. However, the analysis does not support previous claims that Consonant Harmony

involving place of articulation is governed by a clear trigger-target hierarchy. I propose that a trigger-target hierarchy (if such exists) is dependent much on input frequency and individual factors.

The present study also deals with the seemingly trivial question “How to identify a case of Consonant Harmony when you see one”. It is often the case that harmonized productions can be described as the result of both assimilation and context-free substitutions, such as velar fronting (e.g. the pronunciation of /ˈtuki/ ‘parrot’ as [ˈtuti] in which the *k* → *t* change can be viewed as assimilation or the context-free fronting of the *k*) . In this study, I propose a statistically based method to separate unambiguous Consonant Harmony from potential context-free substitutions. With this method I show that a large part of the harmonized words produced by the children can be attributed to context-free substitutions, and thus suggest that Consonant Harmony may not be as common as previously assumed. Nevertheless, I argue that certain identification (or dismissal) of Consonant Harmony is not always possible since we do not know, in principle, the exact mechanism behind a given deviation from the adult target word.

Finally, the results of the present study are affected to some degree by inter-subject variation. The children in this study exhibited differences both in the use of Consonant Harmony (pervasiveness, duration, etc.) and in general language development (segmental, prosodic and lexical). These findings, other than being indicative of individuality in language acquisition, limit the extent to which general conclusions can be made.

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1. Introduction

Consonant Harmony (hereinafter, CH) is defined as assimilation between non-adjacent consonants (e.g. Cruttenden 1978), as in English /dɔg/ 'dog' → [gɔg] or Hebrew /panas/ 'flashlight' → /nanas/. It is relatively rare in adult languages (Hansson 2001), and there are no known languages with harmony involving primary place of articulation (Pater and Werle 2003).[1] In contrast, CH has been widely reported in the speech of children acquiring various languages; a partial list includes:[2] English (Lewis 1936/1951), Dutch (Levelt 1994), German (Stern and Stern 1907), French (Deville 1891), Italian (Keren-Portnoy et al. 2009), Spanish (Macken 1978), Greek (Drachman 1975), Hebrew (Ben-David 2001) and the following languages (Vihman 1978 and references therein): Estonian, Czech, Slovenian and Chinese. In addition to the abundant and cross-linguistic appearance of child CH, it has been found that harmony involving primary place of articulation is the most common type of child CH (Berg 1992, Goad 1997, Pater 1997).

The seeming universality of CH in child language and the apparent differences between child and adult CH have made child CH the topic of many studies. Some of the main research questions addressed in the literature relate to the source of CH, its phonological characteristics, its relation to adult grammars and its status in the course of acquisition. These questions and related studies will be discussed in the next section.

In the present study, I examine CH in the acquisition of Hebrew. The first part of the study is devoted to developing a method for separating true consonant-consonant assimilation from other context-free substitutions, an often undertreated issue. Applying the proposed method to the examined corpora reveals that a good many harmonized productions can be attributed to context-free assimilation and this may suggest that pervasiveness of CH in child language has been previously overrated.

In the second part of the study, I analyze the harmonized productions that were filtered in the first part, trying to find a possible account for each one. The analysis reveals several possible functions for CH; it can be used to replace unacquired segments in general or in certain prosodic positions, resolve difficult consonant sequences and compensate for

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[1] Hansson (2001) provides a list of about 100 languages and dialects (including some extinct ones) that have some form of CH (some have more than one type of CH). He does not specify the number of languages examined in total but claims that the survey was extensive. If these data represents all existing cases of CH then only about 2% of the world's languages (6909 according to Lewis 2009) have CH. On any event, the claim of the present study is that child CH is substantially different from adult's CH so the exact pervasiveness of adult's CH is not crucial.

[2] In general, I have cited the earliest or most notable study to report CH for each language.

prosodically complex productions. In many cases CH is observed on the first attempt of a target word, even if there is no apparent phonological need for using CH. In some cases it seems that CH is lexicalized as some words are harmonized consistently for long periods of time while the data in general do not provide evidence for a productive use of CH. The existence of many harmonized tokens for which there is no apparent motivation suggests that CH can be some form of non-productive error, much like adult slips of the tongue.

In the third and last part of the study, I analyze the properties of CH, focusing on its interaction with the segmental and prosodic development. The present study does not support previous claims that place harmony is governed by markedness hierarchies; for the children in this study, input frequencies seem to offer a better account for their trigger-target choice. In addition, the great diversity of trigger-target combinations and the fact that some of the most common triggers are also the most common targets indicate that CH is not exclusively dominated by segmental factors. Regarding manner harmony the picture is less clear - for one child, trigger-target selection reflects input frequency, while the other child tends to assimilate more sonorant to less sonorant consonants.

The analysis of prosodic factors reveals some positive correlation with CH. It is found that when the trigger and the target are in differently stressed syllables, a stressed trigger is preferred over an unstressed trigger. In addition, the directionality of assimilation between identical prosodic positions (e.g. onset-onset) seems to be correlated with the order of acquisition, namely that the prosodic word is acquired from right to left and newly acquired positions are assimilated to well-established ones. On the other hand, directionality of assimilation between onset and coda is less consistent with the order of acquisition, and in general the findings presented here are not absolute and have many counter examples.

One remarkable observation made in the present study is inter-child variation. The participants in the study differed from one another in several aspects: rate of development, extent of use in CH (and other processes), order of prosodic acquisition, etc. These differences highlight the individuality factor in the course of acquisition. However, these individual differences also limit the possibility to reach large scale generalizations.

2. Literature review

The fact that children harmonize words which are non-harmonic in the ambient language naturally brings up the question - why? The literature contains different proposals for the source of CH. These hypotheses depend much on the data available to the authors and on the theoretical framework they adopt. The latter was often a key factor in previous reviews of the phenomenon - studies were contrasted based on the formal treatment they proposed for CH, which often masked similar views of its cognitive source. This review attempts to bring previous studies to a common ground by “hiding” differences that stem from the choice of theoretical framework and adopting a functionalist point of view.

2.1 The source of Consonant Harmony

CH has been proposed to be some kind of a simplification mechanism, which helps the child handling the language acquisition task, by reducing the number of articulatory gestures (e.g. Waterson 1978, Klein 1981). The source of difficulty has been studied from two perspectives: a specific phonological/phonetic perspective and a general data processing perspective. These perspectives are discussed below.

2.1.1 Phonological aspect

Three main possible phonological/phonetic sources for CH have been suggested: segmental, phonotactic and prosodic. Vihman (1978) and Berg (1992) propose that CH may stem from a segmental source, i.e. that it is used for substituting consonants the child has not mastered yet. This claim is also raised in Leonard et al. (1980) with respect to CH in children with language disorders.

Many studies relate CH to phonotactic demands (though, not always as explicitly as suggested here), which can be either combinatorial or non-combinatorial. Combinatorial limitations mean that the child generally prefers harmonic over disharmonic productions or avoids the co-occurrence of certain feature sequences (Menn 1983, Donahue 1986, Matthei 1989, Pater 1997, Bernhardt and Stemberger 1998, Pater and Werle 2001, Pater and Werle 2003, Vihman and Croft 2007, Gerlach 2010, Becker and Tessier 2011). For example, Bernhardt and Stemberger (1998) claim that CH is “one way to avoid a [Coroanl…Labial] sequence”. Another type of combinatorial phonotactic account (Levelt 1994, Gafos 1999, Fikkert and Levelt 2008) proposes that apparent cases of CH may in fact result from assimilation of a consonant to the adjacent vowel (e.g. when the target word contains a front vowel only coronal consonants can be realized). A preference for harmonic patterns is typical of grammars with *harmony templates*, while restrictions on the co-occurrence of feature sequences define *melody templates* (Macken 1992, Macken 1995, Vihman and Croft 2007, Keren-Portnoy et al. 2009, Gerlach 2010).

Non-combinatorial limitations refer to the preference to license (or align) certain features to certain prosodic positions (Goad 1997, Rose 2000, Kappa 2001, Goad 2001, Goad 2004, Fikkert and Levelt 2008, Qu 2011) or the tendency to avoid certain features in certain prosodic positions (Berg 1992). For example, Goad (1997) attributes the predominant dorsal harmony in child's English to a demand for word-initial dorsal. Note that CH stemming from non-combinatorial limitations is actually not a pure consonant-consonant interaction, but rather an "epiphenomenon" of more general licensing demands.

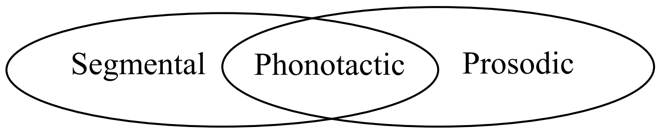
Phonotactic accounts of CH are supported by other child-specific non-assimilatory phenomena that give the same effects. For example, Kappa (2001), Fikkert and Levelt (2008) and Gerlach (2010) claim that metathesis may serve the same motivation as CH - aligning labials to word initial onset (e.g. /sup/ 'soup' → [fup] vs. /kɪp/ 'chicken' → [pɪk]) or avoiding non-labial…labial sequence. Similarly, Menn (1983) and Donahue (1986) suggest that deletion is an alternative means to avoid disharmonic sequences, and Macken (1978) proposes that children may use intra-word pauses to the same end.

Finally, CH may be related to the development of prosody, where it simplifies the articulation to help the child focus on new prosodic positions or deal with long words (Vihman 1978, Keren-Portnoy et al. 2009). This is what Ben-David (2001) and Bat-El (2009) propose in their studies of CH in Hebrew. They observe a synchronism between CH and the development of prosody, where syllables in polysyllabic words are acquired from right to left and onsets of newly acquired syllables are more likely to assimilate to onsets of more established syllables. Ben-David also refers to the interaction between CH and stress, noting that the first onset of disyllabic words is acquired (and assimilated) earlier when stress is penultimate while still omitted when the stress is ultimate. For example, in an early stage the child might utter /ˈsaba/ 'grandpa' as /ˈbaba/ but /saˈpa/ 'sofa' as [aˈpa]. According to Bat-El, the decrease in segmental faithfulness accompanying the expansion of the prosodic word reflects a "trade-off" effect whereby children simplify already acquired structures when they start to produce new ones (Garnica and Edwards 1977, Donahue 1986, Berg and Schade 2000, Bat-El 2009).

Some studies propose that CH may also be related to the development of the syntax and the lexicon. Waterson (1978) notes that the first CVC words in the lexicon of the child in her study had place and manner contrasts (e.g. /gʊd/ ‘good’ → [gʊd]), but later-acquired words failed to show such contrasts (e.g. /dʒʌg/ ‘jug’ → [gʌk]). As Waterson notes, the decline in contrast handling was observed during a stage characterized by a fast lexical growth and frequent use of two-word utterances. Thus, she claims that the child used CH as a means to cope with the growing complexity of his linguistic system, and that in general, increasing utterance or word length is first achieved by repetition of units. Similar claims regarding the interaction between CH and lexical/syntactic development are brought up in Donahue (1986) and Matthei (1989), who also note that the transition between single- and two-word utterances is governed by CH that operates across word boundaries (e.g. /baɪ keɪti/ ‘bye Katie’ → [gaɪ keki]) and avoiding word combinations with place contrast (i.e. lexical selection - see 2.4).

The inter-relation between the different hypothesized sources of CH is roughly sketched in (1).

(1) The Source of Child Consonant Harmony: Phonological/Phonetic Aspect

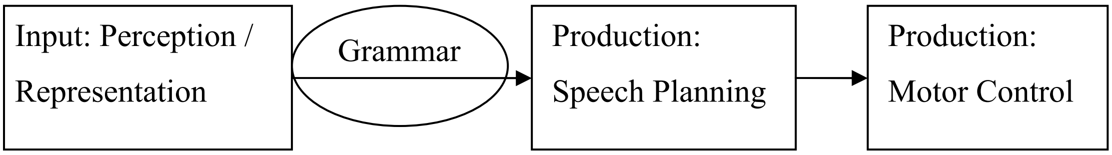


The illustration above demonstrates that the phonotactic account of CH can be seen as a special case of both segmental and prosodic limitations. The Segmental account refers only to the segmental content of the utterance (whether a certain consonant can be produced at all), while the prosodic account refers to the structure of the utterance (whether a certain prosodic position can be realized). The phonotactic account combines the other two accounts by putting limits on the production of certain consonants in certain positions or within a certain sequence.

2.1.2 Data processing aspect

The source of CH may also be addressed from a more general "data processing" point of view. In this approach, CH is treated as an indication of a problem along the input-output axis of data handling. The problem which leads to CH may reside on different loci along this axis: perception, storage and production. This is illustrated in (2).

(2) The Source of Child Consonant Harmony: Data Processing Aspect



In the case of CH, input problems mean that the target word is stored inaccurately in the child's lexicon. Although there are claims that child's representations are identical to the adult surface forms (e.g. Smith 1973, Berg 1992), some studies suggest that CH may result from underdeveloped representational or perceptual system. In such cases, the word is stored in either harmonized or incomplete form with underspecified consonant slots which are filled during retrieval (Fikkert and Levelt 2008, Qu 2011; see also Drachman 1975 and Dinnsen et al. 1997).

On the other hand, if the word is stored in a complete non-harmonic form then CH is a result of output failure. Output problems may arise in the processing phase during which the child retrieves the item from the mental lexicon and plans the utterance (Cruttenden 1978, Berg 1992, Berg and Schade 2000, Gormley 2003), or it may occur during the execution phase where commands are sent to the motoric system which is unable to perform accurately (Gafos 1999, but see Gormley 2003).

In between perception and production lies another component - the grammar (Gormley 2003). Children may analyze the word and alter it to conform with their current grammar (see Menn 1983, Spencer 1986, Becker and Tessier 2011). The question of whether this happens during storage or after retrieval is related to the *single vs. dual lexicon* problem (see Menn 1983, Spencer 1986, Goad 1997, Becker and Tessier 2011 among others) which is beyond the scope of this paper.

The data processing aspect of CH does not contradict the phonological/phonetic aspect, but rather complements it. Data processing is a general cognitive capacity which can be implemented to deal with data of acoustic type. For example, if the source of CH is segmental it can be related to either imperfect representation system (i.e. the problematic segment is missing from the representation altogether) or to underdeveloped motor system (i.e. the child can discriminate the sound but is unable to produce it). Similarly, CH can result from phonotactic limitations which probably reflect faulty speech planning, i.e. a difficulty in planning certain complex articulatory sequences.

2.2 The properties of Consonant Harmony

Most studies of CH have concentrated on its properties and on the interaction between them: the degree of harmony (partial or full), its valence (single or multi feature), the consonants (features) participating in the process,[3] directionality, the intervening vowel and the harmonic domain. Assessment of these parameters may shed light on the source of CH.

2.2.1 Valence and degree

CH can be *single featured*, i.e. involve a change in one feature - either *Place of Articulation* (e.g. /boʊt/ 'boat'→ [bop]) or *Manner of Articulation* (e.g. /lɪzɹ̩d/ 'lizzard' → [zɪzoʊd]), and it can be *multi featured*, i.e. involve a change in place and manner (e.g. /soʊp/ 'soap' → [bop]).[4]

Harmony can be *partial*, i.e. the trigger and the outcome agree in either place or manner (e.g. place agreement in /sneɪk/ 'snake' → [neɪt]), or *full* (=*complete)*, i.e. the trigger and outcome are identical (e.g. /tiːvi/ 'TV' → [tʰitʰi]).[5] According to Berg (1992) partial CH is somewhat more frequent than full CH and there are more cases of single than multi feature harmonies (the latter is also reported in Berg and Schade 2000 and Tzakosta 2007; see also Vihman 1978).

2.2.2 Features

Much attention has been devoted to the properties of the consonants involved in CH - the *trigger* consonant (the one carrying the features that are "borrowed" in the process), and the *target* consonant (the affected consonant). Studies focusing on this aspect often argue that

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[3] Here and everywhere else I use the term *process* in a descriptive way to refer to the change between the assumed target form and the child's production. I do not address the question of whether an actual phonological process is taking place as hypothesized in derivational theories.

[4] Examples are drawn from Bernhardt and Stemberger (1998).

[5] The terms 'partial' and 'full' are used ambiguously in the literature. Sometimes they refer to the number of changed features, where 'partial' denotes a change in either place or manner, regardless of the result (see for example, Tzakosta 2007). In other cases they denote the degree of similarity between the trigger and the outcome (e.g. Vihman 1978).

there is a certain hierarchy between triggers and targets, which may be universal, language-specific or partially both. Three main factors have been proposed to account for such hierarchies: (a) order of acquisition; (b) universal *markedness* (or *specification)* scales; and (c) language-specific input frequency or feature distributions. These proposals are often in conflict with one another and authors often provide counter evidence against each.

Lewis (1936/1951) proposes that the order of acquisition determines the hierarchy - late acquired segments are assimilated to well-established ones. This claim is contradicted by Cruttenden (1978) and Stoel-Gammon and Stemberger (1994). A more popular approach suggests that the strength hierarchy reflects universal markedness, i.e. that CH replaces unmarked (or underspecified) segments with marked (specified) ones. This proposal is based mostly on studies from English, where typically coronals are assimilated to labials and dorsals (Menn 1975, Cruttenden 1978, Stemberger and Stoel-Gammon 1991, Stoel-Gammon and Stemberger 1994, Pater and Werle 2003, Goad 2004 among others). However, this approach has it shortcomings as well: first, it has been shown that coronals can also trigger CH (Goad 1997, Pater and Werle 2003, Becker and Tessier 2011). Second, the relative strength of dorsals and labials is not agreed upon (e.g. Cruttenden 1978 vs. Pater and Werle 2003). Qu (2011) proposes to solve this conflict by assuming that the markedness of a consonant is reflected by the amount of structure it has in the representation system, and that the structure of different segments develops through time and in different paths for different children. For example, at some point of acquisition for some children, labials can be more complex and thus more marked than coronals and dorsal, and for other children dorsals can be the most marked segments.

Cross-linguistic comparison of CH has lead to the proposal that the strength trigger-target hierarchy is also affected, at least to some extent, by language-specific properties. Fikkert et al. (2002) note that in Dutch, unlike in English, labial harmony is far more common than dorsal harmony. They attribute this distinction to difference in place distributions between the ambient languages. Similarly, Berg (1992) accounts for the predominance of labial harmony in a German-acquiring child by the high frequency of words containing labials in critical positions in her lexicon. Tzakosta (2007) reports that harmony in Greek is triggered mostly by unmarked segments (i.e. coronals and stops), due to their high frequency in the language. Finally, Rose (2000) reports a French-acquiring child that has the following strength hierarchy: labial > coronal > dorsal. The status difference of coronals between English and French leads him to propose that CH is not governed by a universal trigger-target hierarchy.

Finally, another factor worth mentioning regarding the participants in CH is *similarity*. Vihman (1978), Berg (1992) and Bernhardt and Stemberger (1998) propose that assimilation is more likely when the trigger and the target are similar, i.e. share a certain feature, especially manner (see Rose and Walker 2004 and Wayment 2009 on the role of similarity in adult CH).

2.2.3 Directionality

The directionality of assimilation is perhaps the only parameter that gives cross-linguistic consistent results. CH is said to be *progressive* (left-to-right, or *perseveratory*) if the trigger precedes the target (e.g. /kæt/ 'cat' → [kæg]), and *regressive* (right-to-left, or *anticipatory*) if the trigger follows the target (e.g. /dɔɡ/ 'dog' → [ɡɔɡ]). All studies examining assimilation directionality report that regressive harmony is dominant compared to progressive harmony (Cruttenden 1978, Vihman 1978, Berg 1992, Pater 1997, Ben-David 2001, Tzakosta 2007 among others).

This seeming universality of directionality has been attributed to different factors. Some studies attribute directionality to phonotactics, i.e. the child replaces segments in specific positions in order to avoid certain sequences or to assign specific features to specific prosodic positions (Stemberger and Bernhardt 1997, Bernhardt and Stemberger 1998, Rose 2000, Pater and Werle 2003, Goad 2001, Goad 2004, Gerlach 2010). Donahue (1986) states, regarding this matter, that "direction of assimilation… is less important than place of articulation in accounting for consonant harmony". For example, Pater and Werle (2003) account for the predominant regressive dorsal harmony in Trevor's data as the result of avoiding sequences of [no dorsal…dorsal]. Tzakosta (2007) claims that directionality does not result from segmental considerations in general, but cases of progressive harmony usually involve the replacement of marked segments. To sum, under phonotactic accounts directionality is merely a consequence of limitations on utterance content.

Directionality can also be a consequence of prosodic limitations. Berg (1992) claims that CH in a German-acquiring child is mostly regressive "since she is comfortable with medial loci but initial loci are problematic for her" (p. 232). In terms of processing, Berg claims that the predominance of regressive harmony indicates *parallel processing*, i.e. that segments to come later in the word are planned simultaneously with those that come earlier. Similarly, according to Ben-David (2001), regressive harmony is the result of prosodic development which starts at the right edge of the word and advances leftwards with newly acquired positions being assimilated to well established ones. Kappa (2001) reports that directionality of CH in Greek is related to stress, namely that consonants in unstressed syllable are more likely to assimilate to consonants in stressed syllable than vice versa (see also Bernhardt and Stemberger 1998, Ben-David 2001).

2.2.4 The Harmonic domain

The harmonic domain (the extent to which harmony may spread) has been studied in some detail. Harmonic and other templatic patterns found in the speech of young children suggest that the harmonic domain is the whole word (e.g. Menn 1983, Vihman and Croft 2007, Fikkert and Levelt 2008). However, this evidence comes mostly from early produced words and from languages such as English and Dutch, in which CH is found mostly in mono- and disyllabic words, so they provide little evidence regarding the potential expansion of the harmonic domain (Goad 2004).

Furthermore, some studies try to define the dimensions of the harmonic domain in terms of smaller prosodic units. Rose (2000), Kappa (2001), Goad (2004), based on data from French, Greek and English, respectively, claim that the domain of CH is a foot. On the other hand, Tzakosta (2007) claims that the harmonic domain IS the prosodic word, based on evidence from Greek, where CH appears in utterances up to 5 syllables long (e.g. /a.fto.ˈko.li.ta/ ‘sticker-PL’ → [po.ˈpo.li.ta]), and is observed to spread to non-adjacent syllables (/ka.ˈpɛ.lo/ ‘hat’ → [ta.ˈtɛ.lo]).

Bat-El (2009) compares the properties of the harmonic domain (in onset-onset harmony) between typical and atypical harmony in Hebrew. She suggests that the harmonic domain is usually: (i) limited to two consonants in typical development (4 consonants in atypical development); (ii) aligns with the left edge of the prosodic word in typical development (but not necessarily in atypical development); (iii) limited to maximally trisyllabic productions in typical development (but is found in quadrisyllabic productions in atypical development).

Finally, as noted in 2.1, some studies report that CH may cross word boundaries (e.g. /bɪg mus/ ‘big moose’ → [mɪ mu] in Matthei 1989), suggesting that the harmonic domain may also encompass a whole utterance in the earliest stages of acquisition (Donahue 1986, Matthei 1989, Macken 1992). In their work on *Optimal Domains Theory of Harmony* (originally proposed for adult vowel harmony), Cole and Kisseberth (1994) propose the principle of *Extension* according to which, large harmonic domains enhance perceptibility of features and provide articulatory stability. This principle can provide a phonetic motivation for child CH as well, while restrictions on the size of the harmonic domain can reflect the need to preserve contrast and enhance communication.

2.2.5 Intervening segments

Most studies regard CH as a pure consonant-consonant interaction, and the intervening vowel is normally regarded as transparent to the process (e.g. Rose 2000, Goad 2001, Kappa 2001, Gormley 2003). However, some studies acknowledge the effect of the intervening vowel in CH. Levelt (1994) and Fikkert and Levelt (2008) suggest that at least a part of CH in child's Dutch is in fact a result of consonant-to-vowel assimilation. Similarly, there is evidence from English that CH triggered by coronal consonants is more common when the intervening vowel is front and that CH triggered by dorsal consonants is more common through a back vowel (Macken 1995, Bernhardt and Stemberger 1998, Pater and Werle 2003, Gerlach 2010, Becker and Tessier 2011 among others).

The majority of CH cases involve interaction between "neighboring" consonants, i.e. where only a vowel between them. However, some studies (Bernhard and Stemberger 1998, Tzakosta 2007) report on harmony that affects relatively distant consonants, leaving intervening consonants intact, especially sonorants. For example (Tzakosta 2007), coronal harmony that skips a labial nasal in /kaˈmila/ 'camel'→ [taˈmila] and dorsal harmony that skips a coronal liquid in /sxo.ˈli.ko/ 'school bus' → [ko.ˈli.ko].[6]

2.3 Consonant Harmony and adult grammar

As mentioned earlier, there seems to be an overwhelming difference between child and adult CH. CH is exhibited by children acquiring different languages, including those that have no productive CH in the adult grammar. This finding leads to the question of whether CH is a part of the universal innate grammar. Many studies claim that CH is universal (Smith 1973). This claim often stems from the *Continuity Assumption* of language acquisition which can be defined as the assumption that "the child's grammar is realized in his or her linguistic performance in the same qualitative way as for adults" (Pinker 1984). This assumption is formalized by constructing a grammar that allows both the universal appearance of CH in child language and its "universal absence" from adult grammars (e.g. using CH constraints

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[6] Rona Blumberg (pc) proposed to refer to such transparent consonants as *consonant islands.*

which are highly ranked at the beginning of acquisition and are later demoted gradually until losing effect in the mature grammar).

Some studies attempt to provide empirical evidence in favor of the universality claim, by pointing to similarities between child CH and adult phonological phenomena. Macken (1995) and Pater and Werle (2003) propose that the constraints that govern child CH can also account for adult languages phenomena such as contact place assimilation. Cruttenden (1978) claims that CH also resembles historical change patterns involving assimilation and adult slips of the tongue (see also Hansson 2001 and references therein). He notes that these processes usually operate in regressive directionality and involve substitution of coronals.

In this context it should be noted that although CH is usually treated as a systematic process in the child's productive grammar, it is not to say that all cases of CH are of the same nature. Stemberger (1989) reports that young children show non-systematic errors which closely resemble adult slips of the tongue, some of them can be described as CH (however, these cases usually involve interactions between words, while CH usually involve intra-word assimilation). In addition, some words exhibiting CH for a long period of time may be, in fact, "fossilized" forms that persist for some period after the rule that created them ceases to exist.

In addition to some examples of non-systematic CH, some studies even claim that CH is not universal to begin with. The fact that not all children use CH systematically (Vihman 1978) may serve as counter argument against universality. Furthermore, it has been reported that CH is an emerging phenomenon, in that it is not always present from the beginning, but rather appears in the child's productions in same later stage. Some authors claim that the emergent nature of CH suggests that it is the result of children analyzing their lexicon and making overgeneralizations (Vihman 1978, Menn 1983, Berg 1992, Vihman and Croft 2007, Fikkert and Levelt 2008, Becker and Tessier 2011).[7]

2.4 Consonant Harmony in the scope of language development

CH is only one of many phonological processes attested in child's speech which is rare or completely absent from the ambient language. These processes (see Grunwell 1982/1984) include *consonant deletion* (e.g. /dʒuːs/ 'juice' → [du]), *fricative stopping* (/feɪs/ 'face' →

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[7] This emergence of harmonic patterns in the child's productions causes what seems like a regression in development, a phenomenon also known as *regressive overgeneralization* (Stoel-Gammon and Stemberger 1994) and *U-shaped pattern of development* (Donahue 1986, Fikkert and Levelt 2008, Becker and Tessier 2011), and is strongly connected to the *trade-off effect* (see 2.1).

[peɪt]), *velar fronting* (/bæk/ 'back' → [bæt]) and *reduplication* (/pʊdiŋ/ 'pudding' → [pʊpʊ]) among others.

Reduplication is of special interest to the study of CH since many productions are ambiguous between CH and reduplication, which can be viewed as a combination of (full) CH and vowel harmony (Ferguson et al. 1973, Smith 1973, Leonard et al. 1980), e.g. /wɪndoʊ/ 'window' → [nono]. Goad (1997, 2001) proposes that both CH and reduplication are motivated by licensing constraints, but with some difference: CH stems from prosodic (or rather phonotactic) requirements, while reduplication is a morphological phenomenon which occurs to give content to an affix. Goad claims that CH formally resembles reduplication as they both involve melody copy as opposed to vowel harmony which involves feature spreading. Tzakosta (2007) differentiates between CH and reduplication by arguing that CH involves segmental or featural copy while reduplication involves syllabic or foot copy. In this study I will consider all instances of fully harmonized consonants as instances of CH and not reduplication.

In addition to the phonological repairs mentioned above, children are also reported to use a *lexical selection* strategy, i.e. avoiding words which contain certain difficult elements or combination of elements, such as consonants with place contrast (Menn 1975, Vihman 1978, Menn 1983, Donahue 1986, Matthei 1989, Vihman and Croft 2007 among others).

In this context, it would be natural to ask what the relation between CH and other phenomena is. Chronologically, CH is observed in the earliest stages of the acquisition and it is one of the first processes to disappear from the child's system, normally around the age of 2;06 years (Grunwell 1982/1984). It might replace or be used in parallel to other strategies such as lexical selection, deletion and debuccalization, all "conspiring" to simplify the utterance. For example, Menn (1983) claims that a child may use CH or delete a segment in order to avoid disharmonic sequences (e.g. /dɔg/ 'dog' → [gɔg] vs. /geɪt/ 'gate' → [gej]). According to Berg and Schade (2000) and Ben-David (2001) CH is used in newly acquired prosodic structures which exhibited deletion on earlier stages. Vihman (1978) proposes that CH is a successor strategy to lexical selection - both are used to avoid words with difficult segments.

The relation between CH and other substitution (or feature change) processes is extremely important to the present study. As is often the case, a certain consonant substitution (e.g. stopping, fronting) resulting in a harmonic form can be described as a result of either assimilatory or non-assimilatory substitution. Tzakosta (2007) explicitly addresses this issue and claims to use only clear cases of CH in her study (excluding productions that can be described e.g. as stopping). Similarly, in order to isolate CH from other phonological processes, Stoel-Gammon and Stemberger (1994) examine different types of feature change and note the number of subjects who use each type in assimilatory and non-assimilatory fashion.

Klein (1981) provides a more detailed criterion for determining CH: first, context-free substitutions were identified in monosyllabic items that did not present the opportunity for the operation of assimilation processes. Then, after identifying these processes for each lexical item, CH was assessed with the requirement of two occurrences in separate lexical items. Finally, Fikkert and Levelt (2008) claim that many apparent cases of CH in child's Dutch can be explained away as incidental surface realizations of other phenomena that serve a common motivation (e.g. labial initial licensing). In this study, I carefully attend to the distinction between context-free substitutions and CH which is context-dependant by definition. I will propose a statistically based method to separate genuine cases of CH from context-free consonant substitutions that occasionally result in harmonic productions.

3. Consonant Harmony identification

The first part of the study lays the foundations for the analysis of CH, but it is also important on its own. Here, I propose a methodology for identifying context sensitive assimilation, which might be used for other purposes as well.

3.1 Database and corpus analysis

The database for this study comprises of transcribed speech samples from two typically-developing Hebrew-acquiring children. The participants were a boy (SR) between ages 1;02.00 and 2;03:24 years (Lustigman 2007) and a girl (RM) between ages 1;03.13-2;11.28 years (Levinger-Gottlieb 2007). They were audio-recorded in weekly sessions for a period of several years while interacting with the investigators and occasionally additional participants (mostly family members). The data, mainly in the form of spontaneous speech samples and some elicitation tasks (picture naming and telling stories from picture-books) were collected and transcribed in the frame of the Tel Aviv University *Child Language Project*.[8]

For the purpose of this study, I examined in detail a large portion of each child's corpus. This includes most of the target words attempted by the child which are potential candidates for CH, namely, words with at least two non-adjacent consonants.[9] I considered only token words for which a clear relation between input and output consonants could be established (at least under reasonable assumptions).[10] For all the examined token words, the relations between input and output consonants were coded according to different phonological processes. For example, in /ze.ˈev/ 'wolf' → [de.ˈev] the relation between target *z* and surface *d* was coded as 'fricative stopping' and the relation between target and surface *v* was coded as faithful. In addition, every consonant substitution occurring in a harmonic environment was marked as possible CH (e.g. for /ken/ 'yes' → [ten] the relation between /k/ and [t] was coded as velar fronting + possible CH).[11]

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[8] The project was supported by ISF grant #554/04 (2004-2008) with Outi Bat-El and Galit Adam as principal investigators.

[9] Words that do not qualify as candidates to undergo CH are words with one consonant (e.g. /po/ 'here') and words in which all consonants are clustered (e.g. /dli/ 'bucket').

[10] Examples for excluded words due to non-clarity: /jal.ˈda/ 'girl' → [taχ] (RM 1;07.10), /kaˈduʁ/ 'ball' → [ˈbuma] (SR 1;03.14)

[11] Assimilation to a string adjacent consonant is not considered as case of CH. This is true even for target words that contain a consonant with the relevant harmonic feature, which is not string adjacent to the changed consonant (e.g. /lif.ˈtoaχ/ → /[liʃ.ˈtoaχ] is not CH even though the change /f/ → [ʃ] could theoretically be triggered by *l*).

The following table provides details on corpora sizes and amount of substitutions, specifically those resulting in harmony. Note that, up to this point, I did not address the question of whether a certain substitution type is the result of long distance consonant-consonant assimilation. To prevent confusion, I use the term *harmony* in reference to utterances that are harmonic with respect to a certain feature, regardless of the cause of harmony, and reserve the term *assimilation* when referring specifically to the process known as CH (e.g. consonant-to-consonant assimilation).

(3) General corpus analysis

	SR			**RM**		
	N	**% of tokens**	**% of subs.**	**N**	**% of tokens**	**% of subs.**
Tokens	13471	100%		19217	100%	
Substitution	687	5%		3462	18%	
Harmony	356	3%	52%	1017	5%	29%

Examining the details above it can be seen that the children have somewhat different developmental inclinations, even though they are both considered as typical developers. RM is quite an average developer showing a substantial amount of substitutions. SR, on the other hand, is a relatively fast learner exhibiting a high rate of faithful productions and a marginal use of substitutions. Within the class of substitutions it seems that many instances result in harmonic productions which may give the impression that harmony is a major force in their grammars.

The phonological development of the children can be evaluated also from a segmental point of view. Table (4) provides details on three major behavior types of consonants: faithful production, deletion, and substitution (the differences in the category of substitution between (3) and (4) are due to the fact that some tokens contain more than one instance of substitution).

(4) Consonant production

	SR			RM		
	N	% of total	% of subs.	N	% of total	% of subs.
Total	38366	100%		53144	100%	
Faithful	32483	85%		42069	79%	
Deletion	5160	13%		7093	13%	
Substitution	723	2%		3982	7%	
Harmony	375	1%	52%	1210	3%	30%

The difference between the children is reflected here as well. They delete consonants at the same rate, but SR has a higher rate of faithfully produced consonants and a lower rate of substitution. This difference between the children is important for the present study as will be demonstrated in the following sections.

In addition to evaluation of individual development, this study aims to provide a comparative analysis of the children. However, since different children have different developmental rates and tracks (Waterson 1978, Vihman 1978, Klein 1981, Menn 1983, Menyuk et al. 1986, Macken 1995 among others), and since the age ranges covered in the study are different, a scaling device is required. I chose to compare the children based on lexical development. As described in Adam and Bat-El (2009), I defined stages of lexical development based on cumulative target words attempted by the child. Stage 1 was defined as the period covering the first 10 words, and advanced stages were defined as integer multiples of 50 cumulative attempted target words.

The notion of "target word" deserves some explanation. In the construction of the lexicon, I considered as lexical entry every item that the child appeared to use as a unit of meaning. This includes everything that is normally considered as a word (object names, verbs, etc.), compounds (e.g. /jom+huledet/ 'birthday') and even different kinds of interjections (e.g. /waw/ 'wow') and onomatopoeias (e.g. /mjaw/ 'meow'). I excluded from the list all inflection forms, e.g. /kelev/ 'dog' - /klavim/ 'dogs' (the question of whether they belong to one or two lexical items is beyond the scope of this paper).

Table (5) portrays the lexical development of SR and RM (see an alternative construction in Karni 2011).

(5) Lexical development

Stage	(Cumulative attempted targets)	SR	(Sessions)	RM	(Sessions)
1	(~10)	1;02.00-1;02.20	(4)	1;03.13-1;04.02	(4)
2	(~50)	1;02.24-1;04.17	(8)	1;04.09-1;05.29	(8)
3	(~100)	1;04.24-1;05.08	(3)	1;06.05-1;07.10	(6)
4	(~150)	1;05.15-1;05.21	(2)	1;07.24-1;08.27	(5)
5	(~200)	1;05.29-1;06.02	(2)	1;09.10-1;09.27	(3)
6	(~250)	1;06.12-1;06.20	(2)	1;10.06-1;10.28	(3)
7	(~300)	1;06.26-1;07.02	(2)	1;11.18-1;11.18	(1)
8	(~350)	1;07.09-1;07.09	(1)	1;11.25-2;00.02	(2)
9	(~400)	1;07.17-1;07.23	(2)	2;00.09-2;00.09	(1)
10	(~450)	1;08.03-1;08.24	(4)	2;00.16-2;00.16	(1)
11	(~500)	1;09.00-1;09.12	(3)	2;00.30-2;01.12	(3)
12	(~550)	1;09.19-1;10.07	(3)	2;01.19-2;01.19	(1)
13	(~600)	1;10.26-1;11.07	(3)	2;01.27-2;02.11	(3)
14	(~650)	1;11.16-1;11.22	(2)	2;02.18-2;02.25	(2)
15	(~700)	2;00.00-2;00.05	(2)	2;03.01-2;03.01	(1)
16	(~750)	2;00.21-2;00.27	(2)	2;03.14-2;04.05	(4)
17	(~800)	2;01.06-2;01.11	(2)	2;04.12-2;04.25	(3)
18	(~850)	2;01.25-2;02.02	(2)	2;05.09-2;05.27	(3)
19	(~900)	2;02.06-2;02.06	(1)	2;05.29-2;06.19	(4)
20	(~950)	2;02.17-2;02.22	(2)	2;06.29-2;09.06	(3)
21	(~1000)	2;02.27-2;03.24	(2)	2;09.13-2;09.29	(3)
22	(~1050)	2;03.24	(1)	2;10.03-2;11.03	(3)
23	(~1110)	-	-	2;11.14-2;11.28	(2)

The lexical development scheme provides another evidence for the developmental gap between the children: SR's first word is recorded at the age of 1;02.00 - a month and a half earlier than RM (1;03.13). What's more, SR reaches a lexicon size of about 1050 words nearly 8 months before RM.

3.2 Assimilatory vs. non-assimilatory substitutions

3.2.1 Motivation

One of the main issues addressed by the present study is the identification of CH. As discussed in 2.4, independently motivated context-free substitutions may occasionally result in a harmonic production which obscures the motivation behind the process. Previous studies (Klein 1981, Stoel-Gammon and Stemberger 1994, Tzakosta 2007) acknowledge this problem, and differentiate between substitutions in harmonic and non-harmonic environments. In this section, I elaborate their solutions and propose a quantitative method for identification of long distance consonant-consonant assimilation.

3.2.2 Method

In order to determine whether a certain type of consonant substitution is assimilatory for a given child, I compared the developmental distributions of harmonic and non-harmonic occurrences of the given substitution. This was done in the following way: for every stage of lexical development, I counted the occurrences of the substitution in question in harmonic and non-harmonic environments. The counts were based on *production type per stage*, i.e. two productions identical in consonants were listed as one entry if produced on the same stage and as two entries if produced on different stages.[12] This practice was used in order to minimize token frequency effects (i.e. frequent use of certain words that may bias the analysis[13]) and also to create a basis for developmental comparison between the children (since their ages and recording periods are different). The settings used to examine fricative stopping for SR is given in (6) an example.

(6) Fricative stopping comparison (SR)

Stage	**Harmonic**	**Non-Harmonic**
1	0	0
2	1	1
3	5	1
4	0	1
5	2	0
6	2	1
7	2	4
8	0	3
9	1	4

[12] Since I am interested in consonantal interactions I ignore any vowel changes.

[13] For example, some 50 productions of /ken/ ‘yes’ as [ten] by RM, which give extra weight to velar fronting in harmonic environments.

Stage	Harmonic	Non-Harmonic
10	3	2
11	1	6
12	6	4
13	2	2
14	3	4
15	2	1
16	1	0
17	1	1
18	1	3
19	2	2
20	1	1
21	1	2
22	0	0

For each list as above, a Wilcoxon signed-rank test was run[14] to check whether there was a significant difference between the distributions of the harmonic and non-harmonic instances with the null hypothesis that there was no difference (i.e. that the substitution is independent of consonantal environment). I consider a certain type of consonant substitution to be non-assimilatory if the statistical test did not yield a significant result (i.e. $p>0.05$) or if the result was significant but the number of non-harmonic instances was greater than the number of harmonic instances (in the latter case, the significant result supposedly suggests that the child prefers to substitute in non-harmonic environments). Since some substitution types were used rarely by the children a statistical test would not always be reliable. The test was performed only when the number of degrees of freedom (the number of stages in which there was a difference between the number of harmonic and non-harmonic items) was 10 or greater. When the number of degrees of freedom was between 6 and 9 no p-value was obtained and the test statistic *W* was examined against the table of critical values (Lowry 2012):

(7) Critical Values of ±W for Small Samples (α=0.05)

df	$W_{critical}$
6	21
7	24
8	30
9	35

[14] The test was performed online at: http://www.vassarstats.net/wilcoxon.html.

Therefore, I performed a statistical test for every type of substitution that occurred in at least 10 developmental stages (and an evaluation against a critical value in the case of 6-9 degrees of freedom) either in harmonic or non-harmonic environment (so, in the example in (6) stages 1 and 22 are excluded). For substitutions found in less than 6 stages, a statistical test would be less reliable, and thus, I had to rely on linguistic considerations alone in these cases (which usually meant giving the child maximum credit for assimilation).

3.2.3 Results

The following table summarizes the non-assimilatory phonological substitutions. For each substitution type, the table indicates the total number of harmonic and non-harmonic instances, the result of the Wilcoxon test, the test statistic and the degrees of freedom. Entries for the table met one of the following criteria: either statistical analysis ruled the substitution as non-assimilatory for both children; or the substitution was determined as non-assimilatory for RM and there was not enough data for SR to perform the Wilcoxon test (df < 6). In the latter case an evaluation was not performed over SR's data and only the number of instances and degrees of freedom are included. Under the assumption that if a substitution is non-assimilatory for one child it is not assimilatory for the other, I declare all the substitutions in the table as non-assimilatory for both children. I will further elaborate on this assumption in the next section. Note that some of the place change processes were specified for manner (e.g. dorsal stop to labial). This separation for manner was done since different manner groups show different behavior.

(8) Non-assimilatory substitutions

Process	**SR**					**RM**				
	Har.	**Non-Har.**	**p**	**W**	**df**	**Har.**	**Non-Har.**	**p**	**W**	**df**
Devoicing	7	26	0.0027	-96	14	213	341	0.0003	-195	20
Voicing	25	28	0.984	1	14	96	114	0.0375	-120	21
Sonorant Gliding	1	20	0.0178	-47	10	34	291	0.0001	-231	21
Fricative Stopping	37	43	0.5419	-22	15	118	246	0.0005	-161	18
Nasal Stopping	5	3		7	6	80	79	0.7872	16	21
Glide Stopping						11	13		-7	9
Lateral Stopping	3	2			5	25	26	0.984	-1	12
Lateral to Nasal	0	1			1	15	22	0.5552	-12	10
Stop Frication	2	5			2	33	61	0.0209	-90	16

Process	SR					RM				
	Har.	**Non-Har.**	**p**	**W**	**df**	**Har.**	**Non-Har.**	**p**	**W**	**df**
Stop to Nasal	7	2		15	6	16	26	0.2627	-44	16
Dorsal Stop to Coronal	12	6		15	8	77	76	1	0	16
Dorsal Stop to Labial	2	1			3	3	17	0.0091	-67	12
Coronal Stop to Dorsal	9	3		22	8	13	8		16	8
n to *m*	8	2			5	4	15	0.0178	-47	10
n to *ŋ*						10	5	0.2113	25	10
m to *n*	2	5			5	17	8	0.0629	37	10

The following two processes were abundant enough in RM's data to yield significant results for assimilation (SR did not have enough data for these processes for statistical analysis):

(9) Significant assimilatory substitutions

Process	SR					RM				
	Har.	**Non-Har.**	**p**	**W**	**df**	**Har.**	**Non-Har.**	**p**	**W**	**df**
Dorsal Fricative to Coronal						14	5	0.0434	46	11
Labial Fricative to Coronal	3	0			1	17	2	0.0178	47	10

The classification method adopted for this part of the study intended to yield a unified analysis for both children, under the assumption that the motivation behind a given phonological process should be the same for all children acquiring the same language. However, in at least one instance this did not seem the right way to go. The following table compares the substitution of labial stops with coronal stops for both children.

(10) A process in dispute

Process	SR					RM				
	Har.	**Non-Har.**	**p**	**W**	**df**	**Har.**	**Non-Har.**	**p**	**W**	**df**
Labial Stop to Coronal	18	2	0.0155	48	10	9	8		1	6

Looking at the numbers in the table, it seems that the children go in somewhat different directions with respect to the process in question. The statistical analysis suggests that the process is assimilatory for SR, and although the sample size for RM was small (df = 6), we cannot ignore the fact that she did not show a preference for harmonic environment. In this particular case alone I allowed differentiation between the children and analyzed the substitution as harmonic for SR and as non-harmonic for RM. The implications of this decision will be discussed in the next section.

In addition to the cases presented above, the children had a few dozens of substitution types that were not abundant enough to be tested statistically for context dependence. These cases generally involve a change of both place and manner (e.g. /si.ˈka/ 'pin' → [gi.ˈka], RM: 1;09.27), and since they are not observed in non-harmonic environments they are less expected to result from anything other than assimilation. From this point and on, I ignore changes in voice, as the analysis (and also the literature, e.g. Vihman 1978, Tzakosta 2007) suggests that they are rather independent of segmental context (besides, of course, contact voicing assimilation, which was not considered here to begin with). The identification process applied here yielded 89 cases of CH for SR and 142 for RM. Collecting back all the tokens of CH (including repetitions within a stage) we get 176 tokens for SR and 145 RM. These will be analyzed in the following sections. Full lists of CH tokens are provided in an appendix.

Going back to (4), we can now estimate the status of CH in the children's grammars. Recall that 5% of SR's tokens contain substitutions. The 176 assimilatory tokens equal to 26% of his substitution cases but to only 1.3% of his entire corpus size. For RM, substitutions are found in 18% of her data. Her total number of assimilatory tokens amount to only 4% of all her substitution cases and to a negligible 0.8% of her entire corpus.

3.2.4 Discussion

In this section, I proposed a quantitative method for separating long distance consonant-consonant assimilation from context-free consonant substitution. The need for such a method arises especially in borderline cases (e.g. Coronal Nasal to Dorsal, Dorsal Fricative to Coronal) where it is not obvious whether there is enough evidence to determine whether the process is (non-) assimilatory.

Alas, I claim that even this detailed procedure cannot be guaranteed to provide the ultimate results, and for a fundamental reason. Given that children use many different phonological processes which occasionally give ambiguous results, it is essentially impossible to determine the motivation behind a particular phonological change. Even for processes such as velar fronting, which are considered as context-free (e.g. Inkelas and Rose 2008), it is quite possible that the "desire" for harmony is involved in some of their instantiations.

The procedure performed here points another substantial difficulty in recognizing CH - inter-subject differences. Although we would like to assume that a given phonological process serves the same function for different children acquiring the same language, one cannot ignore individual differences in development. In the present study, two inter-subject differences are highlighted. Quantitatively, RM is a productive "substituter" and provides enough data to identify most of her context-free substitutions. SR, on the other hand, is such a fast learner that he barely uses even common processes as velar fronting, and thus it is much harder to determine which of his substitutions are context-free.

The more serious problem arises in processes for which the children provide conflicting evidence. In some cases (e.g. Coronal Nasal to Labial), I "dismissed" the conflict by giving more weight to RM's results due to larger amount of data in her corpus. However, in the case of Labial Stop to Coronal the difference between the children was too large, in my opinion, to "force" unity on their individual assessments. By taking this decision, I practically admit that a given phonological process may appear under different circumstances in different children. I leave it for future studies to argue on this matter.

The identification process enables us to estimate the status of CH within the grammar of a child. I have found that 26% of SR's substitutions can be attributed to CH as opposed to only 4% in RM's case. This can lead to a conclusion that SR is a productive user of CH while RM is not. However, the validity of such a conclusion is questionable considering the phonological background of the children. Recall that 18% of RM's tokens exhibit substitutions as opposed to only 5% in SR's data. It is very likely that the apparent difference in the use of CH is merely an artifact resulting from the differences in corpora size and the identification process. In order to evaluate this possibility, let us recall the data in (3). When considering the amount of harmonization in their data, whether resulting from assimilation or not, only a small fraction of these instances can be attributed to assimilation with certainty. It might be the case that the criterion for assimilation was too rigid, leaving out genuine cases of CH. On any event, even when assuming that every instance of harmony is the result of assimilation there is still notable difference between the children: 52% of SR's substitutions lead to harmony, compared to 29% for RM. It might, after all, be the case that harmony is more important for SR than for RM, but since SR uses substitutions to a much lesser degree the results might be misleading.

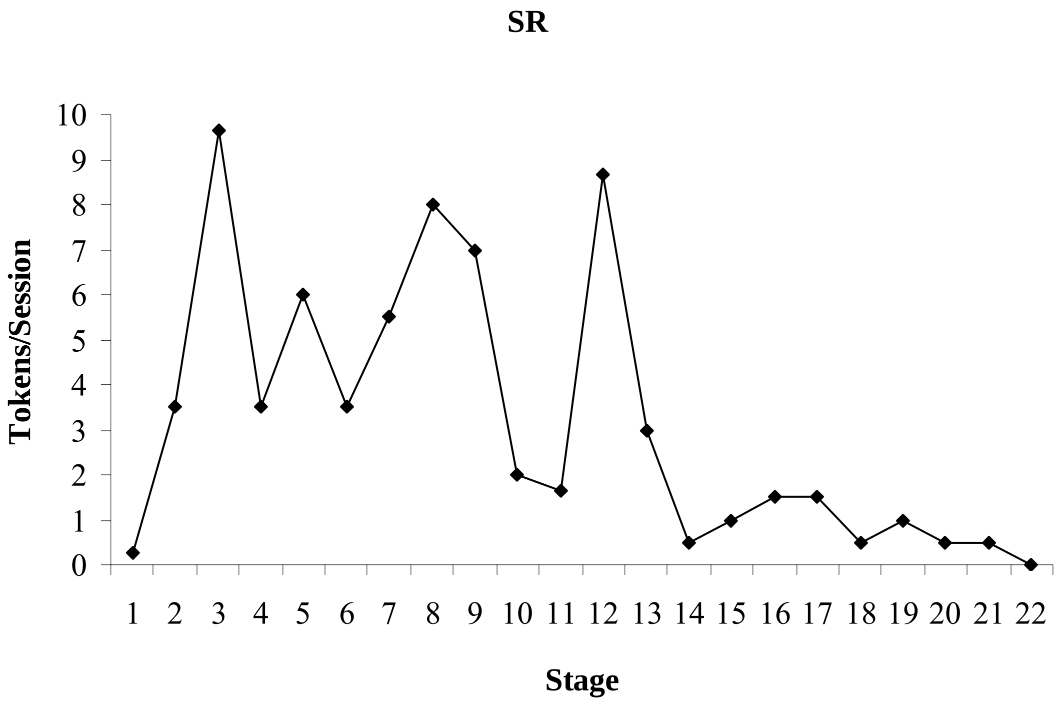
4. The source of Consonant Harmony

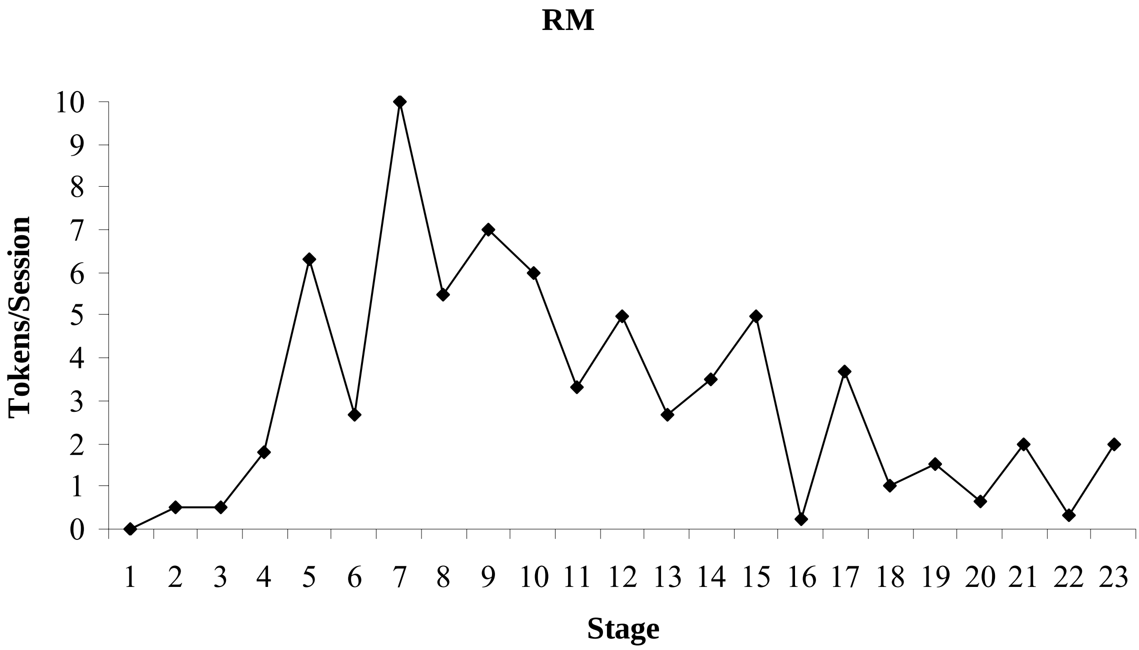
In this part of the study I analyze the utterances that "passed" the identification process for assimilatory substitutions in order to evaluate potential sources for CH. I will start with a general developmental survey to see whether CH is particularly common during certain stages of development.

4.1 Developmental overview

The charts in (11) illustrate the development of harmonic patterns with age for SR and RM, respectively. Each chart indicates the average number of harmonic tokens per session produced by the child on a given stage (see (5)).

(11) Development of Consonant Harmony





The charts above show that CH is present in the children's productions throughout the study period, though not in a high dosage. For SR, the number of assimilatory instances reaches a maximum of 9.7 tokens per session on stage 3 (1;04.24-1;05.08), then oscillates until reaching a peak of 8 tokens on stage 8 (1;07.09) and another peak of stage 8.7 tokens per session on stage 12 (1;09.19-1;10.07), after which it declines and never rises above three tokens per session after stage 13 (1;11.16 and on). The non-monotonic picture is exhibited in RM's data as well. For her, a maximum of 10 assimilated tokens is achieved on stage 7 (1;11.18). She has a smaller peak of 5 on stage 15 (2;03.01) and another 3.7 token per session peak on stage 17 (2;04.12-2;04.25) which comes after only one item in 4 sessions on the previous stage. After stage 17 CH is diminished but does not disappear completely. The analysis presented here demonstrates again that the children develop at different paces - SR's CH virtually disappears around the age of 1;11.16 (stage 14) while RM continues to use CH until nearly the age of 3 (the end of recorded data).

As we saw here and in section 3, CH is a rather marginal phenomenon in the data providing rather small figures, especially for a stage-by-stage analysis. For example, on SR's stage 3 when his harmony is most pervasive he has 29 harmonized tokens compared to 373 tokens in total. For that reason, my analysis from this point on will not focus on the course of development.[15] This matter will be acknowledged again in 5.3 when I discuss prosodic development.

4.2 Phonological aspect

In this section, I examine the harmonized productions in order to determine whether they are related to specific aspects of phonological development, i.e. whether CH is used for replacing unacquired consonants, simplifying difficult sequences or compensating for prosodic complexity.

4.2.1 Segmental

CH is said to have a segmental source if it replaces an unacquired segment. A support for this hypothesis would be the existence of a harmonized token in which the target of assimilation has not been produced faithfully prior to that utterance. In order to asses the CH data for segmental factors, I compared the age of each harmonized token with the first faithful production of the target consonant. The analysis did not find relevant cases in RM's data but did reveal a few such tokens in SR's data. The next table presents the tokens in which the harmony is suspected to come from segmental motivation. The first appearance of the target consonant in SR's productions is also presented for comparison.

(12) Consonant Harmony of segmental source (SR)

Target	Harmonic token				First production of target consonant			
	Target word		**Utter.**	**Age**	**Target word**		**Utter.**	**Age**
ʁ	paʁ.ˈpaʁ	'butterfly'	ˈpa.pap	1;02.16	paʁ.ˈpaʁ	'butterfly'	ˈpa.paʁ	1;03.25
v	tsav	'tortoise'	tsaz	1;04.10	a.fi.ˈfon	'kite'	ʔa.di.ˈvoo	1;04.24
	"	"	taz̪	1;04.10	"	"	"	"
	"	"	ðaθ	1;04.10	"	"	"	"
	a.vi.ˈʁon	'airplane'	ʔa.ni.ˈon	1;04.24	"	"	"	"
f	dʒi.ˈʁa.fa	'giraffe f.'	ʒi.ˈja.ja[16]	1;04.24	kof	'monkey'	kof	1;04.24
	"	"	di.ˈja.ja	1;04.24	"	"	"	"

[15] With the exception of references to selected age points determined by the first appearance or attempt of certain segments, sequences and words.

[16] In some cases the two consonants participating in the assimilation process undergo changes. I take the consonant that undergoes only non-assimilatory changes to be the trigger of CH, e.g. in /dʒi.ˈʁa.fa/ → [ʒi.ˈja.ja] I take the change /ʁ/ → [j] to be non-assimilatory (see 3.2.3).

The items brought here are possible examples for CH of a segmental source. However, the fact that it is found only in a limited number of target words (4 target words, 7 tokens) indicates that CH is not a productive strategy for substituting difficult segments. Note that the harmonized tokens of /a.vi.ˈʁon/ and /dʒi.ˈʁa.fa/ are found in the same session in which SR first produced *v* and *f*, but the faithful productions appear after the harmonic ones. Also note that the analysis presented here is somewhat speculative, since it relies on the child's performance during a time-limited weekly session (however, this is true for acquisition studies in general and we may assume that children's performance during the session reflects their competence around that time).

4.2.2 Phonotactic

Another possible source for CH is phonotactic limitations. One type of phonotactic limitation is combinatorial, i.e. limitations on the co-occurrence of certain segments. In order to determine if a certain case of CH results from co-occurrence restrictions I searched the corpus for earlier productions containing that sequence, e.g. for /ˈʃe.meʃ/ 'sun' → [ˈme.meθ] (SR: 1;09.09), I searched SR's corpus for utterances containing the sequence [ˈʃe.m] up to the age of 1;09.09 (not including). Whenever I could not find an exact match I relaxed the condition in one of several ways: allowing different prosodic pattern (e.g. [ʃe.ˈm] ~ [ʃem]), allowing different intervening vowel (e.g. [ʃa.ˈm]), and in some cases even different consonants (e.g. [se.ˈm]). I took the liberty to do the last move when the consonant in question is used by the child interchangeably with other consonants. This is true mostly for voiced-voiceless consonant pairs and coronal fricatives/affricates. Nevertheless, for all the searching methods I required the same temporal order of the trigger and the target (e.g. [ʃ...m] but not [m...ʃ]).

The following tables indicate harmonized cases for which there is no previous evidence for the co-occurrence of the trigger and the target. The first co-occurrence is also indicated for comparison. The relevant consonants are highlighted.

(13) Consonant Harmony of combinatorial source (SR)

Seq.	**Harmonic token**				**First production of consonant sequence**			
	Target word		**Utter.**	**Age**	**Target word**		**Utter.**	**Age**
b-ts	bej.ˈtsa	'egg'	**t**a.ˈ**tθ**a	1;04.17	bej.ˈtsa	'egg'	**b**ej.ˈ**tθ**a	1;07.23
	ha-.ba.ˈtsal	'the onion'	ʔa.**b**a.ˈ**b**al	1;05.15	"	"	"	"
g-ʁ	ˈken.gu.ʁu	'kangaroo'	**g**u.ˈ**g**uu	1;04.10	ka.ˈʁiʃ	'shark'	**k**i.ˈ**ʁ**iθ	1;06.26

Seq.	Harmonic token				First production of consonant sequence			
	Target word		Utter.	Age	Target word		Utter.	Age
	"	"	ˈgu.gim	1;04.24	"	"	"	"
	"	"	gu.ˈgum	1;05.04	"	"	"	"
j-f	dʒi.ˈʁa.fa	'giraffe.f'	ʒi.ˈja.ja	1;04.24	aˈjef	'tired.m.sg'	ˈjef	1;09.00
k-ʁ	ke.a.ˈʁa	'bowel'	ke.a.ˈka	1;05.21	ka.ˈʁiʃ	'shark'	ki.ˈʁiθ	1;06.26
k-s	kiv.ˈsa	'sheep.f.sg'	θi.ˈθaa	1;05.15	kiv.ˈsa	'sheep.f.sg'	ˈki.s̪aa	1;05.15
m-g	mig.ˈdal	'tower'	ga.ˈgal	1;05.08	ˈmu.zi.ka	'music'	ˈmui.ka	1;06.12
n-s	pa.ˈnas	'flashlight'	pa.ˈs̪aas̪	1;06.02	pa.ˈnas	'flashlight'	ˈba.naθ	1;06.02
n-ts	no.ˈtsa	'feather'	θa.ˈtθa	1;07.09	ˈʃni.tsel	'schnitzel'	ˈni.tθel	1;09.19
p-l	pil	'elephant'	til	1;04.10	pil	'elephant'	pil	1;04.24
	"	"	"	1;04.17	"	"	"	"
p-ʁ	paʁ.ˈpaʁ	'butterfly'	ˈpa.pap	1;02.16	paʁ.ˈpaʁ	'butterfly'	pa.ˈpaʁ	1;03.25
ʁ-n	ˈʁo.ni	'Roni (name)'	ˈna.nii	1;04.17	a.vi.ˈʁon	'airplane'	a.ˈʁon	1;07.02
ʁ-w	ʁa.ˈwan	'Rawan (name)'	wa.ˈwan	1;11.07	N/A[17]			
s-f	saf.ˈsal	'bench'	fa.ˈfal	1;06.02	jan.ˈʃuf	'owl'	an.ˈʃ̪uf	1;06.26
	"	"	ˈfa.fal	1;06.02	"	"	"	"
ʃ-l	ʃa.ˈlom	'hello'	la.ˈlaam	1;06.02	ʃa.ˈlom	'hello'	ʃa.ˈlom	1;06.26
ʃ-v	jo.ˈʃev	'sits.m'	ʔo.ˈfev	1;07.09	ˈʃe.va	'seven'	ˈθe.va	1;08.03
	"	"	ˈfæv	"	"	"	"	"
ts-v	tsav	'tortoise'	tsaz	1;04.10	ha-.ˈtsav	'the tortoise'	ha.ˈtθav	1;06.26
	"	"	taz̪	1;04.10	to.ˈva	'good.f.sg'	to.ˈvaa	1;05.15
	"	"	ðaθ	1;04.10	ˈze.vel	'rubbish'	ze.ˈvel	1;06.02
v-n	a.vi.ˈʁon	'airplane'	ʔa.ni.ˈon	1;04.24	a.fi.ˈfon	'kite'	ʔa.ti.ˈfoon	1;04.24
χ-v	ko.ˈχav	'star'	ko.ˈpav	1;05.21	ko.ˈχav	'star'	ko.ˈχav	1;08.24
	"	"	ko.ˈfav	1;06.26	"	"	"	"
z-χ	ˈza.χal	'caterpillar'	ˈχa.χal	1;06.26	ˈʃa.χaʁ	'Shachar (name)'	ˈs̪a.χaʁ	1;08.24

(14) Consonant Harmony of combinatorial source (RM)

Seq.	Harmonic token				First production of consonant sequence			
	Target word		Utter.	Age	Target word		Utter.	Age
f-s	ta.ˈfas.ti	'caught.1sg'	ta.ˈfaf.tii	2;00.16	ta.ˈpuz	'orange (n)'	ta.ˈfus	2;01.19
f-χ	la.ha.ˈfoχ	'to reverse'	a.ˈχoχ	1;10.28	ha.ˈfuχ	'backwards'	ha.ˈfuχ	1;10.28
g-l	a.ga.ˈla	'cart'	ga.ˈga	1;05.00	i.ˈgul	'circle'	i.ˈgul	1;10.28

17 /w/ is a low frequency phoneme in Hebrew, appearing mostly in loanwords.

Seq.	Harmonic token				First production of consonant sequence			
	Target word		Utter.	Age	Target word		Utter.	Age
l-s	le.so.ˈvev	‘to rotate’	ze.se.ˈvef	1;11.18	le.tsa.ˈjeʁ	‘to draw’	li.sa.ˈjeeʁ	1;11.18
l-χ	la-.ˈχol	‘to the sand’	se.ˈχooj	1;10.28	la.ˈχol	‘to the sand’	le.ˈχooj	1;10.28
m-z	ma~ze	‘what’s that’	va.ze[18]	1;08.14	mi~ze	‘who’s that’	mi.ˈzee	2;01.19
	"	"	"	1;11.25	"	"	"	"
n-l	na.a.ˈlaim	‘shoes’	la.ˈla	1;05.29	le.hi.ka.ˈnes	‘to enter’	e.ka.ˈnel	2;00.09
p-l	pil	‘elephant’	pib	1;08.14	na.ˈfal	‘x fell.m.sg’	ha.ˈpal	1;10.06
p-ʁ	ˈpe.ʁaχ	‘flower’	ˈpaa.pi	1;05.29	i.ˈpuʁ	‘make-up’	puʁ	1;09.27
	ˈpe.ʁaχ	‘flower’	ˈpi.kʰa	1;08.01	"	"	"	"
ʁ-t	la.ˈʁe.det	‘to descend’	aˈde.ded	1;09.27	ˈʁo.tem	‘Rotem (name)’	ʁ.otən	1;09.27
	ˈʁo.tem	‘Rotem (name)’	do.tem	1;09.27	"	"	"	"
s-k	sa.ˈkin	‘knife’	χe.ˈkin	1;09.27	sa.ˈguʁ	‘closed’	sa.ˈkuu	1;10.28
ʃ-f	miʃ.ka.ˈfaim	‘glasses’	kə.ʃa.ˈʃaa	1;09.10	dʒi.ˈʁa.fa	‘giraffe.f’	ʃi.ˈʃa.fa	1;09.10
	miʃ.ka.ˈfaim	‘glasses’	a.ʃu.ˈʃai	1;09.10	"	"	"	"
ʃ-χ	ʃa.ˈχoʁ	‘black.m.sg.’	χa.ˈχoʁ	1;09.27	ʃa.ˈχoʁ	‘black.m.sg.’	ə.ˈʃe.χooʁ	1;09.27
t-v	tov	‘good,well’	ˈtotʰ	1;06.26	ˈde.vek	‘glue’	ˈde.vo	1;08.07
v-t	maχ.ˈvat	‘frying pan’	aˈ.χue.dat	1;09.18	ki.ˈmat	‘almost’	i.ˈvat	1;09.27
χ-d	χa.ˈdaʃ	‘new.m.sg.’	ʃa.ˈtaʃ	1;08.27	χut	‘string’	χut	1;08.27
	maχ.ˈvat	‘frying pan’	æ.da.ˈdat	1;09.18	maχ.ˈvat	‘frying pan’	a.ˈχue.dat	1;09.18
χ-l	ka.ˈχol	‘blue.m.sg.’	sooj	1;08.07	ka.ˈχol	‘blue.m.sg.’	χolʲ	1;08.07
	ˈχa.li	‘Chali (name)’	ʃa.li	1;09.18	mi.ˈχal	‘Michal (name)’	χalʲ	1;09.18
z-l	ze~ole	‘it ascends’	ˈlo.lee	2;01.12	ˈpa.zel	‘puzzle’	ˈpa.zel	2;03.01

From the tables above, we can learn that quite a few cases of CH involve target sequences that are apparently missing from the child’s production “inventory”. There are 28 such items for SR, 4 of which do not seem to have another plausible motivation out of the factors considered here:

(15) Exclusive combinatorial motivation for Consonant Harmony (SR)

Target word		Utter.	Age
ˈken.gu.ʁu	‘kangaroo’	ˈgu.gim	1;04.24
ˈken.gu.ʁu	‘kangaroo’	gu.ˈgum	1;05.04

[18] Whenever stress is not marked on a produced token it is absent in the original transcription.

Target word		Utter.	Age
pa.ˈnas	'flashlight'	pa.ˈs̺aas̺	1;06.02
ko.ˈχav	'star'	ko.ˈfav	1;06.26

In RM's data there are 24 harmonized items which may be related to problematic sequences; 3 of these items do not seem to have another motivation:

(16) Exclusive combinatorial motivation for Consonant Harmony (RM)

Target word		Utter.	Age
pil	'elephant'	pib	1;08.14
ma~ze	'what's that'	va.ze	1;08.14
"	"	"	1;11.25

To summarize, CH is correlated in many cases with the appearance of a consonant sequence in the target word which the child has not produced before. Therefore, we may hypothesize that harmony is used as a solution for difficult sequences. However, it would be hard to find conclusive evidence for a direct connection between CH and consonant co-occurrence.

The second type of phonotactic source of CH is non-combinatorial limitations which prohibit the appearance of certain segments in certain prosodic positions (another possibility is a preference for certain segments in certain positions). It is well known that segmental development is linked to prosodic development, e.g. fricatives tend appear in coda position before they are produced in onset position (cf. Ben-David 2001). Therefore, it is possible that CH will serve to replace segments in certain prosodic positions while leave them intact in others.

To investigate this hypothesis for each harmonized consonant, I compared the age of the harmonized production with the age of the first production in which the target consonant appears in the same prosodic position as in the harmonized token. Note that I focus on the structure of the productions and not on the structure of the target words; for example, in /jo.ˈʃev/ 'sits ms.sg.' → [fæv] (SR: 1;07.09) the attempted target word is disyllabic but the utterance is monosyllabic; I therefore, examine the behavior of the target consonant *ʃ* in the onset of monosyllabic productions. Also note that the notion of "identical prosodic position" is somewhat problematic; for example, it is not obvious that a C_2 position in $C_1V.ˈC_2V$ can be treated as equal to C_2 in $ˈC_1V.C_2V$ or $C_1V.ˈC_2VC_3$ productions. Whenever possible, I selected a production with the exact same structure as the harmonized production in question ([ʃVC], for the above example). When I could not find a matching production (that preceded the harmonized token) I searched for close structures, giving priority to more complex productions ([ʃV.CV] for the above example). Also, when possible, I preferred to use productions that had consonantal contrast similar to the underlying contrast in the harmonized token in question ([ʃ$VC_{[labial, + cont]}$] for the above example) to isolate combinatorial from non-combinatorial limitations. In some cases I broadened the search even further by applying to different consonants. In the example above, if no early production of [ʃVC] is found I may search for [sVC], [ʒVC] or [θVC] instead (see discussion earlier).

The tables in (17) and (18) list the harmonized tokens (for SR and RM, respectively) in which the harmonized consonant has not been produced before in the same prosodic position in question. The first production of the target consonant in the relevant position is also indicated for comparison. The position of interest in each production is highlight.

(17) Consonant Harmony of non-combinatorial source (SR)

Harmonic token				**First production of target consonant in position**			
Target word		**Utter.**	**Age**	**Target word**		**Utter.**	**Age**
paʁ.ˈpaʁ	‘butterfly’	ˈpa.pap	1;02.16	ˈbo.keʁ	‘morning’	ˈbo.keʁ	2;01.11
dʒip	‘jeep’	dit	1;03.25	dʒip	‘jeep’	dip	1;07.23
"	"	"	1;04.10	"	"	"	"
"	"	"	1;05.08	"	"	"	
ˈken.gu.ʁu	‘kangaroo’	gu.ˈguu	1;04.10	dʒi.ˈʁa.fa	‘giraffe.f’	d̪iˈʁa	1;04.10
tsav	‘tortoise’	ðaθ	1;04.10	kof	‘monkey’	kof	1;04.24
"	"	taz̥	1;04.10	"	"	"	"
"	"	tsaz	1;04.10	"	"	"	"
pil	‘elephant’	til	1;04.10	pil	‘elephant’	pil	1;04.24
"	"	"	1;04.17	"	"	"	"
ˈʁo.ni	‘Roni (name)’	ˈna.nii	1;04.17	ˈʁo.ni	‘Roni (name)’	ˈʁo.ni	1;08.10
hi.po.po.ˈtam	‘hippopotamus’	ˈja.ta.ˈta	1;04.24	ve-.pa.ˈʁa	‘and cow’	ve.pa.ˈʁa	1;09.19
dʒi.ˈʁa.fa	‘giraffe.f’	ʒi.ˈja.ja	1;04.24	dʒi.ˈʁa.fa	‘giraffe.f’	dði.ˈʁa.fa	1;10.07
a.vi.ˈʁon	‘airplane’	ʔa.ni.ˈon	1;04.24	se.vi.ˈvon	‘spinning top’	ʔe.vi.ˈvim	1;05.08
"	"	"	1;05.04	"	"	"	"
mig.ˈdal	‘tower’	ga.ˈgal	1;05.08	pa.ˈnas	‘flashlight’	ma.ˈmas	1;06.02

Harmonic token				First production of target consonant in position			
Target word		**Utter.**	**Age**	**Target word**		**Utter.**	**Age**
ha-.ba.ˈtsal	‘the onion’	ʔa.ba.ˈ**b**al	1;05.15	ta-.mo.ˈtsets	‘the pacifier.acc’	ta.mo.ˈ**t**θeθ	2;01.06
ko.ˈχav	‘star’	ko.ˈ**p**av	1;05.21	ka.ˈχol	‘blue.m.sg.’	ka.ˈχol	1;06.20
saf.ˈsal	‘bench’	fa.ˈ**f**al	1;06.02	su.ˈsim	‘horses’	θɪ.ˈθim	1;06.26
ʃa.ˈlom	‘hello’	**l**a.ˈlaam	1;06.02	ʃa.ˈlom	‘hello’	ʃa.ˈlom	1;06.26
ˈʃe.meʃ	‘sun’	ˈ**m**e.meθ	1;06.20	ʃa.ˈlat	‘remote control’	ˈʃa.lat	1;06.26
ˈje.led	‘boy’	ˈ**l**e.led	1;07.02	ˈje.led	‘boy’	ˈje.led	1;07.02
bob~ha-.ba.ˈnaj	‘Bob the bulider’	bo.na.**n**a.ˈnaj	1;08.03	ha-.ku.bi.ˈjot	‘the dices’	ʔa.ku.**b**i.ˈjot	1;11.02
"	"	bo.a.**n**a.ˈnaj	1;09.19	"	"	"	"
"	"	bob.**n**a.ˈnaj	1;09.19	bob~ha-.ba.ˈnaj	‘Bob the bulider’	a.bob.**b**a.ˈnaj	2;02.17

(18) Consonant Harmony of non-combinatorial source (RM)

Harmonic token				First production of target consonant in position			
Target word		**Utter.**	**Age**	**Target word**		**Utter.**	**Age**
a.ga.ˈla	‘cart’	ga.ˈ**g**a	1;05.00	na.a.ˈlaim	‘shoes’	la.ˈla	1;05.29
ˈpe.ʁaχ	‘flower’	ˈpaa.**p**i	1;05.29	ˈsa.ʁa	‘Sara (name)’	ˈʃa.ʁa	2;00.09
na.a.ˈlaim	‘shoes’	la.ˈla	1;05.29	na.ˈmeʁ	‘leopard’	**n**a.ˈma	2;00.09
tov	‘good, well’	ˈtotʰ	1;06.26	daf	‘paper sheet’	daaf	1;08.14
ˈpe.ʁaχ	‘flower’	ˈpi.**k**ʰa	1;08.01	ˈsa.ʁa	‘Sara (name)’	ˈʃa.ʁa	2;00.09
ka.ˈχol	‘blue.m.sg.’	sooj	1;08.07	ka.ˈχol	‘blue.m.sg.’	ˈχʰaj	1;08.07
χa.ˈdaʃ	‘new.m.sg’	ʃa.ˈtaʃ	1;08.27	χa.ˈdaʃ	‘new.m.sg’	χa.ˈtaʃ	1;09.18
miʃ.ka.ˈfaim	‘glasses’	kə.ʃa.ˈʃaa	1;09.10	ji.ʃa.ˈfeχ	‘will spill.3m.sg’	ti.ʃa.ˈfe	2;01.19
miʃ.ka.ˈ faim	‘glasses’	a.ʃu.ˈʃai	1;09.10	"	"	"	"
dʒi.ˈʁa.fa	‘giraffe.f’	ʃi.ˈʃa.fa	1;09.10	dʒi.ˈʁa.fa	‘giraffe.f’	fi.ˈʁa.fa	1;09.18
maχ.ˈvat	‘frying pan’	a.ˈχue.**d**at	1;09.18	le.so.ˈvev	‘to rotate’	e.so.ˈvev	1;11.18
ˈχa.li	‘Chali (name)’	ʃa.li	1;09.18	χa.ˈdaʃ	‘new.m.sg’	χa.ˈtaʃ	1;09.18
ˈʁo.tem	‘Rotem (name)’	**d**o.tem	1;09.27	ˈʁo.tem	‘Rotem (name)’	ʁo.tən	1;09.27
la.ˈʁe.det	‘to descend’	aˈ**d**e.deh	1;09.27	la.ˈʁe.det	‘to descend’	la.ˈʁe.det	1;11.25
te.le.ˈviz.ja	‘television’	a.ˈ**d**e.dæ	1;10.06	ga.ˈvo.ha	‘tall, high’	go.ˈva.wa	2;00.30
"	"	te.ni.ˈ**n**i.tsa	1;11.18	me.fa.χe.ˈdet	‘scared.f.sg.’	ma.fa.ˈχe.det	2;05.15
"	"	te.zi.gi.ˈzaa	1;11.18	ve-.le.ˈma.la	‘and upstairs’	ve.le.ˈma.la	2;03.01

Harmonic token				First production of target consonant in position			
Target word		Utter.	Age	Target word		Utter.	Age
"	"	e.ˈ**d**i.da	1;11.18	ga.ˈvo.ha	'tall, high'	go.ˈ**v**a.wa	2;00.30
"	"	te.ˈ**ts**i.sa	2;00.02	te.le.ˈviz.ja	'television'	te.ˈ**v**i.naa	2;00.02
"	"	e.ˈ**d**i.zaa	2;01.12	a.ˈval	'but'	a.ˈ**v**a.ja	2;01.19
χi.pu.ˈʃit	'beetle'	se.pu.ˈʃis	1;11.25	χa.tu.ˈlim	'cats'	**χ**a.tu.ˈlim	2;02.11
"	"	ʃe.χo.ˈsit	2;00.09	paʁ.ˈtsuf	'face'	pa.**ʁ**ə.ˈsuf	2;04.25
lif.ˈtoaχ	'to open'	ti.ʃi.ˈtoaχ	2;00.09	ba-.o.fa.ˈnaim	'by bicycle'	ba.**f**a.ˈnaim	2;03.29
ˈte.le.fon	'telephone'	ˈte.je.ʃon	2;00.30	ˈte.le.fon	'telephone'	ˈte.le.**f**on	2;00.30
hit.ja.ˈbeʃ	'dried (intr.)'	nit.**b**a.ˈbeeʃ	2;02.25	mitʁi.ˈjot	'umbrellas'	mitʁi.ˈ**j**ot	2;08.24

As in the combinatorial analysis, we can see that a good many cases of CH previously unproduced phonotactics. In SR's data there are 25 tokens in which the harmonized consonant was not produced in the relevant prosodic position before. For 8 of these items none of other examined factors provides a plausible account.

(19) Exclusive non-combinatorial motivation for Consonant Harmony (SR)

Target word		Utter.	Age
dʒip	'jeep'	dit	1;04.10
"	"	"	1;05.08
hi.po.po.ˈtam	'hippopotamus'	ja.**t**a.ˈta	1;04.24
a.vi.ˈʁon	'airplane'	ʔa.**n**i.ˈon	1;04.24
ˈʃe.meʃ	'sun'	ˈ**m**e.meθ	1;06.20
bob~ha-.ba.ˈnaj	'Bob the bulider'	bo.na.**n**a.ˈnaj	1;08.03
"	"	bo.a.**n**a.ˈnaj	1;09.19
"	"	bob.**n**a.ˈnaj	1;09.19

In RM's corpus there are also 25 items in which CH might be associated with segmental licensing, and 11 items which are not related to other factors:

(20) Exclusive non-combinatorial motivation for Consonant Harmony (RM)

Target word		Utter.	Age
dʒi.ˈʁa.fa	'giraffe.f'	ʃi.ˈʃa.fa	1;09.10
te.le.ˈviz.ja	'television'	e.ˈ**d**i.da	1;11.18
"	"	te.ni.ˈ**n**i.tsa	1;11.18
"	"	te.**z**i.gi.ˈzaa	1;11.18

Target word		**Utter**.	**Age**
"	"	e.ˈdi.zaa	2;01.12
"	"	te.ˈtsi.sa	2;00.02
χi.pu.ˈʃit	'beetle'	se.pu.ˈʃis	1;11.25
"	"	ʃe.χo.ˈsit	2;00.09
lif.ˈtoaχ	'to open'	ti.ʃi.ˈtoaχ	2;00.09
ˈte.le.fon	'telephone'	ˈte.je.ʃon	2;00.30
hit.ja.ˈbeʃ	'dried (intr.)'	nit.ba.ˈbeeʃ	2;02.25

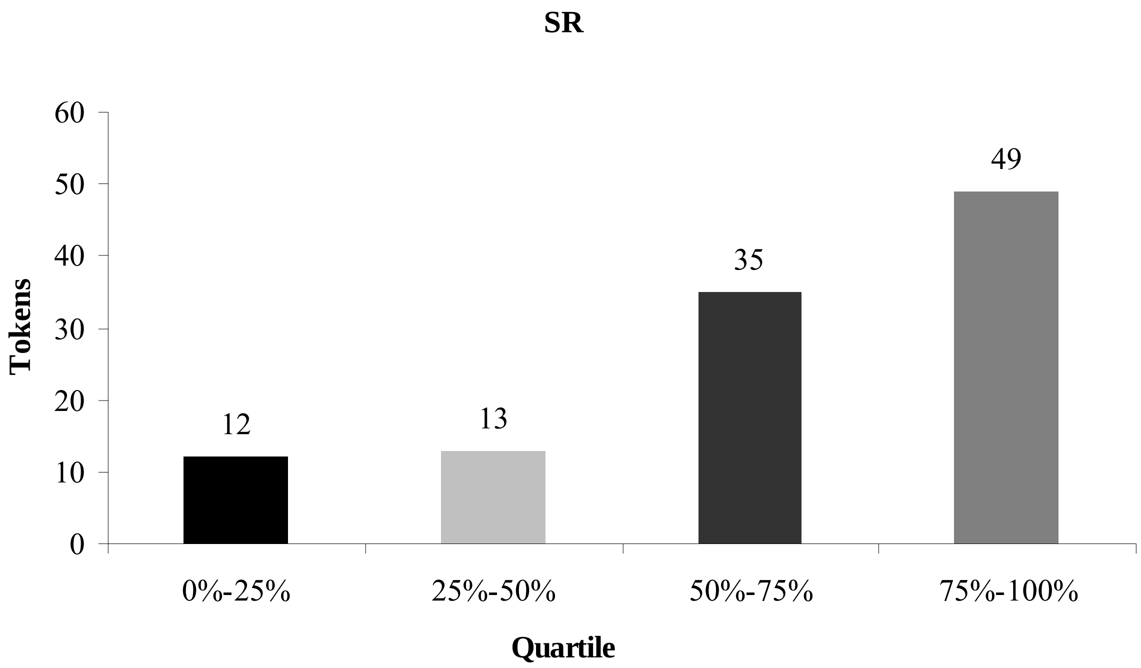
Again, we might say with some caution that CH can be used to resolve phonotactic difficulties by removing a consonant from a position where it creates problems for the child.

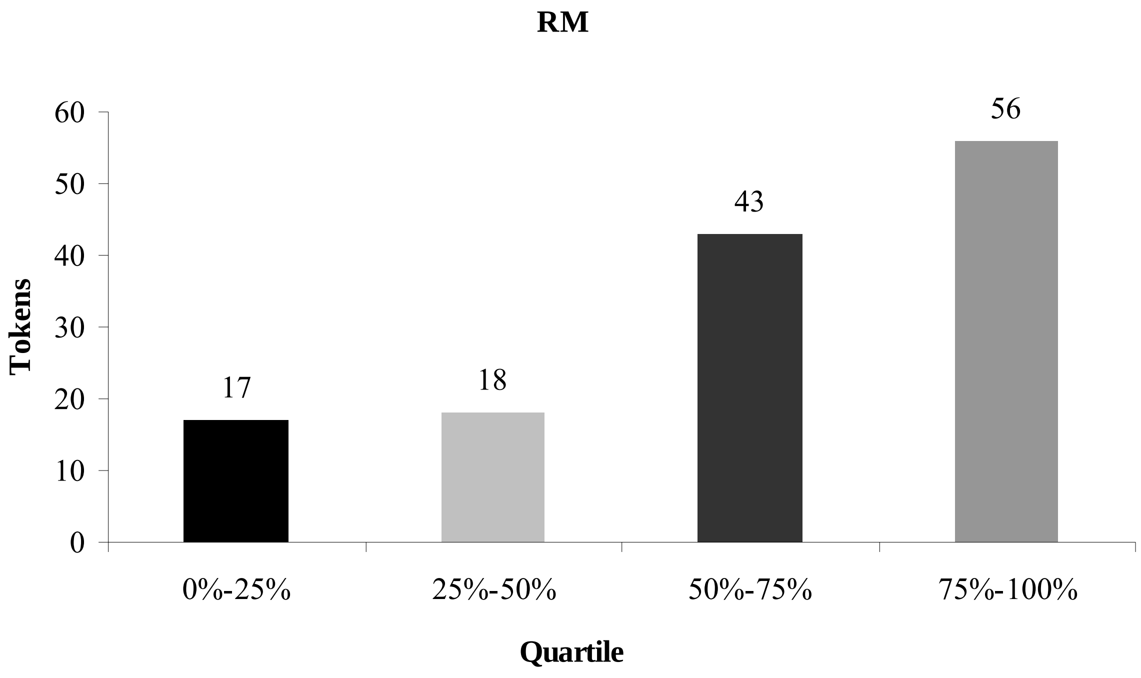
4.2.3 Prosodic

Following the discussion on non-combinatorial phonotactics, I now turn to investigate a third possible source of CH - prosodic development. Here I address the question of whether an instance of CH in a certain prosodic position is related to the prosodic structure in general, regardless of segmental features. The analysis is performed as follows: for every harmonized token, I extract all the produced tokens with the same prosodic structure up to (and including) the age of occurrence of the harmonized token and examine the rate of faithful productions in the prosodic position exhibiting harmony. For example, in /hi.po.po.ˈtam/ 'hippopotamus'→ [ta.ˈtam] (SR: 1;05.15) CH occurs in C_1 in $C_1V.ˈC_2VC_3$; I therefore list all SR's productions of the form $C_1V.ˈC_2VC_3$ up to the age of 1;05.15 and determine the rate of faithful productions in C_1. This analysis would not provide direct evidence for the connection between CH and prosodic development, but it may hint to such a connection if the examined prosodic position has low faithfulness or if the entire structure is rarely used.

The following charts provide a prosodic analysis for the examined corpora. They are organized as follows: the harmonized tokens are divided into groups by quartiles, i.e. a token is included in the 50%-75% group, if up to the age of the production between 50% and 75% of the tokens in the corpus with the same prosodic structure contained a faithfully produced consonant in the relevant prosodic position. The example above is included in the 50%-75% group, since 66% of the tokens in SR's corpus of the structure $C_1V.ˈC_2VC_3$ up to the age of 1;05.15 have a faithful C_1.

(21) Consonant Harmony and the development of prosodic positions





From the charts in (21) we can learn that in most cases CH occurs in a prosodic position which the child has a relatively good control of. Yet, there are some 20-30 items for each child in which it is likely that CH is used to resolve a prosodic difficulty. The tables in (22) and (23) list the harmonized tokens in the two lower groups. The harmonized position is highlighted in each item.

(22) Consonant Harmony in “difficult” prosodic positions (SR)

Target word		Utterance	Age	Tokens of prosodic structure	% of faithfulness
paʁ.ˈpaʁ	‘butterfly’	ˈpa.pap	1;02.16	1	0%
a.vi.ˈʁon	‘airplane’	ʔa.ni.ˈon	1;04.24	9	0%
dʒi.ˈʁa.fa	‘giraffe.f’	ʒi.ˈja.ja	1;04.24	2	0%
hi.po.po.ˈtam	‘hippopotamus’	ˈja.ta.ˈta	1;04.24	1	0%
a.vi.ˈʁon	‘airplane’	ʔa.ni.ˈon	1;05.04	11	0%
ke.a.ˈʁa	‘bowel’	ke.a.ˈka	1;05.21	1	0%
a.vi.ˈʁon	‘airplane’	a.ni.ˈin	1;05.29	1	0%
a.vi.ˈʁon	‘airplane’	ʔa.ni.ˈin	1;05.29	12	0%
ha.-ba.ˈnaj	‘the-builder’	a.da.ˈnaj	1;06.20	2	0%
bob~ha-.ba.ˈnaj	‘bob the bulider’	bo.na.na.ˈnaj	1;08.03	1	0%
bob~ha-.ba.ˈnaj	‘bob the bulider’	bo.a.na.ˈnaj	1;09.19	2	0%
ˈken.gu.ʁu	‘kangaroo’	guˈgum	1;04.10	13	31%
dʒip	‘jeep’	dit	1;03.25	20	35%
bob~ha-.ba.ˈnaj	‘bob the bulider’	a.na.ˈnaj	1;09.19	5	40%
bob~ha-.ba.ˈnaj	‘bob the bulider’	bo.na.na.ˈnaj	1;11.07	10	40%
tsav	‘tortoise’	tsaz	1;04.10	37	41%
tsav	‘tortoise’	taz̪	1;04.10	37	41%
tsav	‘tortoise’	ðaθ	1;04.10	37	41%
dʒip	‘jeep’	dit	1;04.10	37	41%
ˈʁo.ni	‘Roni (name)’	ˈna.nii	1;04.17	28	43%
ˈken.gu.ʁu	‘kangaroo’	gu.ˈgum	1;05.04	25	44%
bob~ha-.ba.ˈnaj	‘bob the bulider’	bo.na.na.ˈnaj	1;11.07	9	44%
hi.po.po.ˈtam	‘hippopotamus’	ˈta.ta	1;04.24	39	49%
ha-.ba.ˈtsal	‘the onion’	ʔa.ba.ˈbal	1;05.15	4	50%

(23) Consonant Harmony in “difficult” prosodic positions (RM)

Target word		Utterance	Age	Tokens of prosodic structure	% of faithfulness
ˈde.vek	‘glue’	ə.ˈbe.be	1;08.07	2	0%
miʃ.ka.ˈfaim	‘glasses’	a.ʃu.ˈʃai	1;09.10	1	0%
dʒi.ˈʁa.fa	‘giraffe’	ʃi.ˈʃa.fa	1;09.10	1	0%
dʒi.ˈʁa.fa	‘giraffe’	fi.ˈʁa.fa	1;09.18	2	0%
maχˈvat	‘frying pen’	a.ˈχue.dat	1;09.18	2	0%
od-pa.ˈʁa	‘another-cow’	o.ˈpa.pa.wa	1;09.27	1	0%

Target word		Utterance	Age	Tokens of prosodic structure	% of faithfulness
te.le.ˈviz.ja	‘television’	te.ni.ˈni.tsa	1;11.18	1	0%
te.le.ˈviz.ja	‘television’	te.zi.gi.ˈzaa	1;11.18	2	0%
te.le.ˈviz.ja	‘television’	ta.ˈziz.jaa	2;00.09	1	0%
hit.bal.ˈbal.ti	‘got mixed up 1sg’	il.bal.ˈbal.ti	2;01.19	1	0%
mis.to.ˈve.vet	‘rotating. fm.sg.	is.pe.ˈve.vet	2;02.04	1	0%
maf.ˈχid	‘scarry ms.sg.’	maf.ˈχi.ʁe.ʔi	2;06.19	1	0%
maχ.zi.ˈʁa	‘returning fm.sg.’	bχa.bi.ˈʁa	2;09.17	1	0%
χa.ˈdaʃ	‘new ms.sg.’	ʃa.ˈtaʃ	1;08.27	5	20%
su.kaʁ.ˈja	‘candy’	le.kə.ˈlaa	1;11.25	13	23%
ˈpe.ʁaχ	‘flower’	ˈpaa.pi	1;05.29	4	25%
χi.ˈtul	‘diaper’	ə.ʃi.ˈtul	1;10.06	4	25%
la.ˈʁe.det	‘to descend’	a.ˈdee.det	1;10.13	7	29%
le.so.ˈvev	‘to rotate’	ze.se.ˈvef	1;11.18	7	29%
maχˈvat	‘frying pen’	æ.da.ˈdat	1;09.18	3	33%
la.ˈʁe.det	‘to descend’	a.ˈdee.deh	1;09.27	6	33%
ha.ˈi.ti	‘was 1sg’	de.ˈi.ti	2;01.12	6	33%
ba.-te.le.ˈviz.ja	‘on.the-television’	ba.ti.je.ˈviv.ja	2;04.25	3	33%
ˈʁo.tem	‘Rotem (proper name)’	do.tim	1;10.13	14	36%
χi.pu.ˈʃit	‘beetle’	se.pu.ˈʃis	1;11.25	13	38%
ken	‘yes’	nẽn	1;06.05	54	41%
ˈʁo.tem	‘Rotem (proper name)’	ˈdo.tem	1;09.27	12	42%
χi.pu.ˈʃit	‘beetle’	ʃe.χo.ˈsit	2;00.09	21	48%
ˈdu.bi	‘teddy bear’	bu.bi	1;10.13	96	49%
a.ga.ˈla	‘cart’	ga.ˈga	1;05.00	2	50%
ken	‘yes’	geg	1;05.10	8	50%
miʃ.ka.ˈfaim	‘glasses’	kə.ʃa.ˈʃaa	1;09.10	2	50%
a.ˈdom	‘red ms.sg.’	a.di.ˈde	1;09.27	4	50%
ta.ˈfas.ti	‘caught 1sg.’	ta.ˈfaf.tii	2;00.16	2	50%
mal.bi.ˈʃa	‘dressing fm.sg.’	meʃ.ˈpi.ʃa	2;02.04	4	50%

It is difficult to determine that a certain case of CH results from prosodic difficulties only by looking at general percentages. Yet, this could be a plausible account for many items in the lists above, especially for cases in which none of the produced tokens with a given structure have a faithful consonant in the relevant position (e.g. /dʒi.ˈʁa.fa/ ‘giraffe’ → [ʃi.ˈʃa.fa], RM: 1;09.10).

The prosodic analysis has revealed an additional interesting finding - in several cases when examining the same prosodic position in different ages I found that in the later age the faithfulness rate has somewhat dropped. For example, examining C_1 position in ˈ$C_1V.C_2VC_3$ productions in SR’s data, I found 71% of faithfulness up to the age of 1;06.02 (total of 69 productions) but only 65% of faithfulness by 1;06.20 (total of 97 productions). This lower level is also observed with later productions of this structure and only around the age of 1;09.09 faithfulness starts to rise again. Although this decline is not statistically significant (Fisher’s exact test, $p>0.05$) this might imply that SR’s performance has degraded at some point during development. This pattern is also observed with other structures and in both children. I propose to further investigate this regression in development which is also reported previous studies (e.g. Becker and Tessier 2011; see 2.3). It is not clear whether this finding has any implications on the analysis of CH, but it is possible that some instances of CH are caused by the same force that is responsible for this regression.

4.3 Data processing aspect

As discussed in 2.1, CH might stem from input, storage and output problems. In many cases, these factors can correspond to phonological restrictions. For example, CH on input/storage level occurs when the target word contains a segment, sequence or structure that the child currently does not have an appropriate representation for. We saw many potential examples of this sort in the previous section. In the representation/output level, CH can be a grammatical device that affects a perfectly faithful representation, either by altering an existing representation or by creating an alternative representation in the “output lexicon” (cf. Menn 1983, Becker and Tessier 2011). The examined corpora do not provide strong evidence for the existence of a “grammatical CH”, since the data are relatively scarce and variable.

In this section, I would like to discuss two additional factors that may bring about harmonized productions. These factors go beyond the abstract phonology to the lexical level. First, it is possible that at the beginning of acquisition, each new item may present some challenge to the child. The challenge could be of a perceptual nature, articulatory nature or both. The following tables present the harmonized token which are also the first attempts to produce the target word (in some cases a token following the first attempt).

(24) Consonant Harmony on first target word attempt (SR)

Target word		**Utter.**	**Age**
dʒip	‘jeep’	dit	1;03.25
hi.po.po.ˈtam	‘hippopotamus’	gu.go.ˈgaa	1;04.03
ˈken.gu.ʁu	‘kangaroo’	gu.ˈguu	1;04.10
tsav	‘tortoise’	tsaz	1;04.10
"	"	taz̪	1;04.10
"	"	ðaθ	1;04.10
bej.ˈtsa	‘egg’	ta.ˈtθa	1;04.17
a.vi.ˈʁon	‘airplane’	ʔa.ni.ˈon	1;04.24
ˈbe.ten	‘tummy’	ˈbe.pem	1;05.04
mig.ˈdal	‘tower’	ga.ˈgal	1;05.08
ha-.ba.ˈtsal	‘the onion’	ʔa.ba.ˈbal	1;05.15
kiv.ˈsa	‘sheep.f’	θi.ˈθaa	1;05.15
ke.a.ˈʁa	‘bowel’	ke.a.ˈka	1;05.21
ʃa.ˈlom	‘hello’	la.ˈlaam	1;06.02
saf.ˈsal	‘bench’	fa.ˈfal	1;06.02
"	"	fafal	1;06.02
ha-.ba.naj	‘the builder’	adaˈnaj	1;06.20
"	"	hadaˈnaj	1;06.20
ˈza.χal	‘caterpillar’	ˈχa.χal	1;06.26
ˈje.led	‘boy’	ˈle.led	1;07.02
jo.ˈʃev	‘sits.m’	ˈfæv	1;07.09
"	"	ʔo.ˈfev	1;07.09
no.ˈtsa	‘feather’	θa.ˈtθa	1;07.09
sim.ˈla	‘dress (n)’	la.ˈla	1;07.09
bob~ha-.ba.ˈnaj	‘Bob the builder’	bonaˈnaj	1;07.17
heχ.ˈzik	‘held 3m.sg.’	kik	1;07.17
ˈne.ʃeʁ	‘vulture’	ˈneχeʁ	1;08.03
niʃ.be.ˈʁa	‘broke.3f.sg’	geˈʁa	1;09.09
ʁa.ˈwan	‘Rawan (name)’	wa.ˈwan	1;11.07
le.va.ˈʃel	‘to cook’	le.fa.ˈvel	2;01.11
ˈpla.stik	‘plastic’	ˈka.tik	2;02.22
a.vi.ʁo.ˈnim	‘airplanes’	ʔa.vi.ʁo.ˈʁim	2;03.24

(25) Consonant Harmony on first target word attempt (RM)

Target word		Utter.	Age
a.ga.ˈla	‘cart’	ga.ˈga	1;05.00
na.a.ˈlaim	‘shoes’	la.ˈla	1;05.29
ˈde.vek	‘glue’	ə.'be.be	1;08.07
ka.ˈχol	‘blue.m.sg.’	sooj	1;08.07
χa.ˈdaʃ	‘new.m.sg’	ʃa.ˈtaʃ	1;08.27
miʃ.ka.ˈfaim	‘glasses’	kə.ʃa.ˈʃaa	1;09.10
"	"	a.ʃu.ˈʃai	1;09.10
maχ.ˈvat	‘frying pan’	a.ˈχue.dat	1;09.18
"	"	æ.da.ˈdat	1;09.18
ˈχa.li	‘Chali (name)’	ʃa.li	1;09.18
ʃa.ˈχoʁ	‘black.m.sg.’	χa.ˈχoʁ	1;09.27
od~pa.ˈʁa	‘another cow’	o'papawa	1;09.27
sa.ˈkin	‘knife’	χe.ˈkin	1;09.27
te.le.ˈviz.ja	‘television’	a'de.dæ	1;10.06
la.ˈʁe.det	‘to descend’	aˈde.deh	1;09.27
la-.ˈχol	‘to the sand’	se.ˈχooj	1;10.28
la.ha.ˈfoχ	‘to reverse’	a.ˈχoχ	1;10.28
va.ˈʁod	‘pink.m.sg’	dee.'ŋod	1;11.18
"	"	va.'vod	1;11.18
ve-.ˈze	‘and this’	ze.'ze	1;11.18
le.so.ˈvev	‘to rotate’	ze.se.ˈvef	1;11.18
dol.ˈfin	‘dolphin’	ta.'ʃiin	1;11.25
su.kaʁ.ˈja	‘candy’	le.kə.'laa	1;11.25
na.ˈze.let	‘runny nose’	na.'je.jet	2;00.16
ta.ˈfas.ti	‘caught.1sg.’	ta.'faf.tii	2;00.16
me.χa.ˈjeχ	‘smiles.m’	χe.'ʁaχ	2;00.16
na.ˈχaʃ	‘snake’	sa.'χas	2;01.06
o.ˈse.fet	‘collects.f’	o.'fee.ve	2;01.12
ze~o.ˈle	‘it ascends’	ˈlo.lee	2;01.12
ha.ˈi.ti	‘I was’	de.'i.ti	2;01.12
hit.bal.ˈbal.ti	‘got mixed up 1sg’	il.bal.'bal.ti	2;01.19
hit.laχ.ˈlaχ.ti	‘got dirty 1sg’	ti.'lak.li	2;01.19
ʁa.ˈi.nu	‘saw.1pl’	ne.'ʔi.nu	2;01.27

Target word		**Utter.**	**Age**
mal.bi.ˈʃa	‘dressing.f’	meʃ.'pi.ʃa	2;02.04
lik.ˈnot	‘to buy’	lik.'lot	2;02.04
mis.to.ˈve.vet	‘rotates.f (intr.)’	is.pe.'ve.vet	2;02.04
me.tsa.ˈjeʁ	‘drawing.m’	ze.'tsee	2;02.11
ho.ˈfe.χet	‘reversing f.sg.’	a.'fe.tet	2;02.18
hit.ja.ˈbeʃ	‘dried (intr.)’	i.ba.ˈbes	2;02.25
te.ka.ˈlef	‘will peel 2ms.sg’	ka.ka.'vif	2;02.25
ʃo.ˈχe.vet	‘lies down fm.sg.’	so.'fe.ve	2;03.01
"	"	ʃo.'fe.fet	2;03.01
je.la.ˈdot	‘girls’	lal.'dot	2;03.01
ha-.ˈχe.lek	‘the part’	a.'sal	2;03.29
te.sap.ˈʁi	‘will tell 2fm.sg.’	ʒis.paa.'kɪɪ	2;04.12
aχ.ˈlif	‘will change 1sg’	χa.'vif	2;04.19
le.haχ.ˈlif	‘to change’	laχ.'liʃ	2;04.19
maʁ.gi.ˈʃa	‘feels.f.sg’	meʃ.gi.'ʃa	2;04.19
me.χa.ˈle.ket	‘dividing fm.sg.’	ma.χal.'kel	2;04.19
ʃe-.ˈχo.ʃeχ	‘that (comp)-darkness’	se.'ʃo.ʃeʁ	2;04.25
ba.te.le.ˈviz.ja	‘on.the-television’	ba.ti.je.'viv.ja	2;04.25
ha-.ˈzug	‘the-pair’	ða.'zug	2;05.09
me.χa.me.ˈmim	‘heating ms.pl.’	me.χaχ.'mim	2;05.27
χa.ˈmuts	‘sour m.sg.’	χa.'vus	2;05.29
niχ.na.ˈsim	‘entering pl.’	iχ.na.'siv	2;09.17
maχ.zi.ˈʁa	‘returns.3f.sg’	bχa.bi.ˈʁa	2;09.17
a.χa.ˈbeʁ	‘will connect 1sg’	χa.'beg	2;09.29

The lists above provide evidence that CH may be related to lexicon learning. 32 items in SR’s list appear in the first session in which the target word was attempted. They equal to about 18% of all the harmonized tokens in his data (5 items in the list are repetitions of another harmonized token). In 11 cases, segmental or phonotactic factors do not provide a solid account for harmony, i.e. the segments, sequences and prosodic structures involved are not expected be difficult for the child. Theses are listed in (26).

(26) Exclusive lexical motivation for Consonant Harmony (SR)

Target word		**Utter.**	**Age**
ˈbe.ten	'tummy'	ˈbe.pem	1;05.04
ha-.ba.naj	'the builder'	adaˈnaj	1;06.20
"	"	hadaˈnaj	1;06.20
sim.ˈla	'dress (n)'	la.ˈla	1;07.09
bob~ha-.ba.ˈnaj	'Bob the builder'	bonaˈnaj	1;07.17
heχ.ˈzik	'held 3m.sg.'	kik	1;07.17
ˈne.ʃeʁ	'vulture'	ˈneχeʁ	1;08.03
niʃ.be.ˈʁa	'broke.3f.sg'	geˈʁa	1;09.09
le.va.ˈʃel	'to cook'	le.fa.ˈvel	2;01.11
ˈpla.stik	'plastic'	ˈka.tik	2;02.22
a.vi.ʁo.ˈnim	'airplanes'	ʔa.vi.ʁo.ˈʁim	2;03.24

The lexical factor of CH seems even more prominent for RM. As many as 57 items or 39% of her harmonized tokens can be attributed to first use of a word (4 items are repetitive attempts following another harmonized token). For 38 cases there is no plausible segmental or phonotactic motivation. These items are listed in (27).

(27) Exclusive lexical motivation for Consonant Harmony (RM)

Target word		**Utter.**	**Age**
ˈde.vek	'glue'	ə.'be.be	1;08.07
od~pa.ˈʁa	'another cow'	o'papawa	1;09.27
va.ˈʁod	'pink.m.sg'	dee.'ɱod	1;11.18
"	"	va.'vod	1;11.18
ve-.ˈze	'and this'	ze.'ze	1;11.18
dol.ˈfin	'dolphin'	ta.'ʃiin	1;11.25
su.kaʁ.ˈja	'candy'	le.kə.'laa	1;11.25
na.ˈze.let	'runny nose'	na.'je.jet	2;00.16
me.χa.ˈjeχ	'smiles.m'	χe.'ʁaχ	2;00.16
na.ˈχaʃ	'snake'	sa.'χas	2;01.06
o.ˈse.fet	'collects.f'	o.'fee.ve	2;01.12
ha.ˈi.ti	'I was'	de.'i.ti	2;01.12
hit.bal.ˈbal.ti	'got mixed up 1sg'	il.bal.'bal.ti	2;01.19
hit.laχ.ˈlaχ.ti	'got dirty 1sg'	ti.'lak.li	2;01.19

Target word		Utter.	Age
ʁa.ˈi.nu	'saw.1pl'	ne.'ʔi.nu	2;01.27
mal.bi.ˈʃa	'dressing.f'	meʃ.'pi.ʃa	2;02.04
lik.ˈnot	'to buy'	lik.'lot	2;02.04
mis.to.ˈve.vet	'rotates.f (intr.)'	is.pe.'ve.vet	2;02.04
me.tsa.ˈjeʁ	'drawing.m'	ze.'tsee	2;02.11
ho.ˈfe.χet	'reversing f.sg.'	a.'fe.tet	2;02.18
hit.ja.ˈbeʃ	'dried (intr.)'	i.ba.ˈbes	2;02.25
te.ka.ˈlef	'will peel 2ms.sg'	ka.ka.'vif	2;02.25
ʃo.ˈχe.vet	'lies down fm.sg.'	so.'fe.ve	2;03.01
"	"	ʃo.'fe.fet	2;03.01
je.la.ˈdot	'girls'	lal.'dot	2;03.01
ha-.ˈχe.lek	'the part'	a.'sal	2;03.29
te.sap.ˈʁi	'will tell 2fm.sg.'	ʒis.paa.'kɪɪ	2;04.12
aχ.ˈlif	'will change 1sg'	χa.'vif	2;04.19
le.haχ.ˈlif	'to change'	laχ.'liʃ	2;04.19
maʁ.gi.ˈʃa	'feels.f.sg'	meʃ.gi.'ʃa	2;04.19
me.χa.ˈle.ket	'dividing fm.sg.'	ma.χal.'kel	2;04.19
ʃe-.ˈχo.ʃeχ	'that (comp)-darkness'	se.'ʃo.ʃeʁ	2;04.25
ba.te.le.ˈviz.ja	'on.the-television'	ba.ti.je.'viv.ja	2;04.25
ha-.ˈzug	'the-pair'	ða.'zug	2;05.09
me.χa.me.ˈmim	'heating ms.pl.'	me.χaχ.'mim	2;05.27
χa.ˈmuts	'sour m.sg.'	χa.'vus	2;05.29
niχ.na.ˈsim	'entering pl.'	iχ.na.'siv	2;09.17
a.χa.ˈbeʁ	'will connect 1sg'	χa.'beg	2;09.29

All in all, the data presented here suggest that CH is likely to appear in the first use of a word, for whatever reason. One may point out that the analysis demonstrated here does not take into account the possibility that the child is already familiar with (some of) the lexical items in question, and referring to the productions here is "first use" might be incorrect. This of course can be a real problem and I do not have evidence to support or refute the claim. If the first use of the word is indeed the first (probably through imitation of an adult) it can indicate a misperception on behalf of the child. If the child has already used that word in the past (with no recordings of the attempt) it may either have an inaccurate representation or that CH resulted from faulty planning or execution.

The idea of an inaccurate lexical representation as a source of CH is not a very popular hypothesis. The common assumption is that children have good perceptual qualities and that their underlying representations are close (if not identical) to the adult surface forms (cf. Smith 1973). However, there is some evidence suggesting that the children in the present study store some words in a harmonized (or generally inaccurate) form from the beginning. While most of the harmonized tokens examined here are unique, some others are used repeatedly during a certain period of time. This observation is true mostly for long words which the children attempt relatively early when they are incapable of producing such complex constructions. In such cases harmony can persist even when its original motivation is no longer effective. Table (28) lists some multiple harmonized productions found in the SR's data (excluding immediate identical repetitions).

(28) Lexicalized Consonant Harmony (SR)

Target word		**Utter.**	**Age**
a.vi.ˈʁon	'airplane'	ʔa.ni.ˈon	1;04.24
		ʔa.ni.ˈon	1;05.04
		ʔa.ni.ˈin	1;05.29
bob~ha-.ba.ˈnaj	'Bob the bulider'	bo.na.ˈnaj	1;07.17
		bo.na.ˈnaj	1;08.03
		bo.na.na.ˈnaj	1;08.03
		bo.na.ˈnaj	1;08.10
		bo.na.ˈnaj	1;09.19
		bo.da.ˈnaj	1;09.19
		bob.na.ˈnaj	1;09.19
		bo.a.na.ˈnaj	1;09.19
		a.na.ˈnaj	1;09.19
		bo.na.ˈnaj	1;10.07
		bo.na.na.ˈnaj	1;11.07
		a.bo.na.ˈnaj	1;11.07

Target word		Utter.	Age
dʒip[19]	‘jeep’	dit	1;03.25
		dit	1;04.10
		dit	1;05.08
hi.po.po.ˈtam	‘hippopotamus’	ˈja.ta.ˈta	1;04.24
		ˈta.ta	1;04.24
		ˈta.tam	1;04.24
		ti.ˈtaam	1;05.04
		ˈta.taam	1;05.08
		ˈta.tam	1;05.15
		ta.ˈtam	1;05.15
		ˈti.tam	1;06.20
		ta.ˈtam	1;06.20
		ta.ˈtam	1;06.26
		ˈto.tam	1;06.26
		ˈto.tam	1;07.02
		to.ˈtam	1;07.09
		hi.po.tot	2;00.21
ˈken.gu.ʁu	‘kangaroo’	gu.ˈguu	1;04.10
		gu.ˈgum	1;04.10
		ˈgu.gim	1;04.24
		gu.ˈgum	1;05.04
		gu.ˈgum	1;07.02
		gu.ˈgum	1;07.09
		ga.ˈgom	1;09.27
ˈʃe.meʃ	‘sun’	ˈme.meθ	1;06.20
		ˈme.meθ	1;06.26
		ˈme.meθ	1;07.23
		ˈme.meθ	1;09.09
pil	‘elephant’	til	1;04.10
		til	1;04.17

[19] An anonymous reviewer has brought to my attention that /dʒip/ is an atypical word in Hebrew: it contains a *dʒ* and a coda *p* which are both rare in Hebrew and appear mainly in loanwords. This fact may contribute to the mispronunciation of the word.

Target word	Utter.	Age
	til	1;04.24
	til	1;05.29

Recall from 3.1 that SR is generally quite faithful in his productions to the target words. It is therefore not expected from the data to find such consistent harmonization. Take for example SR's productions of /ˈken.gu.ʁu/ 'kangaroo, which he consistently harmonizes from the age of 1;04.10 to 1;07.02 (later on he uses CH in variation with faithful productions, e.g. [gu.ˈʁum], 1;07.09). Remarkably, many of his productions contain a "mysterious" nasal coda (e.g. [gu.ˈgum]) which continues to appear even when he stops harmonizing the word. Thus, I hypothesize that some of the earliest harmonized productions could be "fossilized" forms initially caused by misperception or inaccurate representation, and on the long run their appearance does not represent active "rule" of CH (see Stemberger 1989).

In RM's data there is not much evidence for this type of lexicalized harmony. She does have multiple harmonized tokens for the same target word, but they tend to be different from one another (see for example her productions for /te.le.ˈviz.ja/ 'television'). Cases of this sort are most challenging for the analysis of CH - it is difficult to determine the cause for CH when it is used in different fashions with the same word (especially if one aims to find a feature-based theoretic model to account for CH). More specifically, it puts the child's underlying representation of the target word in doubt. This problem brings us to the last point of this section - CH with no apparent motivation.

When considering segmental, phonotactic and lexical factors as possible motivations for CH, there are 31 items in SR's data and 50 in RM's data for which none of the factors seems to provide a good explanation (basically all the items which appear in the appendix and were not listed in this and previous sections). The prosodic analysis in 4.2.3 can provide an account for some of the items; in RM's data, 7 items which were not classified as having a segmental, phonotactic or lexical motivation were rated as 50% or lower in faithfulness in the relevant prosodic position. In SR's data there is only one such item. Still, there are several dozens of items which the analysis could not account for in a satisfactory way. This means that CH can occur when the child is familiar with the target word, and is not expected to encounter phonological difficulties when using the word. Take for example RM's production [ˈke.lez] for /ˈke.lev/ 'dog.M' (2;06.12); this production occurs after 28 attempts of the target word, most of them are completely faithful, and it is followed by several additional faithful productions. In addition, the harmonization occurs in C_3 position in $^{ˈ}C_1V.C_2VC_3$ production, which up to that point exhibits 90% faithfulness. Thus, there is no plausible explanation for this one-time v-z alternation, at least not in terms of the factors considered here. In the absence of plausible accounts for productions of this sort, I hypothesize that some cases of CH can be after all "innocent" mistakes, isolated errors of similar nature to adult slips of the tongue.

4.4 Discussion

In the second part of the study I evaluated some possible factors that can give rise to the harmonized tokens found in section 3. The analysis suggests that CH can come from different sources - it can replace unacquired segments, simplify difficult sequences and compensate for complex prosodic structures. In many cases there is more than one plausible account for the harmonized production. For example, the harmony in /tsav/ 'tortoise' → [tsaz] (SR: 1;04.10) can be attributed to all the aforementioned factors: the previously unproduced *v* and as a consequence previously unproduced *v* in coda position of CVC words and in a *ts-v* sequence. 27 items in SR's data and 24 in RM's data can be attributed to more than one factor. It should be noted though, that even in the less ambiguous cases the reason for each instance of CH cannot be determined with certainty.

The present study also revealed a possible relation between CH and the lexical level. The children harmonize some words when first trying to produce them even if there is no apparent phonological reason for doing so. In some cases the harmonized pattern persists over a considerably long period suggesting that it is lexicalized. These two classes of harmonized productions together with many isolated examples imply representational and speech planning sources for CH. The latter factor is considered to be the source of slips of the tongue, and possibly adult CH (cf. Hansson 2001).

Viewing child CH as a kind of slip of the tongue is not very popular; most studies attempt to place CH in the child's productive grammar. However, the data of the present study do not seem to provide evidence for a productive operation of CH - I could not find evidence that CH operates consistently to any degree at any stage of development. Further research is needed to identify possible general grammatical effects on the children's productions.

5. Consonant Harmony properties

In the third part of the study I analyze the properties of the harmonized tokens, as performed in numerous previous studies, in order to seek for generalizations. The analysis will cover properties such as type of feature change, trigger-target hierarchies, directionality, etc.

5.1 Segmental analysis

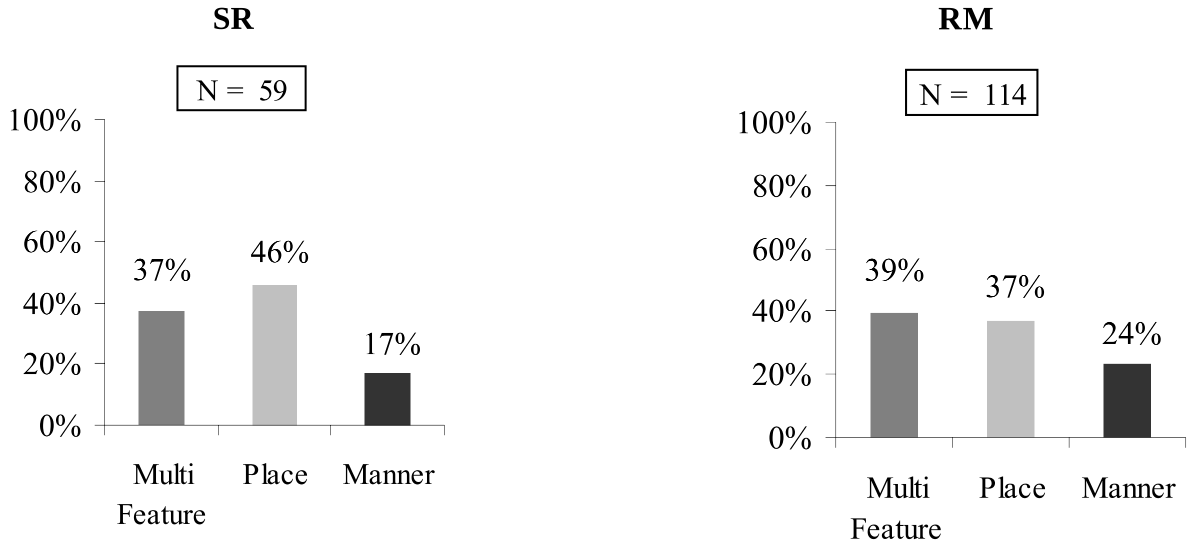
In this section, I examine the segmental component of CH. I start with an analysis of the assimilation process, namely the valence and degree of change. After that, I will analyze the properties of the consonants participating in the process, i.e. the trigger and the target.

5.1.1 Valence and degree

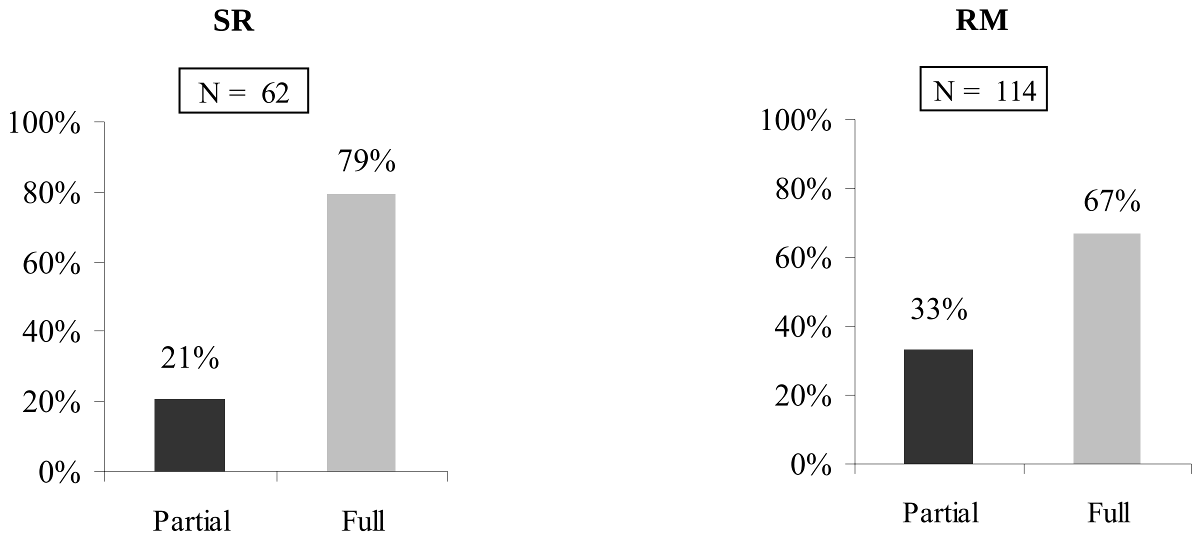
The children in the study exhibit both single featured CH (e.g. place: /ˈza.χal/ 'caterpillar'→ [ˈχa.χal], SR: 1;06.26; manner: /la.ʔa.ˈsot/ 'to do' → [se.ˈʃot], RM: 2;02.25), and *multi featured* CH (e.g. /ʔa.ga.ˈla/ 'cart' → [ga.ˈga], RM: 1;05.00). There is also evidence for partial (e.g. place agreement in: /ˈke.lev/ 'dog.M' → [ˈke.lez], RM 2;06.12), as well as full harmony (e.g. /ˈje.led/ 'boy' → [ˈle.led], SR: 1;07.02).

Chart (29) illustrates the distribution of single- (manner, place) and multi-feature changes, and chart (30) shows the degree of harmony (full or partial). For the analysis here and in the following section, I switch to total production type analysis and eliminate multiple identical tokens (even when produced on different stages) in order to cancel out token frequency effects. For segmental analysis, I exclude even tokens which differ from one another in segments/features which are not relevant to the substitution of interest (e.g. vowel changes and the m-n alternation in /ʁotem/ 'Rotem (proper name)' → [ˈdo.tem] ~ [ˈdo.tim] ~ [ˈdo.ten]) or in prosodic structure (e.g. /hi.po.po.ˈtam/ 'hippopotamus' → [to.ˈtam] ~ [ˈto.tam] ~ [ˈta.ta]). This narrows the lists down to 62 items for SR and 114 for RM. Note that in some cases, besides assimilation, the target undergoes an additional feature change which is likely due to a non-assimilatory substitution (e.g. place assimilation + affrication in: /la.a.ˈsof/ 'to collect' → [le.ˈsatʃ], RM: 1;11.25). In these cases, the additional change is disregarded and the process is considered to be a single-featured CH. In addition, 3 cases in SR's data are ambiguous regarding the identity of the target or trigger (/hi.po.po.ˈtam/ 'hippopotamus' → [go.go.ˈgaa], /dʒi.ˈʁa.fa/ 'giraffe fm.' → [ˈʒi.ʒa], / miχ.na.ˈsaim/ 'pants' → [mi.θa.ˈθaim]). These cases are excluded from the valence calculations.

(29) Valence of change



(30) Degree of Consonant Harmony

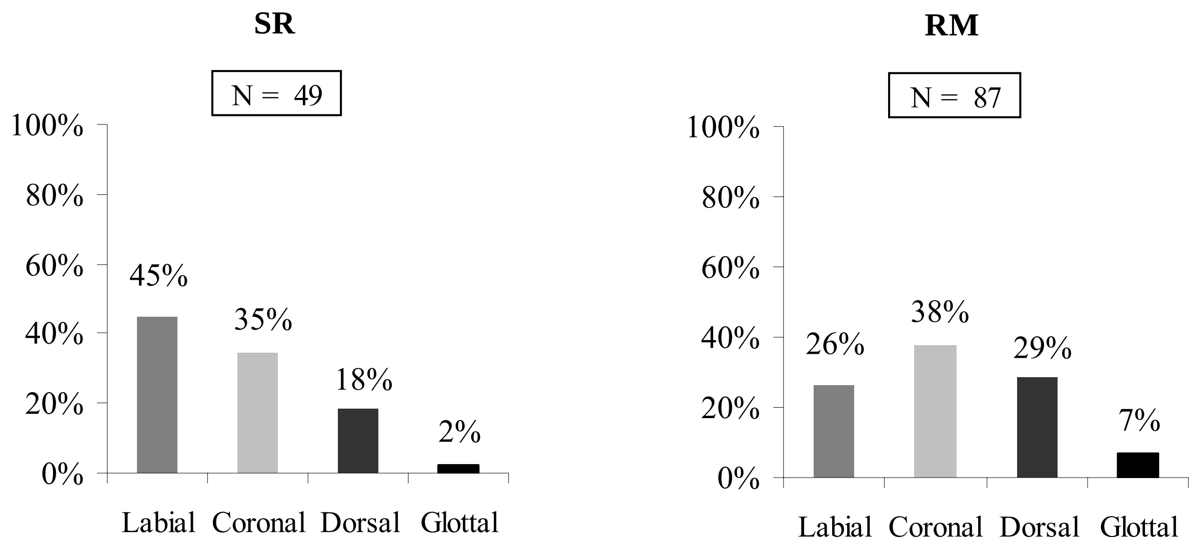


From (29) we can learn that there are more cases of place and combined changes than there are pure manner changes. However, manner changes are not at all negligible as might be hinted from the low attention they receive in the literature (cf. Vihman 1978, Berg 1992, Stoel-Gammon and Stemberger 1994, Tzakosta 2007). Chart (30) reveals that full harmony is more common than partial harmony (see Vihman 1978 but also Berg 1992). This might be, at least partially, due to the fact that many of the clear cases of assimilation involve changes in both place and manner.

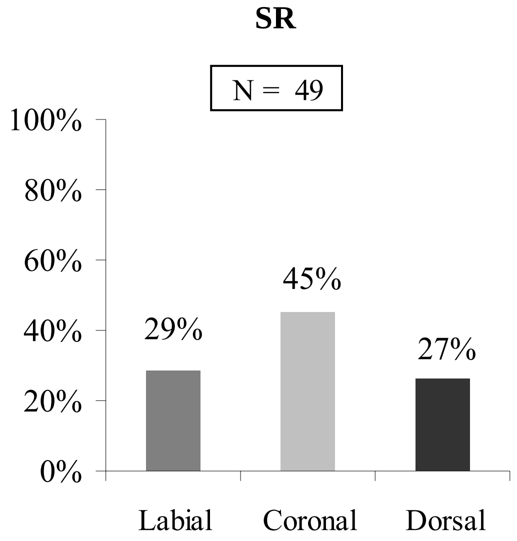
5.1.2 Features

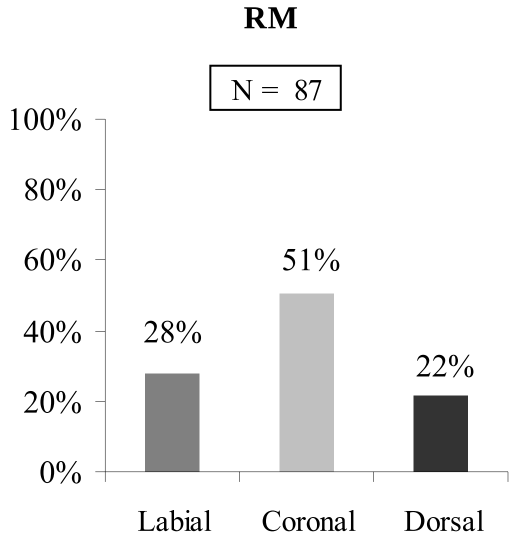
In this section I examine the properties of the consonants involved in the assimilation process (i.e. triggers and targets). Charts (31) and (32) present the distributions of place targets and triggers - both place-of-articulation (PoA) and multi-feature harmonies are included here (49 instances for SR and 87 for RM). Note that in some cases it is difficult to determine the target with certainty due to multiple processes that affect the production (e.g. deletion in /miχ.na.ˈsaim/ ‘pants’→ [mi.θa.ˈθaim], SR: 1;11.02). In these cases the target is not included in the segmental analysis. In other cases there is more than one potential trigger. If the *error* (i.e. the result of CH) is identical to one of the potential triggers (e.g. /χa.ˈdaʃ/ ‘new.SG.M’ → [ʃa.ˈtaʃ], RM: 1;08.27), that trigger would be the “winning” candidate. In addition, there are cases in which the trigger undergoes a non-assimilatory substitution (e.g. liquid gliding in: /na.ˈze.let/ ‘runny nose’ → [na.ˈje.jet], RM: 2;00.16). In such cases I choose the product of the substitution and not its correspondent in the target word (e.g. *j* rather than *l*) as the trigger of CH.

(31) Place targets



(32) Place triggers





The charts in (31) show that SR has a slight and probably insignificant preference for labial targets (22 labial targets vs. 17 coronal targets), and RM has a rather even distribution among the major place targets with a minor bias towards coronals.

With respect to the triggers, we can see that both children prefer coronal over labial and dorsal triggers. These finding are similar to those in Tzakosta (2007), but how strong are they? Table (33) presents a paired analysis of place triggers and targets. In this analysis, for instance, the harmonic case of /ken/ 'yes'→ [nen] (RM: 1;08,27) is analyzed as a paired coronal trigger and a dorsal target (disregarding manner change).

(33) Paired place triggers and targets

Trigger	Target	SR		RM	
Labial	Coronal	10	20%	19	22%
Coronal	Labial	17	35%	18	21%
Dorsal	Coronal	7	14%	14	16%
Coronal	Dorsal	5	10%	20	23%
Labial	Dorsal	4	8%	5	6%
Dorsal	Labial	5	10%	5	6%
Dorsal	Glottal	1	2%	0	0%
Coronal	Glottal	0	0%	6	7%
Total		49		87	

The analysis above strengthens the impression that there is no true bias towards a certain PoA. For example, in RM's data there is almost an equal number of coronal harmony affecting labials as the opposite. The fact that there are more coronal triggers (and to some extent more coronal targets) than other types could be some property of the language. The following table compares the triggers and targets rates with the PoA frequency in the target words attempted by the children. In order to see if the PoA distributions in the attempted words are representative of the ambient language, I compare these distributions to the PoA frequencies in Hebrew as calculated by Schocken (2008).[20] The analysis is performed over 38,370 consonants for SR and 53,141 for RM.

(34) Consonant Harmony and place frequency

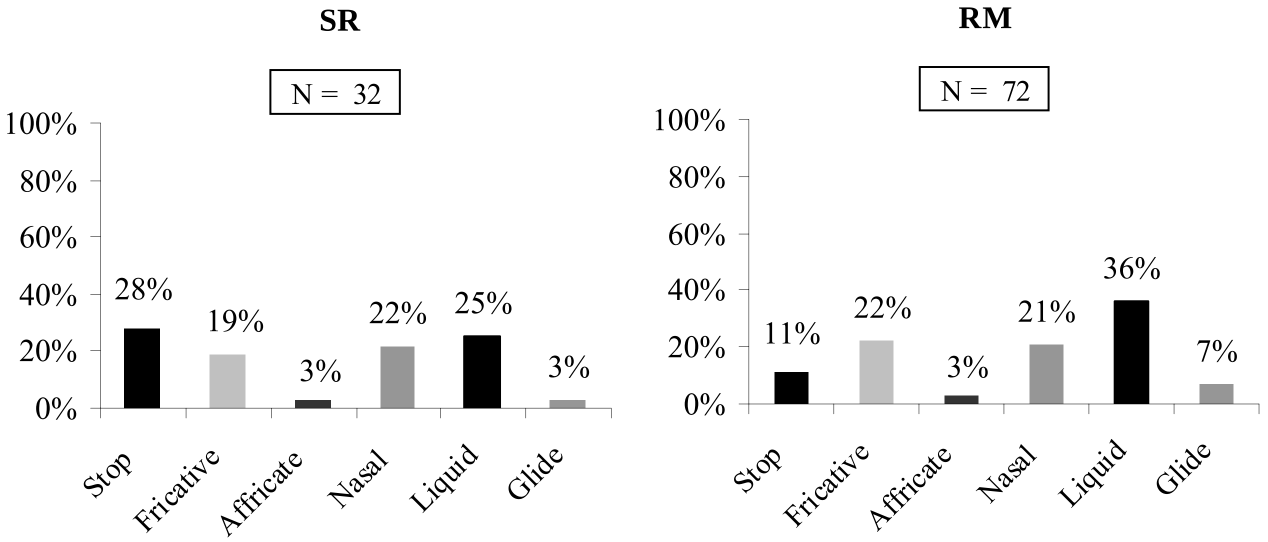
Place	Language Frequency	SR			RM		
		Corpus Frequency	Triggers	Targets	Corpus Frequency	Triggers	Targets
Labial	25%	22%	29%	45%	20%	28%	26%
Coronal	49%	45%	44%	35%	49%	50%	38%
Dorsal	23%	28%	27%	18%	27%	22%	29%
Glottal	3%	5%	0%	2%	4%	0%	7%

As we can see in (34), the distributions of place frequency in the attempted target words are similar for the children, and they seem to adequately represent the input frequency of the language. The rates of coronal triggers are quite close to their frequencies in the input and the rates of coronal target are somewhat lower for both children. In addition, with the exception of high rates of labial targets for SR, labials and dorsal seem to be close to their input frequency both as triggers and as targets. Given these observations it seems reasonable to conclude that input frequency is responsible, to some extent, for the trigger-target distribution for the subjects in this study.

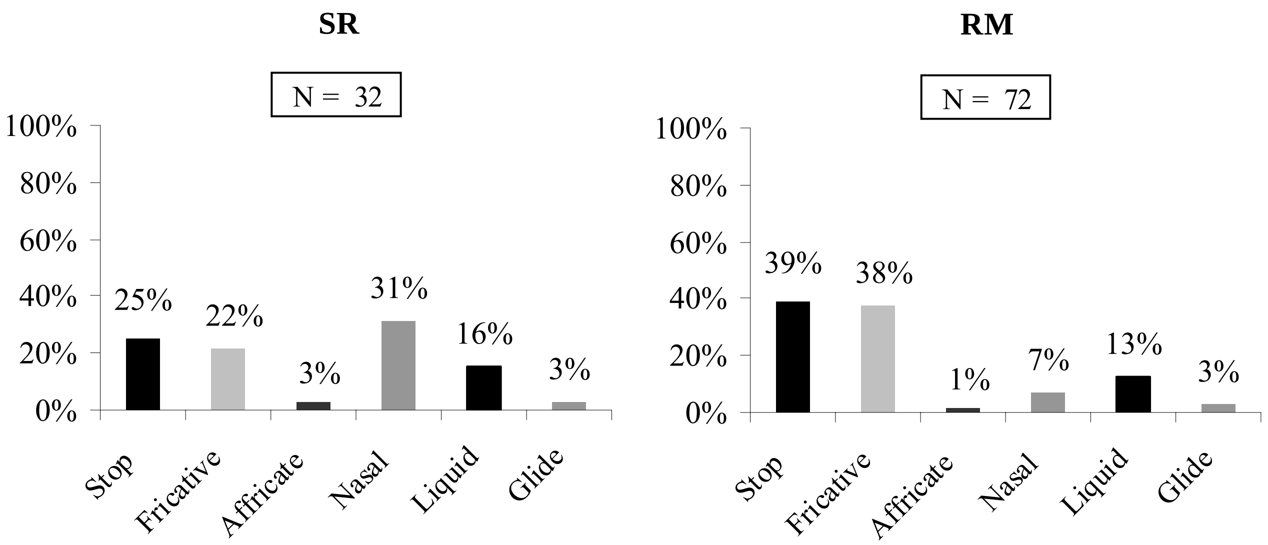
Next, let us turn to investigating the properties of manner harmony. Charts (35) and (36) present the distributions of manner-of-articulation (MoA) targets and triggers. Again, both single- and multi-feature harmonies are included (32 instances for SR and 72 for RM).

[20] The language frequency data are drawn from a corpus of the 99,808 most frequent words in Hebrew appearing in randomly selected internet sites during 2003.

(35) Manner targets



(36) Manner Triggers



The charts above provide interesting findings. The children seem to be somewhat different regarding their trigger and target preferences. SR has quite an even distribution of stop, fricative, nasal and liquid[21] targets. RM has higher rates of liquid targets followed by fricative and nasals, with only 11% of stop targets. As for the triggers, SR has high rates of stops, nasals and fricatives, while for RM, most of the “burden” lies on stops and fricatives.

As with the place analysis, it seems worthwhile to check the paired trigger-target distribution, which is shown on table (37).

[21] The Hebrew rhotic is a uvular approximant ʁ̞. I represent it with ʁ for convenience.

(37) Paired manner triggers and targets

Trigger	Target	SR		RM	
Stop	Fricative	0	0%	10	14%
Stop	Affricate	1	3%	0	0%
Stop	Nasal	3	9%	4	6%
Stop	Liquid	4	13%	13	18%
Stop	Glide	0	0%	1	1%
Affricate	Nasal	1	3%	1	1%
Fricative	Stop	3	9%	3	4%
Fricative	Affricate	0	0%	2	3%
Fricative	Nasal	2	6%	8	11%
Fricative	Liquid	2	6%	12	17%
Fricative	Glide	0	0%	2	3%
Nasal	Stop	6	19%	1	1%
Nasal	Fricative	2	6%	2	3%
Nasal	Liquid	2	6%	1	1%
Nasal	Glide	0	0%	1	1%
Liquid	Stop	0	0%	4	6%
Liquid	Fricative	3	9%	2	3%
Liquid	Nasal	1	3%	2	3%
Liquid	Glide	1	3%	1	1%
Glide	Fricative	1	3%	2	3%
Total		32		72	
Sonority: Trigger < Target		16	50%	54	75%
Sonority: Trigger > Target		16	50%	18	25%

Here again, we can see some difference between the children - SR does not show a particular preference for a certain hierarchy, while RM shows a rather strong tendency to assimilate in more sonorants to less sonorants. The following sonority scale is assumed for Hebrew (Clements 1990, Bat-El 1996, Parker 2002):

(38) Sonority Scale for Hebrew

Glides > Liquids > Nasals > Fricatives > (Affricates) > Stops

Do the results of manner distribution have some correlation with MoA frequency in the ambient language? Table (39) compares the trigger and target rates with the MoA frequency in SR's and RM's target words and the MoA frequencies in the language (Schocken 2008).

(39) Consonant Harmony and manner frequency

Manner	**Language Frequency**	**SR**			**RM**		
		Corpus Frequency	**Triggers**	**Targets**	**Corpus Frequency**	**Triggers**	**Targets**
Stop	29%	32%	25%	28%	31%	38%	11%
Fricative	27%	25%	22%	19%	27%	38%	22%
Affricate	2%	3%	3%	3%	4%	1%	3%
Nasal	20%	19%	31%	22%	19%	7%	21%
Liquid	19%	18%	16%	25%	17%	13%	36%
Glide	3%	2%	3%	3%	3%	3%	7%

As we saw in the place analysis, the MoA frequency distribution in the target words is similar for both children and the numbers are close to the language frequency. Here again it seems that SR's choice of triggers and targets is guided mostly by input frequencies. On the other hand, RM shows a notable bias from the input frequencies; obstruents appear as triggers in considerably higher rates than as targets, while the opposite it true for sonorants. To summarize, it seems that the trigger-target sonority difference seems to provide the best generalization regarding RM's data, while input frequency seems to best account for SR's data. It is important to note, however, that data amounts are rather small (especially for SR) to allow strong conclusions to be made.

To complement the segmental analysis, I counted the different number of paired trigger-target combinations in the children's productions. For example, in /a.ˈdom/ 'red ms.sg.' → [a.di.ˈde] (RM: 1;09.27) the trigger is *d* and the target is *m*. The 62 tokens in SR's data contained 48 different trigger-target combinations, and only 10 combinations appeared more than once. In RM's data, I found 80 different combinations in 114 tokens. No combination appeared more than 4 times. Such diversity can indicate, in addition to the pervious analyses, that segmental factors have a rather minor influence on CH.

5.2 Prosodic analysis

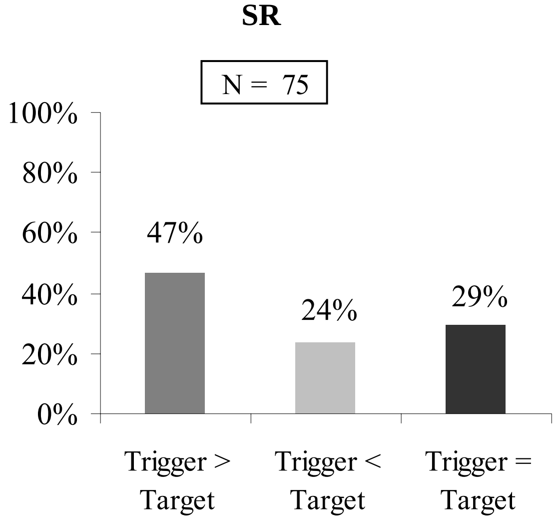
In this section, I inspect the correlations between CH and prosodic properties: stress pattern, prosodic positions and number of syllables. Here I use slightly different data than in the previous two sections by including tokens of the same target word with the same type of harmony but different prosodic structure (e.g. /hipopoˈtam/ 'hippopotamus' → [to.ˈtam] / [ˈto.tam] / [ˈta.ta]). However, I disregard vowel length as it is not phonemic in Hebrew (e.g. /bej.ˈtsa/ 'egg' → [ta.ˈtθa] ~ [ta.ˈtθaa]). Table (40) analyzes paired trigger-target with respect to stress, indicating whether the syllables containing the trigger and target are stressed or unstressed. For example, in /ʃa.ˈχoʁ/ 'black.SG.M' → [χa.ˈχoʁ], SR: 1;09.27 the trigger *χ* is in a stressed syllable and the target *ʃ* is in an unstressed syllable. When the trigger and the target are in the same syllable, "tautosyllabic" is used for polysyllabic words (e.g. /ˈne.ʃeʁ/ 'vulture' → [ˈne.χeʁ], SR: 1;08.03) and "monosyllabic" is used for monosyllables (e.g. /ken/ 'yes' → [keg], RM: 2;00.09).

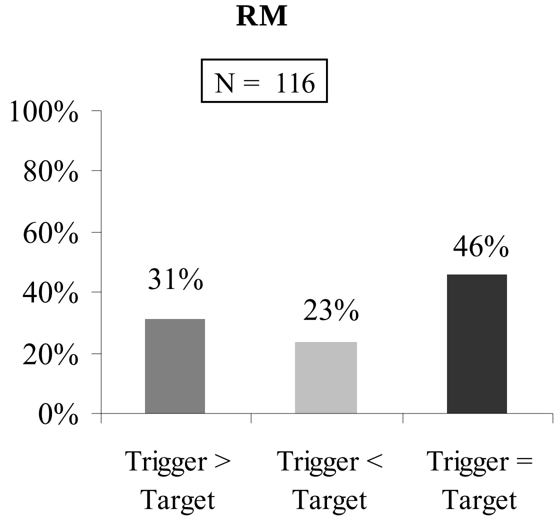
(40) Paired stress analysis

Trigger	Target	SR		RM	
Stressed	Unstressed	35	47%	36	31%
Unstressed	Stressed	18	24%	27	23%
Unstressed	Unstressed	3	4%	10	9%
Tautosyllabic	Stressed	8	11%	21	18%
Tautosyllabic	Unstressed	4	5%	9	8%
Monosyllabic		7	9%	13	11%
Total		75		116	

The table above does not provide conclusive evidence regarding the interaction between stress and CH. It seems that when the trigger and the target are heterosyllabic with different stress degrees (first two rows in (40)), a stressed trigger is preferred over an unstressed trigger, especially for SR. Yet, a relatively large portion of the documented cases (29% for SR, 46% for RM) do not involve stress differences between the trigger and the target. This is visualized in the paired stress hierarchy analysis in chart (41). The label "Trigger = Target" covers all the cases where the trigger and the target are equally stressed, including tautosyllabic harmony and harmony between consonants in separate unstressed syllables.

(41) Paired stress hierarchy

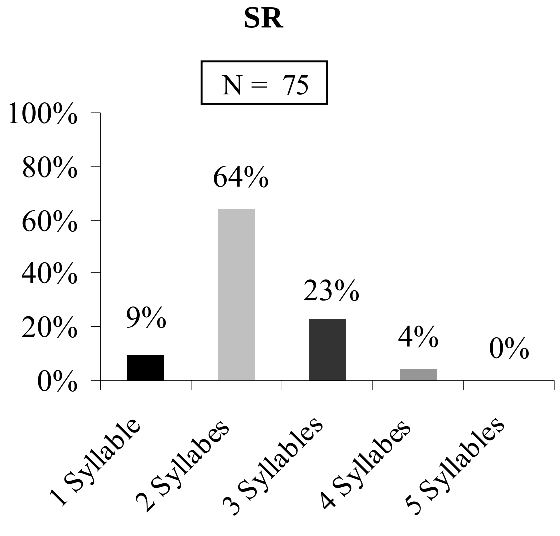


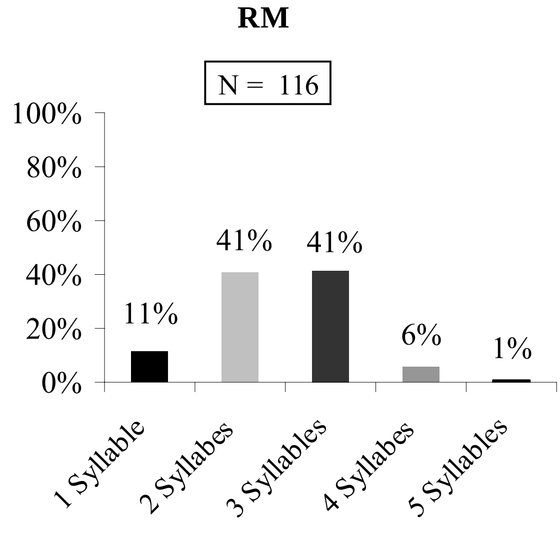


We can see that the children exhibit different trends in the “Trigger>Target” and “Trigger=Target” groups. SR has more cases with different stress degrees than cases with no stress difference, and for RM the opposite is true. In summary, it seems that stress has some interaction with CH but with different degrees for the children.

Next, I turn to investigate the harmonic domain, starting with the number of syllables in the harmonized word. The charts in (42) describe the proportions of CH instances occurred in monosyllables, disyllables etc. Note that, the number of syllables is calculated with respect to the production and not the target word (e.g. /hi.po.po.ˈtam/ ‘hippopotamus’ → [ta.ˈta], SR: 1;04.17 - is counted as CH in a disyllabic and not in a quadrisyllabic word).

(42) Consonant Harmony and number of syllables





The charts demonstrate that the majority of CH cases occur in up to trisyllabic words, as reported in Bat-El (2009); only 4% of SR's and 7% of RM's CH occur in quadrisyllabic and longer words (and not a single instance in "pentasyllabic" words in SR's data). However, the charts show a remarkable difference between the children: most of SR's CH occurs in disyllabic words, and only 27% of the cases in trisyllabic and longer words. RM, in contrast, assimilates trisyllables as much as she does disyllables. This finding is another indication of their different phonological developments.

Other properties of the harmonic domain are its affective size and alignment. In general, the data indicate that CH affects a single consonant, as reported in Bat-El (2009). I found only 3 cases in which harmony spreads over more than one consonant. They are presented in (43).

(43) More than one target

Child	Age	Utterance	Target	
SR	1;04.03	go.go.ˈgaa	hipopotam	'hippopotamus'
	1;05.04	ˈbe.pem	beten	'tummy'
RM	1;09.18	æ.da.ˈdat	maχvat	'frying pen'

The domain can be left-aligned with the prosodic word (e.g. /dʒi.ˈʁa.fa/ 'giraffe.F' → [ʃi.ˈʃa.fa], RM: 1;09.10), right-aligned (e.g. /ˈbob-ha + .ba.ˈn'aj/ 'Bob-the-builder (animated character)'→ [bo.na.ˈnaj], SR: 1;07.17) and even be bounded in word mid (e.g. /nis.ta.ˈkel/ 'will look.1PL' → [ni.χə.ˈkel], RM: 2;11.28). There are also cases in which the harmonic domain encompasses the entire word and its alignment cannot be determined (e.g. /hi.po.po.ˈtam/ 'hippopotamus' → [gu.go.ˈgaa], SR: 1;04.03). However, the latter situation occurs mostly in mono- and disyllabic words which usually contain two consonants to begin with, and therefore they are not appropriate to determine domain alignment. The next table analyzes the alignment of the harmonic domain in trisyllabic and longer productions (provided that at least 3 of the produced syllables contain consonants) taking into consideration different prosodic configurations (e.g. onset-onset and onset-coda assimilations).

(44) The Harmonic domain and prosodic positions

Trigger	Target	Alignment	SR		RM	
Onset	Onset	Left-aligned	1	(6%)	10	(42%)
		Right-aligned	10	(67%)	7	(21%)
		Whole word	0	(0%)	5	(21%)
		Word mid	3	(25%)	6	(17%)
		Total	15		28	
Onset	Coda	Left-aligned	0	(0%)	1	(17%)
		Right-aligned	1	(100%)	2	(50%)
		Whole word	0	(0%)	1	(17%)
		Word mid	0	(0%)	1	(17%)
		Total	1		5	
Coda	Onset	Left-aligned	0	(0%)	1	(9%)
		Right-aligned	0	(100%)	4	(45%)
		Word mid	0	(0%)	3	(45%)
		Total	0		8	
Coda	Coda	Left-aligned	0	(0%)	1	(50%)
		Right-aligned	0	(0%)	1	(50%)
		Total	0		2	

We can see that most cases of CH in these long productions are onset-onset assimilations (65% for RM, 94% for SR), as reported in Bat-El (2009). RM's data generally support Bat-El's finding that the harmonic domain is usually aligned with the left edge of the prosodic word, although in 38% of the onset-onset assimilations the domain is not aligned with left edge (right-aligned or bounded in mid-word). SR, on the other hand, is not supportive - most of his onset-onset assimilations in long productions are aligned with right edge of the prosodic word. This is another evidence that the children progress on different paths or rates in the course of language acquisition. Regarding the remaining (rare) configurations, we can see that the harmonic domain is usually not aligned to the left of the prosodic word. This is expected to some degree since these cases involve coda position, which cannot occur at the left edge of the prosodic word by definition.

Finally, there is little evidence that CH operates across morpheme or word boundaries. I could not find a single such case in SR's data, and I encountered only a few examples in RM's data, which are presented in (45).

(45) Consonant Harmony across word/morpheme boundary (RM)

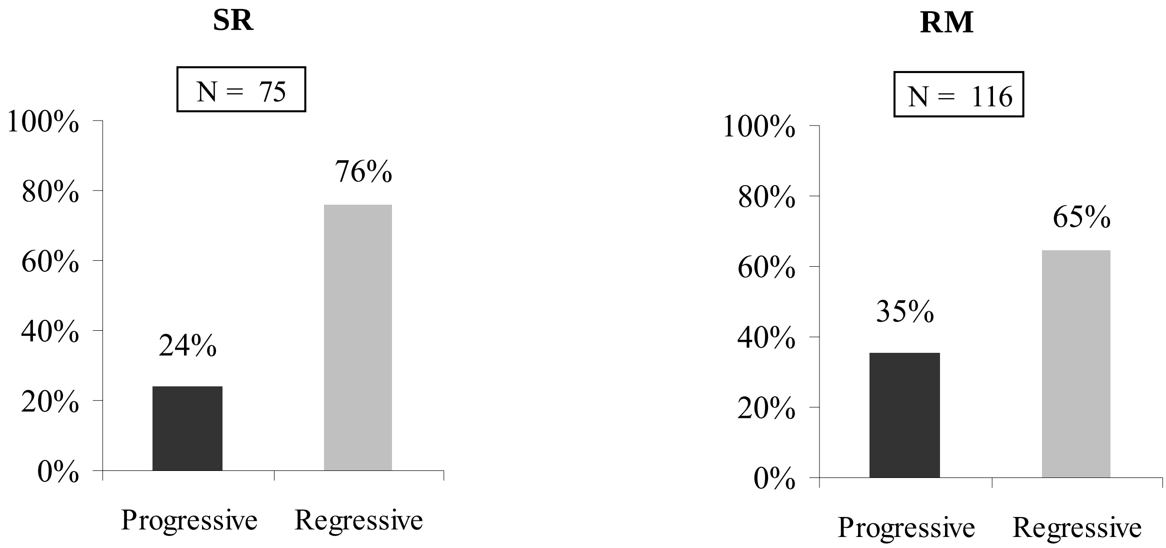
Age	Utterance	Target	
1;08.14	va-ze	ˈma-ze	‘what’s that’
1;09.27	o.ˈpa.pa.wa	od-pa.ˈʁa	‘another cow’
1;10.28	se.ˈχooj	la + .ˈχol	‘to the sand’
1;11.18	ze.ˈze	ve + .ˈze	‘and-this’
1;11.25	va-ze	ˈma-ze	‘what’s that’
2;01.12	ˈlo.lee	ze-o.ˈle	‘this-ascends’
2;05.09	ða.ˈzug	ha + .ˈzug	‘the pair’

The majority of examples were produced between stage 4 (1;07.24-1;08.27) and stage 8 (1;11.25-2;00.02). These stages are characterized by a moderate increase of mean utterance length (from 1.017 words in stage 4 to 1.175 words in stage 8; compare to a mean length of 1.003 words during the first three stages and 3.02 words in stage 23), and also by an increase in lexical growth rate (stage 7 is completed in one session, and the following stages are also relatively short with respect to the first six stages). Note also that RM reaches the peak of CH use in stage 5. It might be the case that early word combinations are submitted to phonological constraints, but the CH data are too sparse to provide solid evidence. Further research is needed to examine this issue.

5.3 Directionality

The subjects in this study showed both *progressive* (left-to-right) CH (e.g. /va.ˈʁod/ ‘pink ms.sg.’→ [va. ˈvod], RM 1;11.18), and *regressive* (right-to-left) CH (e.g. /ʃo.ˈχe.vet/ ‘she lies down’→ [ʃo.ˈfe.fet], RM 2;03.01). The proportion of progressive vs. regressive CH can be seen in (46). The charts are constructed based on the prosodic analysis, but the segmental analysis yields similar results.

(46) Directionality



We can clearly see that regressive harmony is dominant in both children, as expected from previous results (cf. Cruttenden 1978, Vihman 1978, Berg 1992, Ben-David 2001). In what follows, I will attempt to find correlations between directionality and other parameters, starting with the participating consonants.

In order to determine whether CH is driven by sequencing limitations I analyzed the directionality of CH for different PoA configurations. Each row in Table (47) presents a sequence of two PoAs, as appear in attempted target words, and the number of assimilatory cases. The table is divided according to directionality (and is constructed based on the segmental analysis in 5.1.2). For example, /ko.ˈχav/ 'star' → [ko.ˈfav] (SR: 1;06.26) is a [dorsal…labial] sequence exhibiting regressive CH. Note that harmonic productions containing a consonant island (e.g. /dʒi.ˈʁa.fa/ 'giraffe.sg.f' → [fi.ˈʁa.fa], RM: 1;09.18. See more in 5.4) are not counted here since the trigger and the target do not form a sequence of consonants.

(47) Directionality and PoA

Directionality	Configuration	SR		RM	
Regressive	Labial-Coronal	11	(31%)	8	(15%)
	Coronal-Labial	6	(17%)	13	(25%)
	Coronal-Dorsal	5	(14%)	5	(10%)
	Dorsal-Coronal	4	(11%)	16	(31%)
	Dorsal-Labial	3	(9%)	1	(2%)
	Labial-Dorsal	5	(14%)	4	(8%)
	Glottal-Coronal	0	(0%)	5	(10%)
	Glottal-Dorsal	1	(3%)	0	(0%)
	Total	35		52	
Progressive	Labial-Coronal	4	(29%)	6	(19%)
	Coronal-Labial	6	(43%)	9	(28%)
	Coronal-Dorsal	1	(7%)	3	(9%)
	Dorsal-Coronal	2	(14%)	8	(25%)
	Dorsal-Labial	0	(0%)	1	(3%)
	Labial-Dorsal	1	(7%)	4	(13%)
	Dorsal-Glottal	0	(0%)	1	(3%)
	Total	14		32	

Looking at the data, it seems that there is not much evidence that directionality is determined by the need to avoid certain orders of PoAs as CH applies in both directions for most configurations. Given that regressive is the "default" direction for CH (Tzakosta 2007), we might expect that progressive CH will involve special configurations. However, looking at the data of both children we can see that it is not the case; the most common two groups involve both coronal triggers and coronal targets. All in all, I can say with some cautious (since data amounts are small) that directionality of CH is not much affected by the participating PoAs. I propose to conduct further research to examine sequencing limitations in the acquisition of Hebrew. Such a study should take into considerations additional phenomena such as lexical selection strategies and metathesis.

Next, the combined analysis of directionality and manner is shown in (48). Recall that RM tends to use manner assimilation to decrease the sonority of the sequence, and therefore the table is constructed based on sonority order configurations. For example, /ʁak/ 'only' →

[kak] (RM: 2;09.17) is a manner harmony that decreases the sonority of ʁ. Here again cases contained consonant islands are excluded.

(48) Directionality and MoA

Directionality	Output configuration	SR		RM	
Regressive	Decreased Sonority	10	(43%)	31	(74%)
	Increased Sonority	13	(57%)	11	(26%)
	Total	23		42	
Progressive	Decreased Sonority	6	(75%)	21	(75%)
	Increased Sonority	2	(25%)	7	(25%)
	Total	8		28	

The results of this cross-analysis confirm to some degree the findings in 5.1.2: RM harmonizes to decrease the sequence sonority in both directions, while SR much less so. It is interesting to note that there is some quantitative difference between the children with respect to directionality. In both place and manner tables RM has a considerably higher percentage of progressive cases than SR. This is demonstrated in (49).

(49) Directionality and features

Feature	Directionality	SR	RM
PoA	Regressive	74%	61%
	Progressive	26%	39%
MoA	Regressive	79%	58%
	Progressive	21%	42%

* Multiple feature assimilations are counted multiple times. Productions with consonant islands are excluded.

It is not clear whether the difference demonstrated above is meaningful, but it may indicate that CH interacts differently with articulatory features for the two children.

Next, I analyze the interaction between directionality and prosody. The relation between directionality and stress is presented in (50). For every type of stress hierarchy (e.g. Trigger > Target) the table indicates the number of regressive and progressive cases of CH.

(50) Directionality and stress hierarchy

Stress Hierarchy	Directionality	SR		RM	
Trigger > Target	Regressive	29	(83%)	29	(81%)
	Progressive	6	(17%)	7	(19%)
	Total	35		36	
Trigger < Target	Regressive	10	(56%)	15	(56%)
	Progressive	8	(44%)	12	(44%)
	Total	18		28	
Trigger = Target	Regressive	17	(77%)	31	(58%)
	Progressive	5	(23%)	22	(42%)
	Total	22		53	

The table shows that regressive harmony is preferred on any configuration. However, when the trigger is in an unstressed syllable and the target is in a stressed syllable, directionality is more even. Note that RM has a relatively large number of progressive CH cases where stress is neutralized (i.e. tautosyllabic or between two unstressed syllables). To further explore the link between directionality and prosody I analyze the correlation between directionality and the number of syllables. The results are presented in table (51).

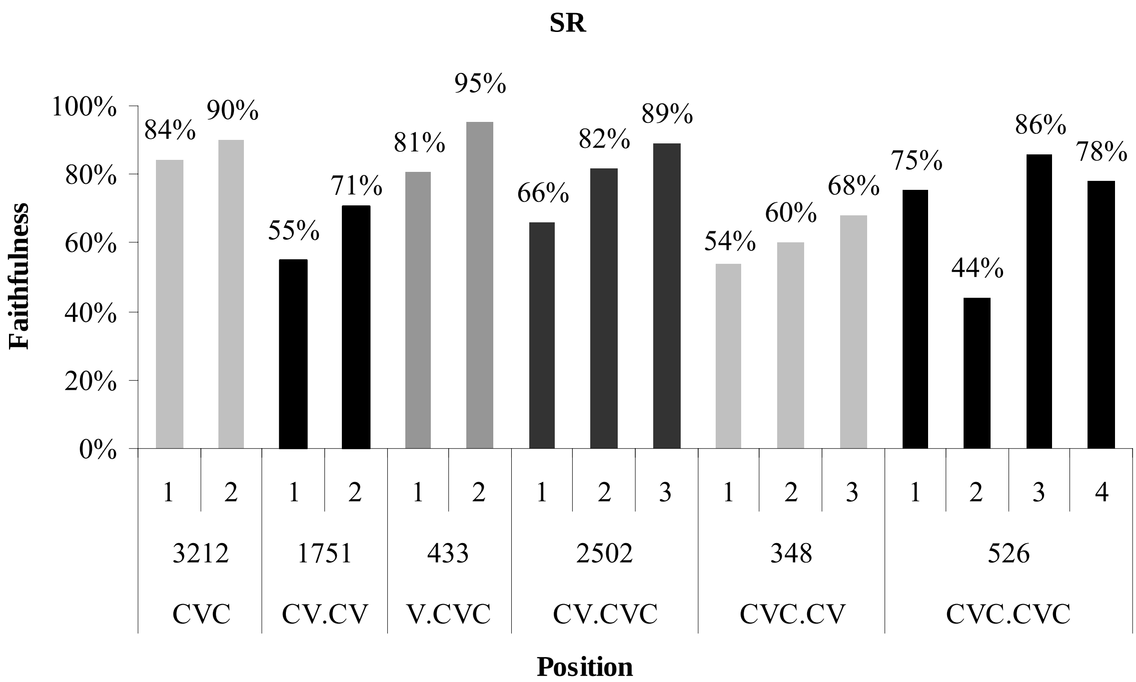
(51) Directionality and number of syllables

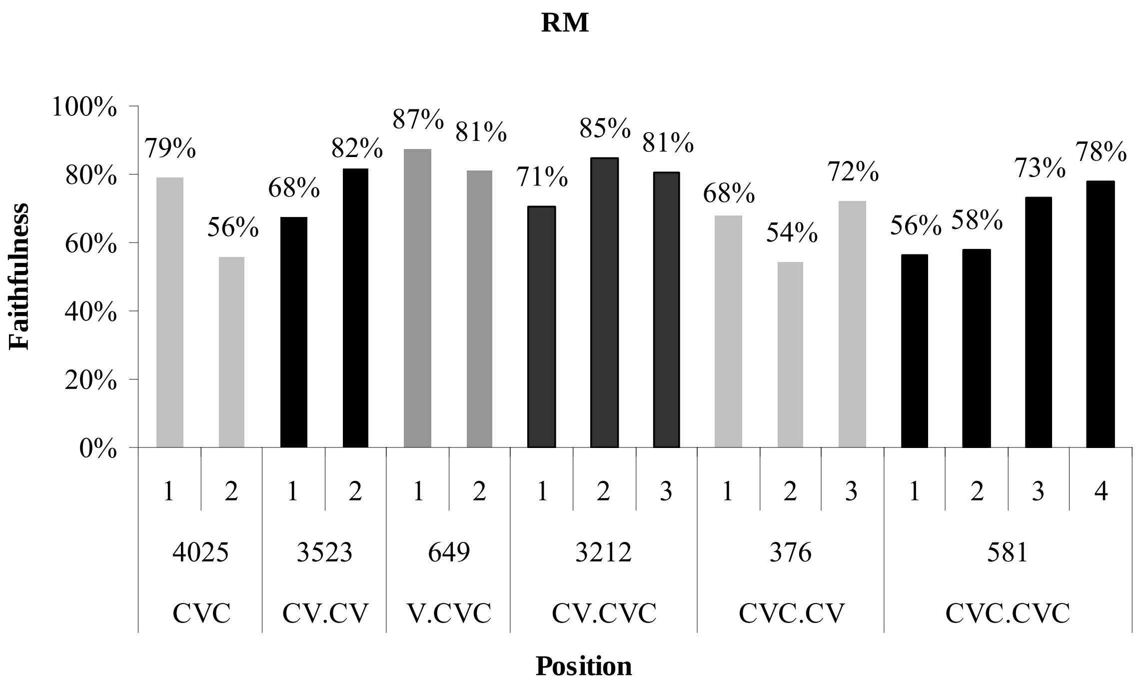
Syllables	Directionality	SR		RM	
1	Regressive	3	(4%)	5	(4%)
	Progressive	4	(5%)	8	(7%)
2	Regressive	37	(49%)	33	(28%)
	Progressive	11	(15%)	14	(12%)
3	Regressive	14	(19%)	33	(28%)
	Progressive	3	(4%)	15	(13%)
4	Regressive	2	(3%)	4	(3%)
	Progressive	1	(1%)	3	(3%)
5	Regressive	0	(0%)	0	(0%)
	Progressive	0	(0%)	1	(1%)
	Total	75		116	

Here we see again that regressive harmony is dominant with any number of syllables, except for monosyllabic productions. The data on polysyllabic words are compatible with Ben-David's (2001) claim that CH is related to prosodic development; syllables are acquired from right to left and new onsets are more susceptible to CH than old ones. In monosyllabic words, the onset is usually acquired before the coda, but Ben-David reports that CH usually occurs regressively nonetheless, probably due to segmental effects. In the present study, CH in monosyllabic words is mostly progressive, which seems to support the old-to-new direction found in polysyllabic words. However, the number of examples is too small to allow firm conclusions. To see whether these results indeed reflect general properties of prosodic development, I analyze the general behavior of different prosodic positions in the children's productions.

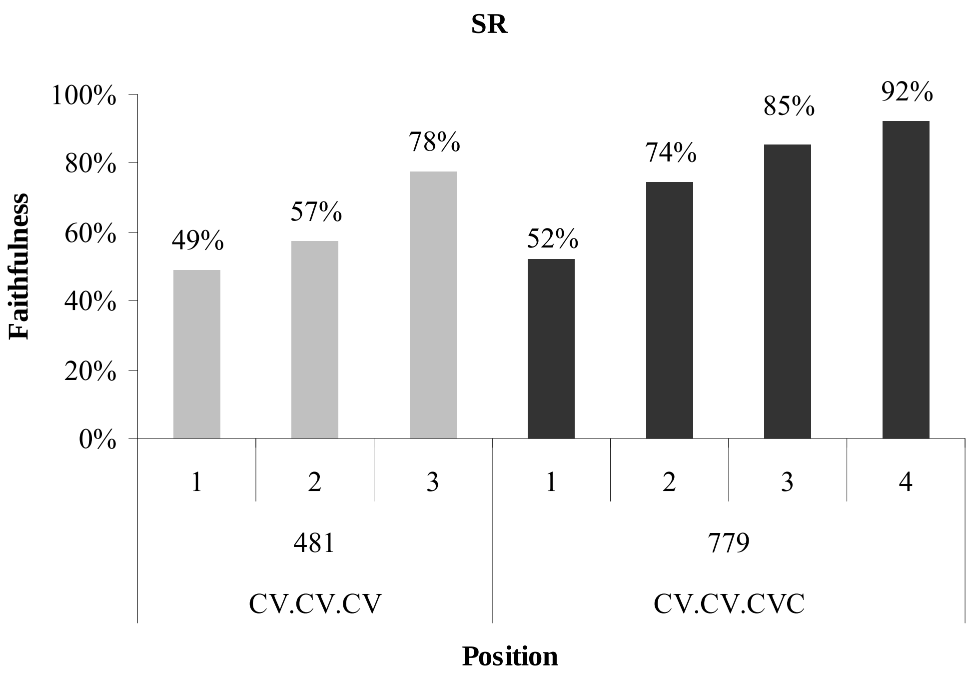
The following charts show the percentages of faithful productions of consonants in different prosodic positions throughout the complete examined corpora (unfaithful productions can be either deletion or substitution, not to be confused with the analysis in 4.2.3 which referred to the structure of the productions alone). For this illustration I chose mono- di- and trisyllabic target words of the most commonly used structures. The charts are organized by structure and each column represents a certain position. The marking numbers designate the relative position in the word (e.g. column '1' in the CVC group is for the first C and column '2' is for the second C). In addition, the charts indicate the number of examined token words of each structure (e.g. SR attempted 3212 CVC target words during the recorded sessions). The analysis of mono- and disyllabic words is shown in (52), and trisyllabic structures are presented in (53).

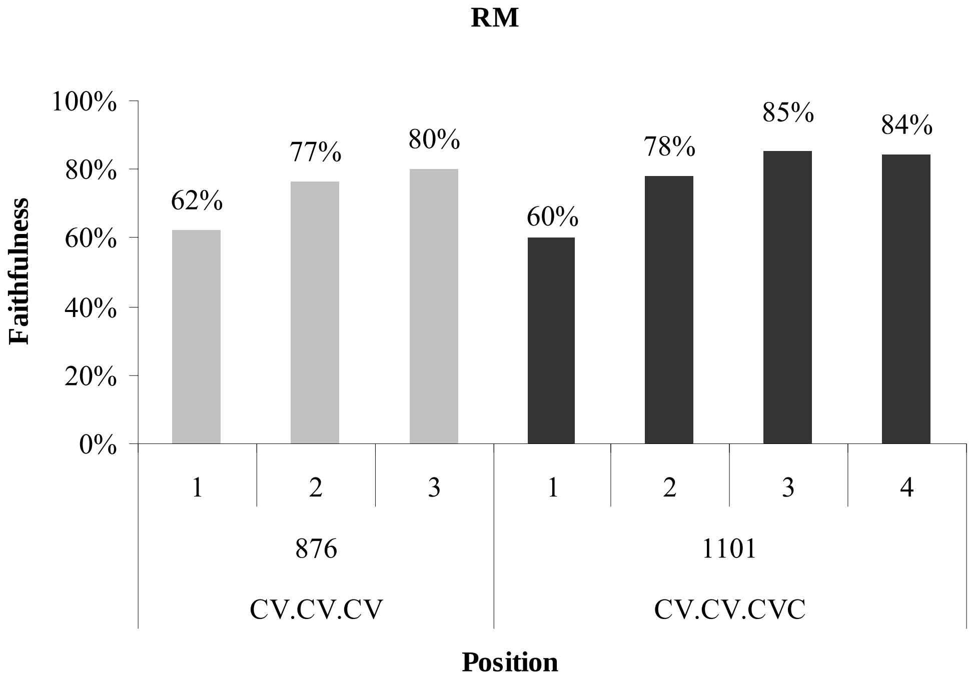
(52) Faithfulness by prosodic position - monosyllabic and disyllabic words





(53) Faithfulness by prosodic position - trisyllabic words





The charts above are roughly compatible with Ben-David's findings, i.e. that the prosodic word in Hebrew is acquired from right to left, and newly acquired positions tend to be less faithful than well-established positions. According to Ben-David, the order of acquisition is as follows: onset of final syllable → coda of final syllable ↔ onset of non-final syllable → coda of non-final syllable (where ↔ indicates inter-child variation). A closer look reveals that the scheme is partially borne out by the data. Both children follow the scheme when considering onsets and codas; onsets/codas on the right are more faithful than onsets/codas on the left. The only discrepancy is found in mixed configurations where RM usually conforms to the generalization (with the exception of CVC.CVC words), i.e. onsets are more faithful than tautosyllabic codas, while the opposite is true for SR.

This deviation from Ben-David's findings may highlight once again the different paths that children may take during acquisition. However, this can also be an artifact of the present analysis - Ben-David's generalizations are based on dynamic developmental analysis, while the present analysis is static with no differentiation into stages of development. It is likely that the current results are somewhat skewed and do not truly reflect the prosodic development of the children.

It is worth examining whether the above findings are reflected in the CH data. The following table cross-analyzes directionality and prosodic configuration. If CH follows the same patterns as prosodic faithfulness we would expect to find more regressive than progressive assimilations between identical positions in both children, and mixed tendencies in mixed configurations.

(54) Directionality and prosodic configuration[22]

Configuration		Directionality	SR		RM	
Onset	Onset	Regressive	38	(54%)	36	(36%)
		Progressive	12	(17%)	20	(20%)
Coda	Coda	Regressive	0	(0%)	1	(1%)
		Progressive	0	(0%)	1	(1%)
Onset	Coda	Regressive	15	(21%)	24	(24%)
		Progressive	5	(7%)	19	(19%)
Total			70		101	

The results confirm those in earlier studies, that regressive assimilation is more abundant than progressive assimilation in all configurations. In onset-onset assimilation the right-to-left (regressive) direction correlates with the new-to-old direction. The results of onset-coda assimilation are inconclusive, given the variation between the children. The validity of the findings is limited due to the low amount of data. Note that coda-coda assimilations are hardly attested, probably since productions containing two codas appear relatively late when the segmental system is developed enough to save the need for simplification.

5.4 Intervening segments

The issue of intervening segments was not covered in depth in this study. However, my impression is that the intervening vowel does not affect CH, as assimilation can occur with different settings of PoA and different vowel qualities. For example, SR harmonizes /hi.po.po.ˈtam/ ‘hippopotamus’ while realizing the intervening vowel in several different ways: [ˈta.tam] / [ˈto.tam] / [ˈti.tam]. In general, the children seem to use vowels rather variably and independently from consonantal environment. If there are consonant-vowel interactions in the data they are probably rather sparse and hard to recognize. Further research may shed light on this issue.

Regarding intervening consonants - I have found 19 cases where assimilation seems to skip an intervening consonant. There are several positional relations between the island and

[22] These data exclude cases where CH skips identical positions (e.g. assimilation between C1 and C3 in C1V.C2VC3 or C1V.C2V.C3V) and where there is more than one potential trigger (e.g. /me.χa.ˈjeχ/ ‘smiles ms.sg’ → [χe.ˈʁaχ] RM: 2;00.16).

the harmonic domain: (A) harmony between two identical positions (e.g. onset-onset) with an island in a different position (e.g. coda); (B) harmony between the first consonant in a complex onset and a consonant in a simple onset, where the island is the second consonant in the complex onset; (C) harmony between coda and onset in non-adjacent syllables, skipping an onset that is in string adjacency to the participating coda; (D) onset-onset harmony that skips an intervening onset; and (E) onset-coda harmony skipping an intervening onset which is not string adjacent with any of the participants. All the examples in the corpora are listed in (55). Note that only islands of type E are found in SR's data.

(55) Consonant islands

Type	**Child**	**Age**	**Utterance**	**Target**	
A	RM	2;01.19	ti.ˈlak.li	hit.laχ.ˈlaχ.ti	'got dirty.1SG'
		2;02.04	lik.ˈlot	lik.ˈnot	'to buy'
		2;01.19	il.bal.ˈbal.ti	hit.bal.ˈbal.ti	'got mixed up.1SG'
		2;04.19	ma.χal.ˈkel	me.χa.ˈle.ket	'dividing.SG.F'
B	RM	2;04.19	k^{n}mə.ˈχa	sme.ˈχa	'happy.SG.F'
		2;09.17	bχa.bi.ˈʁa	maχ.zi.ˈʁa	'returning.sg.f'
C	RM	2;02.04	meʃ.ˈpi.ʃa	mal.bi.ˈʃa	'dressing.SG.F'
		2;04.19	meʃ.gi.ˈʃa	maʁ.gi.ˈʃa	'feels.F'
		2;06.12	ʔag.wu.ˈgeʁ	ˈham.buʁ.geʁ	'hamburger'
D	RM	1;09.18	fi.ˈʁa.fa	dʒi.ˈʁa.fa	'giraffe.sg.f'
		1;11.18	te.zi.gi.ˈzaa	te.le.ˈviz.ja	'television'
		1;11.25	le.kə.ˈlaa	su.kaʁ.ˈja	'candy'
		1;11.25	se.pu.ˈʃis	χi.pu.ˈʃit	'beetle'
		2;02.25	ʃe.bu.ˈʃit	χi.pu.ˈʃit	'beetle'
E	SR	1;07.02	na.ˈtan	ka.ˈtan	'small.sg.m'
		2;01.11	*ne.man	na.ˈmeʁ	'leopard'
		2;02.22	ˈka.tik	ˈplas.tik	'plastic'
	RM	1;11.18	dee.ˈɱod	va.ˈʁod	'pink.sg.m'
		2;01.06	*sa.ˈχas	na.ˈχaʃ	'snake'

* In these examples the island itself is partially harmonic with the assumed the trigger so they may not be good examples of a consonant island.

Some observations can be made based on the above table: there are 9 cases of onset-onset CH (A, D), 2 of coda-coda CH (A), 3 instances of CH applying from onset to coda (C), and 5 from coda to onset (E). In 9 cases (A-C) the island is in contact with either the trigger or the target, and in the remaining 10 cases (D-E) it is isolated. There are 12 cases of a stop in an island, 3 nasals, 2 fricatives and 2 approximants. With respect to place, 8 islands are labial, 2 are coronal and 9 are dorsal. All in all, CH skipping an intervening consonant is rare and its properties are hard to generalize.

5.5 Discussion

In this part of the study I examined the properties of CH in the corpus. The segmental analysis of place harmony indicates that it is governed by the token frequencies of the major places of articulation and involves coronals more than other types of PoA. This is similar to what Tzakosta (2007) reports on Greek, but not to the findings in Ben-David (2001) who notes that place assimilation is triggered mostly by labials and dorsals in the acquisition of Hebrew. Such conflicting evidence from children acquiring the same language may suggest that place harmony is not governed by a universal (or even language-specific) trigger-target hierarchy. Though I do not have access to the full database of Ben-David, I managed to find some anecdotal examples demonstrating the discrepancy between the children in her study and those in mine. In addition, I found a couple of inter-child variation examples in the corpora of the present study and even some cases of intra-child variation. Table (56) compares the production of several target words by different children.

(56) Inter-child and intra-child variation

Target		**Child 1**			**Child 2**		
		Child	**Utter.**	**Age**	**Child**	**Utter.**	**Age**
tsav	'tortoise'	SR (PS)	tsaz	1;04.10	Geffen (BD)	fav	1;01
dʒip	'jeep'	SR (PS)	dit	1;04.10	Nadav (BD)	bip	1;08
tov	'good, well'	RM (PS)	tot^h	1;06.26	Geffen (BD)	pav	1;01
pil	'elephant'	SR (PS)	til	1;04.24	RM (PS)	pib	1;08.14
ˈza.χal	'caterpillar'	SR (PS)	ˈχa.χal	1;06.26	RM (PS)	ˈsa.zal	2;02.25
ken	'yes'	RM (PS)	geg	1;05.10	RM (PS)	nẽn	1;06.05
mig.ˈdal	'tower'	SR (PS)	ga.ˈgal	1;05.08	SR (PS)	di.ˈdal	1;07.17

* PS = present study; BD = Ben-David (2001)

In the examples above, we can see that a given sequence of PoAs (e.g. coronal-labial) can be treated differently by different children. Of course, one cannot jump to conclusions based on a handful of examples, but nevertheless, the fact that children acquiring the same language use CH in opposite manner suggests that the process does not so much depend on segmental hierarchies. Interestingly, the exact same conflict is reported in Tzakosta (2007) - while her study reveals that coronal harmony is dominant in the acquisition of Greek, Kappa (2001) reports that labial harmony is the most frequent on her data. This again strengthens the impression that there is more than segmental hierarchy to CH.

With respect to manner harmony, the picture is less clear - for SR the trigger-target distributions seems to reflect input frequency, and as a consequence there is no clear trigger-target hierarchy (some of the MoAs have close frequencies). RM, on the other seems to often use CH in order to reduce the sonority of the target, whether for segmental or phonotactic reasons.

The analysis here (together with the one in 4.2.3) indicates that CH might be related to prosodic development. The directionality of assimilation goes hand in hand in many cases with the path of prosodic development - CH tends to operate between identical positions from right to left, on the same direction in which prosodic positions are acquired. On the other hand, CH between non-identical positions (i.e. onset-coda) is less consistent with the order of acquisition and may operate in reverse trend, i.e. from new to old position. In addition, CH appears more in short (disyllabic and trisyllabic) productions than in longer productions. This, according to Bat-El (2009), indicates the synchronization between segmental and prosodic development - by the time the children start producing long words their segmental and prosodic systems are developed enough to eliminate the need to harmonize. Finally, the affect of stress on CH is not entirely clear. Although nearly 50% of SR's CH cases are from a stressed to an unstressed syllable, there are still many cases in which stress is irrelevant. RM tends much less to favor a trigger that is more stressed than the target (31%), and the majority of cases (45%) in her corpus involve neutralized stress.

6. Conclusions

This study is devoted to Consonant Harmony in the acquisition of Hebrew. In the first part of the study, I developed a quantitative identification method for CH. The need for such a method arises in cases in which the production is ambiguous and can be analyzed both as CH and as a context-free substitution (e.g. velar fronting). The proposed method estimates the probability that a given consonant substitution depends on a harmonic environment. Nevertheless, I claim that the identification of CH is inherently problematic since there is no way to know the exact motivation behind any instance of consonant substitution; even when the child uses a process that is generally context-free we cannot know for certain that he is not motivated by harmony as well. Further research is needed in order to test the proposed method on data from different languages and with children that are claimed to be productive "harmonizers".

In the second part of the study I evaluated possible causes for CH. From a phonological aspect, it seems that CH can serve all kinds of purposes: it can replace consonants the child cannot produce yet, it can eliminate some disharmonic consonant sequences that might be difficult for the child and it can compensate for the complexity of certain prosodic structures in a "trade-off" effect. In many cases more than one of these factors can in principle account for the use of CH.

The present study also discusses CH from a more general cognitive aspect. In this context there is evidence that CH can be related to both lexical representation and speech planning. In many cases CH appears on the first attempt to produce a target word, even if its prosodic structure and segmental content should not be difficult for the child. This can be either due to inaccurate representation of the target word or due to failure in speech planning/execution. A support for a representational component of CH comes from the consistent prolonging use of harmony in some lexical items which do not seem to reflect general properties of the data. On the other hand, the existence of many isolated cases for which there is no satisfactory explanation gives the impression that CH can sometimes be an incidental error and not the result of a grammatical rule.

In the final part of the study I analyzed the properties of CH. The analysis of place harmony indicates that trigger-target hierarchy is likely to be related to input frequency and even to individual factors. This finding together with conflicting evidence from previous studies does not support the repeated claim in the CH literature that place CH is governed by a universal markedness hierarchy. Regarding manner harmony, SR's data suggest that his trigger-target choice is also determined by input frequency. On the other hand, RM's manner harmony usually reduces the sonority of the target. The analysis also indicates some influence of prosodic factors in both children. Directionality of assimilation between identical prosodic positions converges in most cases (right-to-left) with the direction of acquisition (i.e. old-to-new). However, in onset-coda assimilation, while the right-to-left is still the dominant direction, it is less consistent with the direction of acquisition.

Throughout the study the issue of inter-child variation has raised repeatedly. Although the subjects in this study are considered as typical developers, they are nonetheless quite different in several respects. SR is a fast developer, showing little use of consonant substitutions from the beginning and developing a large lexicon quite rapidly. He also stops using CH rather early - CH mostly affects his disyllabic productions. In addition, his use of CH reflects the frequency of place and manner features in the input. By contrast, RM is a more average developer and uses consonant substitution much more frequently. Her phonological "repertoire" is so rich that most of her harmonized productions are suspected to result from context-free substitutions. She uses CH to a later stage than SR, and often in trisyllabic words. RM is also somewhat different from SR with respect to manner harmony - she seems to use CH rather consistently to reduce the sonority of the target. While inter-child variation is a known phenomenon in the study of language acquisition (see e.g. Bat-El 2009 for references), further research is needed to examine the scope and limits of the variation in CH.

Postscript

This study is mostly descriptive and does not go far into theoretical discussion, nor does it provide a formalistic model of CH. Although this may seem a weak point to some readers, I find it an advantage; by not imposing a particular formalism on the data I managed to gain some valuable insights. At the beginning of this study, I attempted to replicate previous studies by looking for highly abstract generalizations in terms of features with the intention of providing an Optimality Theoretic account for the data. But soon enough and in contrast to some previous studies that attempted to draw a clear and simple picture of CH, I discovered that there was nothing clear or simple in the data I was working on. CH seemed scarce and erratic and I was forced to change my original goal to a more modest one - finding order in the chaos. Thus, I turned from analyzing the harmonized forms in isolation to a complete analysis of the corpora and from looking at the feature level alone to examining the word level as well.

Since I could not arrive at clear generalizations I was unable to construct a formalistic model to account for CH. Nevertheless, the present study does have some results that can serve as reference points for future studies, and in particular the finding that CH may be related to lexical development and the hypothesis that CH may be a child-specific form of slip of the tongue. I believe that by adopting a functionalist point of view in this study (see the beginning of section 2) I managed to see a bit beyond the masking of abstract theories and messy data, and if my conclusions are correct they may serve as a support for "old school" and sometimes forgotten approaches to language acquisition, such as reflected in the citation: "*Children never learn sounds: They only learn words, and the sounds are learned through words*." (Francescato 1968).

Appendix: Lists of Consonant Harmony items

(57) SR

	Stage	Age	Target		Child
1.	1	1;02.16	paʁ.ˈpaʁ	‘butterfly’	ˈpa.pap
2.	2	1;03.25	dʒip	‘jeep’	d̪i̥t̪
3.	2	1;03.25	dʒip	‘jeep’	d̪it̪
4.	2	1;03.25	dʒip	‘jeep’	d̪it̪
5.	2	1;03.25	dʒip	‘jeep’	dit̪
6.	2	1;04.03	hi.po.po.ˈtam	‘hippopotamus’	gu.go.ˈgaa
7.	2	1;04.03	hi.po.po.ˈtam	‘hippopotamus’	go.go.ˈgaa
8.	2	1;04.03	hi.po.po.ˈtam	‘hippopotamus’	go.go.ˈgaa
9.	2	1;04.03	hi.po.po.ˈtam	‘hippopotamus’	go.go.ˈgaa
10.	2	1;04.10	dʒip	‘jeep’	dit
11.	2	1;04.10	dʒip	‘jeep’	dit
12.	2	1;04.10	ˈken.gu.ʁu	‘kangaroo’	gu.ˈguu
13.	2	1;04.10	ˈken.gu.ʁu	‘kangaroo’	gu.ˈgum
14.	2	1;04.10	ˈken.gu.ʁu	‘kangaroo’	gu.ˈgum
15.	2	1;04.10	ˈken.gu.ʁu	‘kangaroo’	gu.ˈguu
16.	2	1;04.10	ˈken.gu.ʁu	‘kangaroo’	gu.ˈgum
17.	2	1;04.10	ˈken.gu.ʁu	‘kangaroo’	gu.ˈgum
18.	2	1;04.10	ˈken.gu.ʁu	‘kangaroo’	gu.ˈgum
19.	2	1;04.10	ˈken.gu.ʁu	‘kangaroo’	gu.ˈgum
20.	2	1;04.10	ˈken.gu.ʁu	‘kangaroo’	gu.ˈgum
21.	2	1;04.10	pil	‘elephant’	til
22.	2	1;04.10	tsav	‘tortoise’	tsaz
23.	2	1;04.10	tsav	‘tortoise’	taz̪
24.	2	1;04.10	tsav	‘tortoise’	ðaθ
25.	2	1;04.17	bej.ˈtsa	‘egg’	ta.ˈtθa
26.	2	1;04.17	bej.ˈtsa	‘egg’	ta.ˈtθaa
27.	2	1;04.17	hi.po.po.ˈtam	‘hippopotamus’	ta.ˈta
28.	2	1;04.17	pil	‘elephant’	til
29.	2	1;04.17	ˈʁo.ni	‘Roni (name)’	ˈna.nii
30.	3	1;04.24	a.vi.ˈʁon	‘airplane’	ʔa.ni.ˈon
31.	3	1;04.24	a.vi.ˈʁon	‘airplane’	ʔa.ni.ˈon
32.	3	1;04.24	a.vi.ˈʁon	‘airplane’	ʔa.ni.ˈon
33.	3	1;04.24	a.vi.ˈʁon	‘airplane’	ʔa.ni.ˈon
34.	3	1;04.24	a.vi.ˈʁon	‘airplane’	ʔa.ni.ˈon
35.	3	1;04.24	a.vi.ˈʁon	‘airplane’	ʔa.ni.ˈon
36.	3	1;04.24	a.vi.ˈʁon	‘airplane’	ʔa.ni.ˈon
37.	3	1;04.24	dʒi.ˈʁa.fa	‘giraffe fm.’	ʒi.ˈja.ja
38.	3	1;04.24	dʒi.ˈʁa.fa	‘giraffe fm.’	di.ˈja.ja
39.	3	1;04.24	hi.po.po.ˈtam	‘hippopotamus’	ja.ta.ˈta
40.	3	1;04.24	hi.po.po.ˈtam	‘hippopotamus’	ˈta.ta
41.	3	1;04.24	hi.po.po.ˈtam	‘hippopotamus’	ˈta.tam
42.	3	1;04.24	hi.po.po.ˈtam	‘hippopotamus’	ˈta.tam
43.	3	1;04.24	ˈken.gu.ʁu	‘kangaroo’	ˈgu.gim
44.	3	1;04.24	pil	‘elephant’	til
45.	3	1;04.24	pil	‘elephant’	til
46.	3	1;04.24	pil	‘elephant’	til
47.	3	1;05.04	a.vi.ˈʁon	‘airplane’	ʔa.ni.ˈon
48.	3	1;05.04	a.vi.ˈʁon	‘airplane’	ʔa.ni.ˈen
49.	3	1;05.04	ˈbe.ten	‘tummy’	ˈbe.pem
50.	3	1;05.04	dʒi.ˈʁa.fa	‘giraffe fm.’	ˈʒi.ʒa
51.	3	1;05.04	hi.po.po.ˈtam	‘hippopotamus’	ˈti.tam
52.	3	1;05.04	hi.po.po.ˈtam	‘hippopotamus’	ti.ˈtaam
53.	3	1;05.04	ˈken.gu.ʁu	‘kangaroo’	gu.ˈgum

	Stage	Age	Target		Child
54.	3	1;05.08	dʒip	‘jeep’	dit̪
55.	3	1;05.08	hi.po.po.ˈtam	‘hippopotamus’	ˈta.taam
56.	3	1;05.08	mig.ˈdal	‘tower’	ga.ˈgal
57.	3	1;05.08	mig.ˈdal	‘tower’	ga.ˈgal
58.	4	1;05.15	ha.-ba.ˈtsal	‘the-onion’	ʔa.ba.ˈbal
59.	4	1;05.15	hi.po.po.ˈtam	‘hippopotamus’	ta.ˈtam
60.	4	1;05.15	hi.po.po.ˈtam	‘hippopotamus’	ta.ˈtam
61.	4	1;05.15	hi.po.po.ˈtam	‘hippopotamus’	ˈta.tam
62.	4	1;05.15	kiv.ˈsa	‘sheep fm.’	θi.ˈθaa
63.	4	1;05.21	ke.a.ˈʁa	‘bowl’	ke.a.ˈka
64.	4	1;05.21	ko.ˈχav	‘star’	ko.ˈpav
65.	5	1;05.29	a.vi.ˈʁon	‘airplane’	a.ni.ˈin
66.	5	1;05.29	a.vi.ˈʁon	‘airplane’	ʔa.ni.ˈin
67.	5	1;05.29	pil	‘elephant’	til
68.	5	1;05.29	pil	‘elephant’	til
69.	5	1;06.02	saf.ˈsal	‘bench’	fa.ˈfal
70.	5	1;06.02	saf.ˈsal	‘bench’	fa.ˈfal
71.	5	1;06.02	saf.ˈsal	‘bench’	ˈfa.fal
72.	5	1;06.02	saf.ˈsal	‘bench’	ˈfa.fal
73.	5	1;06.02	ʃa.ˈlom	‘hello’	la.ˈlaam
74.	5	1;06.02	ʃa.ˈlom	‘hello’	la.ˈlaam
75.	5	1;06.02	pa.ˈnas	‘flashlight’	pa.ˈs̪aas̪
76.	5	1;06.02	pa.ˈnas	‘flashlight’	na.ˈnas
77.	6	1;06.20	ha.-ba.ˈnaj	‘the-builder’	a.da.ˈnaj
78.	6	1;06.20	ha.-ba.ˈnaj	‘the-builder’	ha.da.ˈnaj
79.	6	1;06.20	hi.po.po.ˈtam	‘hippopotamus’	ˈti.tam
80.	6	1;06.20	hi.po.po.ˈtam	‘hippopotamus’	ta.ˈtam
81.	6	1;06.20	ˈʃe.meʃ	‘sun’	ˈme.meθ
82.	6	1;06.20	ˈʃe.meʃ	‘sun’	ˈme.meθ
83.	6	1;06.20	ˈʃe.meʃ	‘sun’	ˈme.meθ
84.	7	1;06.26	hi.po.po.ˈtam	‘hippopotamus’	ta.ˈtam
85.	7	1;06.26	hi.po.po.ˈtam	‘hippopotamus’	ˈto.tam
86.	7	1;06.26	ˈʃe.meʃ	‘sun’	ˈme.meθ
87.	7	1;06.26	taʁ.ne.ˈgol	‘rooster’	ge.ˈgol
88.	7	1;06.26	ko.ˈχav	‘star’	ko.ˈfav
89.	7	1;06.26	ˈza.χal	‘caterpillar’	ˈχa.χal
90.	7	1;07.02	ˈje.led	‘boy’	ˈle.led
91.	7	1;07.02	hi.po.po.ˈtam	‘hippopotamus’	ˈto.tam
92.	7	1;07.02	hi.po.po.ˈtam	‘hippopotamus’	ˈta.tam
93.	7	1;07.02	ka.ˈtan	‘small ms.sg.	na.ˈtan
94.	7	1;07.02	ˈken.gu.ʁu	‘kangaroo’	gu.ˈgum
95.	8	1;07.09	ˈdu.bi	‘teddy bear’	ˈba.bi
96.	8	1;07.09	ˈdu.bi	‘teddy bear’	ˈba.bi
97.	8	1;07.09	hi.po.po.ˈtam	‘hippopotamus’	to.ˈtam
98.	8	1;07.09	jo.ˈʃev	‘sits ms.sg.’	ˈfæv
99.	8	1;07.09	jo.ˈʃev	‘sits ms.sg.’	ʔo.ˈfev
100.	8	1;07.09	ˈken.gu.ʁu	‘kangaroo’	gu.ˈgum
101.	8	1;07.09	no.ˈtsa	‘feather’	θa.ˈtθa
102.	8	1;07.09	sim.ˈla	‘a dress’	la.ˈla
103.	9	1;07.17	ˈbob.ha.ba.ˈnaj	‘Bob-the-builder (animated character)’	bo.na.ˈnaj
104.	9	1;07.17	heχ.ˈzik	‘held 3ms.sg.’	kik
105.	9	1;07.17	heχ.ˈzik	‘held 3ms.sg.’	kik
106.	9	1;07.17	mig.ˈdal	‘tower’	di.ˈdal
107.	9	1;07.17	ti.ˈnok	‘baby’	ˈni.nok
108.	9	1;07.23	ha.ˈlaχ	‘went 3 ms.sg.’	ha.ˈʁaχ
109.	9	1;07.23	ha.ˈlaχ	‘went 3 ms.sg.’	ha.ˈʁaχ
110.	9	1;07.23	ha.ˈlaχ	‘went 3 ms.sg.’	ha.ˈʁaχ

	Stage	Age	Target		Child
111.	9	1;07.23	ha.ˈlaχ	‘went 3 ms.sg.’	ha.ˈʁaχ
112.	9	1;07.23	ˈʃe.meʃ	‘sun’	ˈmæ.meθ
113.	9	1;07.23	ˈʃe.meʃ	‘sun’	ˈme.meθ
114.	9	1;07.23	ˈʃe.meʃ	‘sun’	ˈme.meθ
115.	9	1;07.23	ˈʃe.meʃ	‘sun’	ˈme.meθ
116.	9	1;07.23	ˈʃe.meʃ	‘sun’	ˈme.meθ
117.	10	1;08.03	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	bo.na.ˈnaj
118.	10	1;08.03	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	bo.na.ˈnaj
119.	10	1;08.03	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	bo.na.na.ˈnaj
120.	10	1;08.03	ˈne.ʃeʁ	‘vulture’	ˈne.χeʁ
121.	10	1;08.10	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	bo.na.na.ˈnaj
122.	10	1;08.10	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	bo.na.na.ˈnaj
123.	10	1;08.24	ko.ˈtsim	‘thorns’	θa.ˈθim
124.	11	1;09.00	do.ˈheʁ	‘galloping ms.sg.’	do.ˈʁeʁ
125.	11	1;09.09	niʃ.be.ˈʁa	‘broke 3fm.sg.’	ge.ˈʁa
126.	11	1;09.09	niʃ.be.ˈʁa	‘broke 3fm.sg.’	ge.ˈʁa
127.	11	1;09.09	niʃ.be.ˈʁa	‘broke 3fm.sg.’	ge.ˈʁa
128.	11	1;09.09	ˈʃe.meʃ	‘sun’	ˈme.meθ
129.	12	1;09.19	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	a.na.ˈnaj
130.	12	1;09.19	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	bi.na.ˈnaj
131.	12	1;09.19	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	bo.a.na.ˈnaj
132.	12	1;09.19	ˈbob ha.-ba.ˈnaj	‘Bob-the-builder (animated character)’	bo.a.na.ˈnaj
133.	12	1;09.19	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	bob.na.ˈnaj
134.	12	1;09.19	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	bob.na.ˈnaj
135.	12	1;09.19	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	bo.da.ˈnaj
136.	12	1;09.19	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	bo.da.ˈnaj
137.	12	1;09.19	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	bo.na.ˈnaj
138.	12	1;09.19	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	bo.na.ˈnaj
139.	12	1;09.19	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	bo.na.ˈnaj
140.	12	1;09.19	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	bo.na.ˈnaj
141.	12	1;09.19	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	bo.na.ˈnaj
142.	12	1;09.19	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	bo.na.ˈnaj
143.	12	1;09.19	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	bo.na.ˈnaj
144.	12	1;09.19	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	bo.na.ˈnaj
145.	12	1;09.19	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	bo.na.ˈnaj
146.	12	1;09.19	ha.-ba.ˈnaj	‘the-builder’	na.ˈnaj
147.	12	1;09.19	ˈbob ha.-ba.ˈnaj	‘Bob the-builder (animated character)’	bo.na.ˈnaj
148.	12	1;09.27	ja.ˈʁok	‘green ms.sg.’	ja.ˈkok
149.	12	1;09.27	ˈken.gu.ʁu	‘kangaroo’	ga.ˈgom
150.	12	1;09.27	kla.ˈvim	‘dogs’	va.ˈvim
151.	12	1;09.27	kla.ˈvim	‘dogs’	va.ˈvim
152.	12	1;09.27	ma.sa.ˈit	‘truck’	θa.θa.ˈʔit
153.	12	1;10.07	ˈbob ha-.ba.ˈnaj	‘Bob the-builder (animated character)’	bo.na.ˈnaj
154.	12	1;10.07	ˈbob ha-.ba.ˈnaj	‘Bob the-builder (animated character)’	bo.na.ˈnaj
155.	13	1;11.02	miχ.na.ˈsaim	‘pants’	mi.θa.ˈθaim
156.	13	1;11.02	miχ.na.ˈsaim	‘pants’	mi.θa.ˈθaim
157.	13	1;11.07	ˈbob ha-.ba.ˈnaj	‘Bob the-builder (animated character)’	bo.na.na.ˈnaj
158.	13	1;11.07	ˈbob ha-.ba.ˈnaj	‘Bob the-builder (animated character)’	bo.na.na.ˈnaj
159.	13	1;11.07	ˈbob ha-.ba.ˈnaj	‘Bob the-builder (animated character)’	bo.na.na.ˈnaj
160.	13	1;11.07	ˈbob ha-.ba.ˈnaj	‘Bob the-builder (animated character)’	bo.na.na.ˈnaj
161.	13	1;11.07	ˈbob ha-.ba.ˈnaj	‘Bob the-builder (animated character)’	a.bo.na.ˈnaj
162.	13	1;11.07	o.ˈχe.let	‘eats fm.sg.’	ˈχe.ʁet
163.	13	1;11.07	ʁa.ˈwan	‘Rawan (name)’	wa.ˈwan
164.	14	1;11.22	ˈo.to.bus	‘bus’	ˈʔo.po.buθ
165.	15	2;00.00	ˈpu.pik	‘bellybutton’	ˈpu.kik
166.	15	2;00.00	ˈpu.pik	‘bellybutton’	ˈpu.kik
167.	16	2;00.21	hi.po.po.ˈtam	‘hippopotamus’	hi.po.tot

	Stage	Age	Target		Child
168.	16	2;00.21	niʃ.be.ˈʁa	‘broke 3fm.sg.’	niθ.ke.ˈʁa
169.	16	2;00.21	ˈzeb.ʁa	‘zebra’	ˈðe.da
170.	17	2;01.11	ˈje.led	‘boy’	ˈle.led
171.	17	2;01.11	le.va.ˈʃel	‘to cook’	le.fa.ˈvel
172.	17	2;01.11	na.ˈmeʁ	‘leopard’	ne.man
173.	18	2;01.25	ka.ˈtan	‘small ms.sg.’	ka.ˈnan
174.	19	2;02.06	a.ˈlav	‘on-him’	a.ˈvav
175.	20	2;02.22	ˈplas.tik	‘plastic’	ˈka.tik
176.	21	2;03.24	a.vi.ʁo.ˈnim	‘airplanes’	ʔa.vi.ʁo.ˈʁim

(58) RM

	Stage	Age	Target		Child
1.	2	1;05.00	a.ga.ˈla	‘cart’	ga.ˈga
2.	2	1;05.10	ken	‘yes’	geg
3.	2	1;05.29	na.aˈ.laim	‘shoes’	la.ˈla
4.	2	1;05.29	ˈpe.ʁaχ	‘flower’	ˈpaa.pi
5.	3	1;06.05	ken	‘yes’	nẽn
6.	3	1;06.05	ken	‘yes’	nẽn
7.	3	1;06.26	tov	‘good, well’	tot^{h}
8.	4	1;08.01	ˈpe.ʁaχ	‘flower’	ˈke.aχ
9.	4	1;08.01	ˈpe.ʁaχ	‘flower’	ˈpi.k^{h}a
10.	4	1;08.07	bait	‘house’	ˈbaab
11.	4	1;08.07	ˈde.vek	‘glue’	ə.ˈbe.be
12.	4	1;08.07	ka.ˈχol	‘blue ms.sg.’	sooj
13.	4	1;08.14	ˈma-ze	‘what’s-that’	va-ze
14.	4	1;08.14	pil	‘elephant’	pib
15.	4	1;08.27	ken	‘yes’	nen
16.	4	1;08.27	χa.ˈdaʃ	‘new ms.sg.’	ʃa.ˈtaʃ
17.	5	1;09.10	dʒi.ˈʁa.fa	‘giraffe’	ʃi.ˈʃa.fa
18.	5	1;09.10	ha.ˈkol	‘everything’	kek
19.	5	1;09.10	miʃ.ka.ˈfaim	‘glasses’	kə.ʃa.ˈʃaa
20.	5	1;09.10	miʃ.ka.ˈfaim	‘glasses’	a.ʃu.ˈʃai
21.	5	1;09.18	ˈdu.bi	‘teddy bear’	ˈpu.pi
22.	5	1;09.18	dʒi.ˈʁa.fa	‘giraffe’	fi.ˈʁa.fa
23.	5	1;09.18	maχˈvat	‘frying pen’	a.ˈχue.dat
24.	5	1;09.18	maχˈvat	‘frying pen’	æ.da.ˈdat
25.	5	1;09.18	ˈχa.li	‘Chali (name)’	ʃa.li
26.	5	1;09.27	a.ˈdom	‘red ms.sg.’	a.di.ˈde
27.	5	1;09.27	la.ˈʁe.det	‘to descend’	aˈde.ded
28.	5	1;09.27	la.ˈʁedet	‘to descend’	aˈde.deh
29.	5	1;09.27	od-pa.ˈʁa	‘another-cow’	o.ˈpa.pa.wa
30.	5	1;09.27	ˈʁo.tem	‘Rotem (proper name)’	ˈdo.ten
31.	5	1;09.27	ˈʁo.tem	‘Rotem (proper name)’	ˈdo.tem
32.	5	1;09.27	sa.ˈkin	‘knife’	χe.ˈkin
33.	5	1;09.27	ʃa.ˈχoʁ	‘black ms.sg.’	χa.ˈχoʁ
34.	5	1;09.27	si.ˈka	‘pin’	gi.ˈka
35.	6	1;10.06	te.le.ˈviz.ja	‘television’	a.ˈde.dæ
36.	6	1;10.06	χi.ˈtul	‘diaper’	ə.ʃi.ˈtul
37.	6	1;10.13	ˈdu.bi	‘bear.dim’	bu.bi
38.	6	1;10.13	la.ˈʁe.det	‘to descend’	a.ˈdee.det
39.	6	1;10.13	la.ˈʁe.det	‘to descend’	aˈde.deedz
40.	6	1;10.13	ˈʁo.tem	‘Rotem (proper name)’	ˈdo.tim
41.	6	1;10.28	la.ha.ˈfoχ	‘to reverse’	a.ˈχoχ
42.	6	1;10.28	la.-ˈχol	‘to.the-sand’	se.ˈχooj
43.	7	1;11.18	ˈdu.bi	‘bear.dim’	bu.pi

	Stage	Age	Target		Child
44.	7	1;11.18	ˈhi.ne	‘here (deictic)’	ni.nee
45.	7	1;11.18	le.so.ˈvev	‘to rotate’	ze.se.ˈvef
46.	7	1;11.18	te.le.ˈviz.ja	‘television’	te.ni.ˈni.tsa
47.	7	1;11.18	te.le.ˈviz.ja	‘television’	te.zi.gi.ˈzaa
48.	7	1;11.18	te.le.ˈviz.ja	‘television’	e.ˈdi.da
49.	7	1;11.18	te.le.ˈviz.ja	‘television’	e.ˈdzi.da
50.	7	1;11.18	va.ˈʁod	‘pink ms.sg.’	dee.ˈɱod
51.	7	1;11.18	va.ˈʁod	‘pink ms.sg.’	va.ˈvod
52.	7	1;11.18	ve-.ˈze	‘and-this’	ze.ˈze
53.	8	1;11.25	dol.ˈfin	‘dolphin’	ta.ˈʃiin
54.	8	1;11.25	la.-a.ˈsof	‘to-collect’	le.ˈsatʃ
55.	8	1;11.25	ˈma-ze	‘what’s-that’	va.ze
56.	8	1;11.25	su.kaʁ.ˈja	‘candy’	le.kə.ˈlaa
57.	8	1;11.25	χi.pu.ˈʃit	‘beetle’	se.pu.ˈʃis
58.	8	1;11.25	χi.pu.ˈʃit	‘beetle’	sa.po.ˈʃis
59.	8	2;00.02	ka.ˈχol	‘blue ms.sg.’	ka.ˈʒol
60.	8	2;00.02	ʃtaim	‘two’	ˈʃtaid
61.	8	2;00.02	aʁ.ˈnav	‘rabbit’	ha.ˈðov
62.	8	2;00.02	te.le.ˈviz.ja	‘television’	te.ˈtsi.sa
63.	8	2;00.02	te.le.ˈviz.ja	‘television’	te.ˈti.ʒa
64.	9	2;00.09	je.ˈmi.ma	‘Yemima (name)’	mii.ˈmi.ma
65.	9	2;00.09	ken	‘yes’	keg
66.	9	2;00.09	li-f.ˈtoaχ	‘to-open’	ti.ʃi.ˈtoaχ
67.	9	2;00.09	li-f.ˈtoaχ	‘to-open’	i.ʃi.ˈtoaχ
68.	9	2;00.09	te.le.ˈviz.ja	‘television’	ta.ˈziz.jaa
69.	9	2;00.09	te.le.ˈviz.ja	‘television’	ta.ˈti.ʒaa
70.	9	2;00.09	χi.pu.ˈʃit	‘beetle’	ʃe.χo.ˈsit
71.	10	2;00.16	me.χa.ˈjeχ	‘smiles ms.sg.’	χe.ˈʁaχ
72.	10	2;00.16	na.ˈze.let	‘runny nose’	na.ˈje.jet
73.	10	2;00.16	ta.ˈfas.ti	‘caught 1sg.’	ta.ˈfaf.tii
74.	10	2;00.16	te.le.ˈviz.ja	‘television’	ta.ˈdi.saa
75.	10	2;00.16	te.le.ˈviz.ja	‘television’	te.ˈdzi.za
76.	10	2;00.16	te.le.ˈviz.ja	‘television’	te.ˈti.zaa
77.	11	2;00.30	ˈte.le.fon	‘telephone’	ˈte.je.ʃon
78.	11	2;01.06	ˈhi.ne	‘here (deictic)’	ˈzi.ne
79.	11	2;01.06	na.ˈχaʃ	‘snake’	sa.ˈχas
80.	11	2;01.06	te.le.ˈviz.ja	‘television’	tsa.ˈdi.za
81.	11	2;01.12	ha.ˈi.ti	‘was 1sg’	de.ˈi.ti
82.	11	2;01.12	o.ˈse.fet	‘collects fm.sg.’	o.ˈfee.ve
83.	11	2;01.12	ʃel	‘of’	zes
84.	11	2;01.12	te.le.ˈviz.ja	‘television’	e.ˈdi.zaa
85.	11	2;01.12	te.le.ˈviz.ja	‘television’	he.ˈdi.zaa
86.	11	2;01.12	ze-o.ˈle	‘this-ascends’	ˈlo.lee
87.	12	2;01.19	ha.ˈfuχ	‘reversed’	a.ˈχuχ
88.	12	2;01.19	hit.bal.ˈbal.ti	‘got mixed up 1sg’	il.bal.ˈbal.ti
89.	12	2;01.19	hit.laχ.ˈlaχ.ti	‘got dirty 1sg’	ti.ˈlak.li
90.	12	2;01.19	kos	‘glass (drinkware)’	ˈku.χe
91.	12	2;01.19	ˈpe.ʁaχ	‘flower’	ˈpe.pa
92.	13	2;01.27	ʁa.ˈi.nu	‘saw 1pl’	ne.ˈʔi.nu
93.	13	2;02.04	ka.ˈχol	‘blue ms.sg.’	k̩ˈχaχ
94.	13	2;02.04	li-k.ˈnot	‘to-buy’	lik.ˈlot
95.	13	2;02.04	mal.bi.ˈʃa	‘dressing fm.sg.’	meʃ.ˈpi.ʃa
96.	13	2;02.04	mis.to.ˈve.vet	‘rotating. fm.sg.	is.pe.ˈve.vet
97.	13	2;02.11	me.tsa.ˈjeʁ	‘drawing ms.sg.’	ze.ˈtsee
98.	13	2;02.11	mik.ˈχol	‘paintbrush’	sol
99.	13	2;02.18	ho.ˈfe.χet	‘reversing fm.sg.’	a.ˈfe.tet
100.	14	2;02.25	hit.ja.ˈbeʃ	‘got dried ms.sg.’	nit.ba.ˈbeeʃ

	Stage	Age	Target		Child
101.	14	2;02.25	hit.ja.ˈbeʃ	‘got dried ms.sg.’	i.ba.ˈbes
102.	14	2;02.25	la.-a.ˈsot	‘to-do’	se.ˈʃot
103.	14	2;02.25	ʁo.ˈtsa	‘wants fm.sg.’	dot.ˈja
104.	14	2;02.25	ta.ka.ˈlef	‘will peel 2ms.sg’	ka.ka.ˈvif
105.	14	2;02.25	ˈza.χal	‘caterpillar’	ˈsa.zal
106.	14	2;02.25	χi.pu.ˈʃit	‘beetle’	ʃe.bu.ˈʃit
107.	15	2;03.01	je.la.ˈdot	‘girls’	lal.ˈdot
108.	15	2;03.01	le.-χa.ˈbeʁ	‘to-connect’	je.χa.ˈbev
109.	15	2;03.01	niʃ.be.ˈʁu	‘broke 3pl’	siʃ.bə.ˈʁu
110.	15	2;03.01	ʃo.ˈχe.vet	‘lies down fm.sg.’	so.ˈfe.ve
111.	15	2;03.01	ʃo.ˈχe.vet	‘lies down fm.sg.’	ʃo.ˈfe.fet
112.	16	2;03.29	ha.-ˈχe.lek	‘the-part’	a.ˈsal
113.	17	2;04.12	te.sap.ˈʁi	‘will tell 2fm.sg.’	ʒis.paa.ˈkɪɪ
114.	17	2;04.12	ti.ˈʁi	‘look! fm.sg.’	ti.ˈtə
115.	17	2;04.19	aχ.ˈlif	‘will change 1sg’	χa.ˈvif
116.	17	2;04.19	le.-haχ.ˈlif	‘to-change’	laχ.ˈliʃ
117.	17	2;04.19	maʁ.gi.ˈʃa	‘feels fm.sg.’	meʃ.gi.ˈʃa
118.	17	2;04.19	me.χa.ˈle.ket	‘dividing fm.sg.’	ma.χal.ˈkel
119.	17	2;04.19	sme.ˈχa	‘happy fm.sg.’	k^{n}mə.ˈχa
120.	17	2;04.25	ba.-te.le.ˈviz.ja	‘on.the-television’	ba.ti.je.ˈviv.ja
121.	17	2;04.25	ba.-te.le.ˈviz.ja	‘on.the-television’	ma.te.ja.ˈvɪv.ja
122.	17	2;04.25	mig.ˈdal	‘tower’	mig.ˈlaal
123.	17	2;04.25	ʃe.-ˈχo.ʃeχ	‘that (comp)-darkness’	se.ˈʃo.ʃeʁ
124.	18	2;05.09	ha.-ˈzug	‘the-pair’	ða.ˈzug
125.	18	2;05.15	si.ˈpuʁ	‘story’	sis.ˈpub
126.	18	2;05.27	me.χa.me.ˈmim	‘heating ms.pl.’	me.χaχ.ˈmim
127.	19	2;05.29	χa.ˈmuts	‘sour ms.sg.’	χa.ˈvus
128.	19	2;06.12	ˈham.buʁ.geʁ	‘hamburger’	ʔag.wu.ˈgeʁ
129.	19	2;06.12	ˈke.lev	‘dog’	ˈke.lez
130.	19	2;06.12	ˈmi.ʃe.hu	‘someone’	mii.ˈsu.su
131.	19	2;06.19	maf.ˈχid	‘scarry ms.sg.’	maf.ˈχi.ʁe.ʔi
132.	19	2;06.19	ʃab.ˈlul	‘snail’	bab.ˈlul
133.	20	2;06.29	ba.-mad.ʁe.ˈgot	‘at.the-stairs’	ba.ma.bee.ˈgot
134.	20	2;09.06	χa.da.ˈʃot	‘new fm.pl.’	χa.χa.ˈsot
135.	21	2;09.17	ha.ˈja	‘was 3ms.sg.’	ja.ˈja
136.	21	2;09.17	maχ.zi.ˈʁa	‘returning fm.sg.’	bχa.bi.ˈʁa
137.	21	2;09.17	niχ.na.ˈsim	‘entering pl.’	iχ.na.ˈsiv
138.	21	2;09.17	ʁak	‘only’	kak
139.	21	2;09.29	a.χa.ˈbeʁ	‘will connect 1sg’	χa.ˈbeg
140.	21	2;09.29	va.ˈnil	‘vanilla’	la.ˈviv
141.	22	2;10.03	ba.ˈχuts	‘outside’	ba.ˈχuʁ
142.	23	2;11.28	je.χo.ˈla	‘can fm.sg.’	ze.χo.ˈla
143.	23	2;11.28	nis.ta.ˈkel	‘will look 1pl’	ni.χə.ˈkel
144.	23	2;11.28	o.ˈsim	‘doing ms.pl’	o.ˈfim
145.	23	2;11.28	o.ˈsim	‘doing ms.pl’	o.ˈfiim

References

Adam, Galit, and Outi Bat-El. 2009. When Do Universal Preferences Emerge in Language Development? The Acquisition of Hebrew Stress. *BAALL* 1 (2009), 255-282.

Bat-El, Outi. 1996. Selecting the Best of the Worst: The Grammar of Hebrew Blends. *Phonology* 13 (1996), 283-328. Cambridge University Press.

Bat-El, Outi. 2009. Harmonic Domains and Synchronization in Typically and Atypically Developing Hebrew-Speaking Children. *Language Sciences* 31, 117-135.

Becker, Michael, and Anne-Michelle Tessier. 2011. Trajectories of Faithfulness in Child-Specific Phonology. *Phonology* 28, 163-196.

Ben-David, Avivit. 2001. *Language Acquisition and Phonological Theory: Universal and Variable Processes Across Children and Across Languages*. Ph.D. Dissertation, Tel-Aviv University (in Hebrew).

Berg, Thomas. 1992. Phonological Harmony as a Processing Problem. *Journal of Child Language* 19, 225-257.

Berg, Thomas, and Ulrich Schade. 2000. A Local Connectionist Account of Consonant Harmony in Child Language. *Cognitive Science* 24(1), 123-149.

Bernhardt, Barbara, and Joseph Paul Stemberger. 1998. *Handbook of phonological development: from the perspective of constraint-based nonlinear phonology*. San Diego: Academic Press.

Clements, George N.1990. The Role of the Sonority Cycle in Core Syllabification. In *Papers in Laboratory Phonology I: Between the Grammar and Physics of Speech*, ed. by John Kingston and Mary E. Beckman, 283-333. Cambridge, MA: Cambridge University Press.

Cole, Jennifer, and Charles Kisseberth. 1994. An Optimal Domains Theory of Harmony. *Studies in the Linguistic Sciences* 24 (2).

Cruttenden, Alan. 1978. Assimilation in Child Language and Elsewhere. *Journal of Child Language* 5, 373-378.

Deville, Gabriel Pierre. 1891. *Notes sur le Développement du Langage*. Orléans: Jacob (In French).

Dinnsen, Daniel A., J.A. Barlow, and M.L. Morrisette. 1997. Long-Distance Place Assimilation with an Interacting Error Pattern in Phonological Acquisition. *Clinical Linguistics and Phonetics* 11(4), 319-338.

Donahue, Mavis. 1986. Phonological Constraints on the Emergence of Two-word Utterances. *Journal of Child Language* 13, 209-218.

Drachman, Gaberell. 1975. Generative Phonology and Child Language Acquisition. In *Phonologica 1972: Akten der zweiten Internationalen Phonologie-Tagung, Wien, 5.-8. September 1972*, ed. by Wolfgang U. Dressler, Frantisek Vaclav Mareš, G Neweklowsky, and Oskar E. Pfeiffer, 235-251. München ; Salzburg: W. Fink.

Ferguson, Charles A., David B. Peizer, and Thelma E. Weeks. 1973. Model-and-Replica Phonological Grammar of a Child's First Words. *Lingua* 31, 35-65.

Fikkert, Paula, Clara Levelt, and Joost van de Weijer. 2002. *Input, Intake, and Phonological Development; The Case of Consonant Harmony.* Paper presented at GALA, Utrecht.

Fikkert, Paula, and Clara Levelt. 2008. How Does Place Fall Into Place? The Lexicon and Emergent Constraints in the Developing Phonological Grammar. In *Contrast in phonology: Perception and Acquisition*, ed. by Peter Avery, Bezalel Elan Dresher, and Keren Rice, 231-268. Berlin: Mouton.

Francescato, Giuseppe. 1968. On the Role of the Word in First Language Acquisition. *Lingua* 21, 144-153.

Gafos, Adamantios I. 1999. *The Articulatory Basis of Locality in Phonology*. New York: Garland Publishing, Inc.

Garnica, Olga Kaunoff, and Mary Louise Edwards. 1977. Phonological Variation in Children's Speech: The Trade-Off Phenomenon. *Papers in Psycholinguistics and Sociolinguistics. Working Papers in Linguistics*, No. 22. Ohio State University.

Gerlach, Sharon Ruth. 2010. *The Acquisition of Consonant Feature Sequences: Harmony, Metathesis and Deletion Patterns in Phonological Development*. Ph.D. Dissertation, The University of Minnesota.

Goad, Heather. 1997. Consonant harmony in Child Language: An Optimality-Theoretic Account. In *Focus on phonological acquisition*, ed. by S.J. Hannahs and Martha Young-Scholten, 113–142. Amsterdam: John Benjamins.

Goad, Heather. 2001. Assimilation Phenomena and Initial Constraint Ranking in Early Grammars. In *Proceedings of the 25th Annual Boston University Conference on Language Development*, ed. by Anna H.-J. Do, Laura Domínguez, and Aimee Johansen, 307-318. Somerville, MA: Cascadilla Press.

Goad, Heather. 2004. *Consonant Harmony in Early Grammars Revisited: Domains, Licensing and Directionality*. Paper presented at JEL 2004, Nantes France.

Gormley, Andrea Lucienne. 2003. *The Production of Consonant Harmony in Child Speech*. M.A. Thesis, The University of British Columbia.

Grunwell, Pamela. 1982/1984. *Clinical Phonology*. London and Canberra: Croom Helm

Hansson, Gunnar Ólafur. 2001. *Theoretical and Typological Issues in Consonant Harmony*. Ph.D. Dissertation, University of California Berkeley.

Inkelas, Sharon, and Yvan Rose. 2008. Positional Neutralization: A Case Study from Child Language. *Language* 83 (4), 707-736.

Kappa, Ioanna. 2001. Alignment and Consonant Harmony: Evidence from Greek. In *Proceedings of the 25th Annual Boston University Conference on Language Development*, ed. by Anna H.-J. Do, Laura Domínguez, and Aimee Johansen, 401-412. Somerville, MA: Cascadilla Press.

Karni, Noa. 2011. *Minimal Violation of Faithfulness: Chain Shift and Local Conjunction in the Acquisition of Hebrew Onsets*. M.A. Thesis, Tel-Aviv University.

Keren-Portnoy, Tamar, Marinella Majorano, and, Marilyn M. Vihman. 2009. From Phonetics to Phonology: The Emergence of First Words in Italian. *Journal of Child Language* 36, 235-267.

Klein, Harriet B. 1981. Productive Strategies for the Pronunciation of Early Polysyllabic Lexical Items. *Journal of Speech and Hearing Research* 24, 389-405.

Leonard, Laurence B., Judith A. Miller, and Heather Brown. 1980. Consonant and Syllable Harmony in the Speech of Language-Disordered Children. *Journal of Speech and Hearing Disorders* 45, 336-45.

Levinger-Gottlieb, Michal. 2007. *The Acquisition of Hebrew Plurals: A Morpho-Phonological Account.* M.A. Thesis, Tel-Aviv University.

Lewis, Morris Michael. 1936/1951. *Infant Speech*. London: Routledge & Kegan Paul.

Lewis, M. Paul (ed.). 2009. *Ethnologue: Languages of the World*, Sixteenth edition. Dallas, Tex.: SIL International. <http://www.ethnologue.com>.

Lowry, Richard. 2012. *Concepts & Applications of Inferential Statistics*. <http://www.vassarstats.net/textbook>.

Lustigman, Lyle. 2007. *Selectivity in Early Child Grammar: The Case of Hebrew Verb Morphology.* M.A. Thesis Tel-Aviv University.

Macken, Marlys A. 1978. Permitted Complexity in Phonological Development: One Child's Acquisition of Spanish Consonants. *Lingua* 44, 219-253. North-Holand Publishing Company.

Macken, Marlys A. 1992. Where's Phonology?. In *Phonological Development: Models, Research, Implications*, ed. by Charles A. Ferguson, Lise Menn, and Carol Stoel-Gammon, 249-269. Timonium, Md: York Press.

Macken, Marlys A. 1995. Phonological Acquisition. In *Handbook of Phonological Theory*, ed. by John Goldsmith, 671–696. Oxford: Blackwell.

Matthei, Edward H. 1989. Crossing Boundaries: More Evidence for Phonological Constraints on Early Multi-Word Utterances. *Journal of Child Language* 16, 41-54.

Menn, Lise. 1975. Counter Example to 'Fronting' as a Universal of Child Phonology. *Journal of Child Language* 2, 293-296.

Menn, Lise. 1983. Development of Articulatory, Phonetic, and Phonological Capabilities. In *Language Production* Volume 2, ed. by Brian Butterworth, 3-50. London: Academic Press.

Menyuk, Paula, Lise Menn, and Ronnie Silber. 1986. Early Strategies for the Perception and Production of Words and Sounds. In *Language Acquisition*, second edition, ed. by Paul Fletcher, and Michael Garman, 198-222. Cambridge University Press.

Parker, Stephen G. 2002. *Quantifying the Sonority Hierarchy.* Ph.D. Dissertation, University of Massachusetts.

Pater, Joe. 1997. Minimal Violation and Phonological Development. *Language Acquisition* 6(3), 201-253.

Pater, Joe, and Adam Werle. 2001. Typology and Variation in Child Consonant Harmony. In *Proceedings of the Holland Institute of Linguistics - Phonology 5*, ed. by Caroline Féry, Antony Dubach Green, and Ruben van de Vijver, 119–139. Potsdam: University of Potsdam.

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

Pinker, Steven. 1984. *Language Learnability and Language Development*. Harvard University Press.

Qu, Chen. 2011. Prosodic Licensing, Elaboration of Segmental Structure and Child Consonant Harmony. *Proceedings of the 2011 Annual Conference of the Canadian Linguistic Association.*

Rose, Sharon, and Rachel Walker. 2004. A Typology of Consonant Agreement as Correspondence. *Language* 80 (3), 475-531.

Rose, Yvan. 2000. *Headedness and Prosodic Licensing in the L1 Acquisition of Phonology*. Doctoral dissertation, McGill University, Montréal.

Schocken, Rebecca. 2008. *Characterization and Evaluation of Speech-Reading Support Systems for Hard-of Hearing People*. Ph.D. Dissertation, Tel-Aviv University (in Hebrew).

Smith, Neilson V. 1973. The Acquisition of Phonology: A Case Study. Cambridge: University Press.

Spencer, Andrew. 1986. Towards a Theory of Phonological Development. *Lingua* 68, 3-38. North-Holland.

Stemberger, Joseph Paul. 1989. Speech Errors in Early Child Language Production. *Journal of Memory and Language* 28, 164-188.

Stemberger, Joseph Paul, and Barbara H. Bernhardt. 1997. Optimality Theory. In *The New Phonologies: Developments in Clinical Linguistics*, ed. by Martin J. Ball and Raymond D. Kent, 211-245. San Diego, CA: Singular Publishing Group.

Stemberger, Joseph Paul, and Carol Stoel-Gammon. 1991. The Underspecification of Coronals: Evidence from Language Acquisition and Performance Errors. In *Phonetics and Phonology, Volume 2: The Special Status of Coronals*, ed. by Carole Paradis and Jean-François Prunet, 181- 199. Academic Press.

Stern, Clara, and William Stern. 1907. *Die Kindersprache: Eine Pychologische und Sprachtheoretische Untersuchung*. Leipzig: Bart (in German).

Stoel-Gammon, Carol, and Joseph Paul Stemberger. 1994. Consonant Harmony and Phonological Underspecification in Child Speech. In *First and Second Language Phonology*, ed. by Yavas Mehmet, 63-80. San Diego: Singular Publishing Group.

Tzakosta, Marina. 2007. Genetic and Environmental Effects in L1 Phonological Acquisition: The Case of Consonant Harmony in Greek Child Speech. *Journal of Greek Linguistics* 8 (1), 5-30. BRILL.

Vihman, Marylin May 1978. Consonant Harmony: Its Scope and Function in Child Language. In *Universals of Human Language 2: Phonology*, ed. by Joseph Harold Greenberg, 281-334. Stanford: Stanford University Press.

Vihman, Marylin, and William Croft. 2007. Phonological Development: Toward a "Radical" Templatic Phonology. *Linguistics* 45–4, 683–725.

Waterson, Natalie. 1978. Growth of Complexity in Phonological Development. In *The Development of Communication*, ed. by Natalie Waterson and Catherine Snow, 415-442. John Wiley and Sons, Chichester.

Wayment, Adam. 2009. Assimilation as Attraction: Computing Distance, Similarity, and Locality in Phonology. Ph.D. Dissertation, Johns Hopkins University.

תקציר

הרמוניה עיצורית (Consonant Harmony) היא אחת התופעות המסקרנות והנחקרות ביותר ברכישת שפה. היא מוגדרת כהידמות בין עיצורים שאינם סמוכים, כלומר הידמות דרך תנועה חוצצת (לדוגמה, הגיית המילה *פָּנָס* /panas/ כ-[nanas]). ככלל, הרמוניה עיצורית נחשבת כאסטרטגיה מפשטת המסייעת לילדים להתמודד עם אתגר רכישת שפת אמם. אולם, אין הסכמה גורפת בספרות המדעית לגבי המוטיבציה שמאחורי השימוש באסטרטגיה זו. הצעות שהועלו בעבר כוללות: א. מוטיבציה סגמנטלית, כלומר, החלפה של עיצורים ״קשים״ להגייה בעיצורים ״קלים״ להגייה; ב. מוטיבציה פונוטקטית, כלומר, הימנעות מרצפים מסוימים של עיצורים (או מרצפים לא הרמוניים באופן כללי); ג. מוטיבציה פרוזודית - פישוט ההרכב הסגמנטלי של המבע בכדי לסייע לילד להתמקד ברכישת מבנים פרוזודיים חדשים.

בעבודה זו אני חוקר את המוטיבציה שמאחורי ההרמוניה העיצורית בעזרת נתונים ממחקר אורך על שני ילדים רוכשי עברית כשפת אם. מניתוח הנתונים עולה כי הרמוניה העיצורית עשויה לנבוע ממספר מקורות ולא ניתן להתייחס אליה כאל תופעה אחת מוגדרת, לפחות בכל הנוגע למושאי מחקר זה. מבחינה פונולוגית, הרמוניה עיצורית יכולה לשמש כתחליף לעיצורים שטרם נרכשו וכמנגנון פישוט לרצפים צליליים ומבנים פרוזודיים מורכבים.

מנקודת מבט כללית של תהליך הדיבור כ״עיבוד נתונים״, ניתן לראות את שורשי ההרמוניה במערכת הייצוגית ובתהליכים של תכנון דיבור. שימוש עקבי בצורות הרמוניות מסוימות מצביע על כך שההרמוניה העיצורית עשויה להיות תהליך לקסיקלי הנובע ממערכת ייצוגית שאינה מפותחת דיה. קיומן של צורות הרמוניות יחידאיות ללא מוטיבציה ברורה והמיעוט היחסי של מקרים ברורים של הרמוניה עיצורית מטילים ספק בטענה לפיה הילדים מפעילים חוק דקדוקי של הרמוניה עיצורית, ותומכים בהשערה שההרמוניה נובעת מתקלות בתכנון הדיבור. בנוסף, נמצא כי ההרמוניה העיצורית מופיעה לעיתים קרובות בניסיון הראשון להפיק את מילת המטרה, גם אם מבנה ותוכן המילה לא אמורים לעורר קושי הפקתי עבור הילדים. ממצא זה יכול לנבוע מייצוג לא מושלם של מילת המטרה או מתכנון דיבור לקוי.

בנוסף לאמור לעיל, מחקר זה מנתח את מאפייני ההרמוניה העיצורית כנהוג במחקרים אחרים העוסקים בתופעה. האינטראקציה בין ההרמוניה העיצורית לטעם ולכיווניות ההידמות מציעים תמיכה מסוימת להשערה לפיה ההרמוניה מושפעת מהתפתחות פרוזודית. הנטייה של אחת ממושאי המחקר להפעיל את ההרמוניה על עיצורים בעלי צליליות (sonority) גבוהה מצביעה על האפשרות שההרמוניה מושפעת מגורמים סגמנטליים. מאידך, תוצאות מחקר זה אינן תומכות בטענות קודמות על כך שהרמוניה עיצורית במקום חיתוך מוכתבת ע״י היררכיה ברורה (ואף אוניברסאלית) בין עיצורים הגורמים להידמות ובין עיצורים העוברים הידמות. להתרשמותי, אם קיימת היררכיה כזו היא מוכתבת בעיקר ע״י שכיחות הגאים (ותכוניות) בקלט השפה וע״י גורמים הקשורים בהתפתחות האישית של כל ילד וילדה.

מחקר זו עוסק גם בשאלה הטריוויאלית לכאורה של זיהוי מקרי הרמוניה עיצורית. לעיתים קרובות ניתן לתאר הפקות הרמוניות כנובעות מהידמות או מהחלפה חופשית-הקשר של עיצורים כגון velar fronting (לדוגמה, הגיית המילה *תֻּכִּי* /'tuki/ כ-['tuti] שבה השינוי $k \rightarrow t$ יכול להיות מתואר כתוצאה של הידמות או כתוצאה של הגייה קדמית של ה-*k* שאינה תלוית סביבה פונטית). במחקר זה, אני מציע שיטה סטטיסטית להפרדה בין מקרים ברורים של הרמוניה עיצורית לבין החלפות חופשיות-הקשר. באמצעות שיטה זו הראיתי כי חלק ניכר מן ההפקות ההרמוניות אצל מושאי המחקר עשויות להיות תוצאה של

החלפות חופשיות-הקשר, והדבר עשוי להצביע על כך שהרמוניה עיצורית טהורה אינה שכיחה כפי שנטען בעבר. אף על פי כן, אני טוען כי זיהוי או הפרכה ודאיים של מקרי הרמוניה עיצורית אינם אפשריים תמיד מכיוון שבאופן עקרוני לא ניתן לדעת מהו המנגנון הגורם להפקה שאינה זהה למילת המטרה.

לסיום, תוצאות מחקר זה מושפעות במידת מה משונות בין-נבדקים. הילדים במחקר זה הפגינו שוני גם מבחינת השימוש בהרמוניה העיצורית (הן כמותית והן באורך התקופה שבה ההרמוניה נמצאת בשימוש) וגם מבחינת ההתפתחות הלשונית הכללית (סגמנטלית, פרוזודית ולקסיקלית). ממצאים אלו, מלבד היותם ראיה נוספת לאינדיבידואליות ברכישת שפה מגבילים את היכולת להגיע להכללות על סמך נתוני המחקר.

אוניברסיטת תל-אביב

הפקולטה למדעי הרוח ע״ש לסטר וסאלי אנטין

החוג לבלשנות

הנושא:

הרמוניה עיצורית בראי רכישת השפה

חיבור זה הוגש כעבודת גמר לקראת התואר

"מוסמך אוניברסיטה״ - **.M.A** באוניברסיטת ת״א

על ידי

חן גפני

העבודה הוכנה בהדרכת:

פרופסור אותי בת-אל

ספטמבר 2012