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Acquisition of extended prosodic words in Greek via consonant harmony

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Abstract

The present research examines the use of consonant harmony in the longitudinal data of four Greek-speaking children with typical development and how it facilitates language acquisition in an environment that is not well studied with this process in child speech from a phonological perspective. In particular, it is used for prosodic reasons and in order for children to acquire extended prosodic words. Properties of consonant harmony such as the domain, direction and degree of assimilation are also examined. Our data are couched in Optimality Theory framework (Prince & Smolensky, 1993) and more specifically, they are based on Pater & Werle's (2001, 2003) proposal, who consider this process as agreement between consonants. This proposal can account for harmonies with full assimilation and change of place in targets only. However, children's tokens present variation to the degree of assimilation and the number of distinctive features that change in target. So, we also rely on Multiple Parallel Grammars model (Revithiadou & Tzakosta, 2004), which in combination with the proposal of Pater & Werle's (2001, 2003), can adequately account for the additional and variable properties of consonant harmony presented in children's extended prosodic words.

Keywords: language acquisition, consonant harmony in Greek, optimality theory, extended prosodic word

1. Introduction

Consonant harmony (hereinafter CH) is defined as an *assimilation process* between non adjacent consonantal segments, which plays a decisive role in linguistic development (see Vihman, 1978, p. 288; Kappa, 2001, p. 401; Pater & Werle, 2001, p. 119; Tzakosta, 2007, p. 6, among others). A CH example constitutes the following (1).

Adult's Form		Child's Form	Child: Age
1) [kot]	→	[kok][2] (coat)	Trevor: 1;5.18[3]

(American English, Pater & Werle, 2001, p. 119)

In (1) the consonant [k], which is characterized as [DORSAL[4], -continuant, -voiced] assigns its *place* to [CORONAL, -continuant, -voiced] consonant [t]

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[2] The brackets [...] indicate the adult's and child's output respectively.
[3] The numbers indicate the child's years, months and days. E.g. 1;5.18 means that the child is one year, five months and eighteen days old.

and converts it also to [k]. Some properties of CH which are examined in child speech are the DF that change (place, *manner*, *voice*), the *direction* (progressive, regressive), *degree* (partial, full) and *domain* (e.g. *foot*, *prosodic word*) of assimilation, whether it is affected by stress and others. Alongside the properties of CH, a long standing question that has been formulated and the answer to which has not a generally accepted view is what motivates children to use this process. Several aspects have been formulated which concern the consonantal segments as well as prosodic or phonotactic reasons. Regarding the consonantal segments, children tend to replace consonants that have not yet been acquired (see Vihman, 1978; Berg, 1992; among others) or tend to substitute *marked* consonants with *unmarked* (e.g. Stoel-Gammon & Stemberger, 1994; Goad, 2004). As for prosodic reasons, it is argued that it helps children acquire new prosodic positions (Bat-El, 2009). In Hebrew for example, it is ascertained that the first syllables produced by children are the stressed ones (e.g. Echols & Newport, 1992; Echols 2001). So, given that in Hebrew, stress in most words is located in ultimate or penultimate the first two syllables that children will acquire will be these located as rightmost as possible in a prosodic word (Adam & Bat-El, 2008). Some researchers (e.g. Garnica & Edwards, 1977; Donahue, 1986; Berg & Schade, 2000; Bat-El, 2009) argue that as the prosodic word expands its segmental faithfulness is reduced, namely, when children begin to produce new segments in a word, these do not surface immediately faithfully but with CH (example 2), something that is considered to be the result of a *trade-off* (Bat-El, 2009, p. 121).

Adult's Form	→ Child's Form
2) [tarneˈgolet]	→ [ˈgoget] > [ˈgolet] > [gaˈgolet] > [taˈgolet] (hen)
	(Hebrew, Bat-El 2009, p. 121)

Another view mentions that children's consonants in unstressed syllables are assimilated to consonants in stressed syllables (e.g. Bernhardt & Stemberger, 1998). Other researchers point out that CH is used for phonotactic reasons and in order for specific DF to be licensed or aligned in specific positions or for the avoidance of specific DF in specific positions (see Rose, 2000; Kappa, 2001; Goad, 2004; among others). An instance is illustrated in the below figure (1).

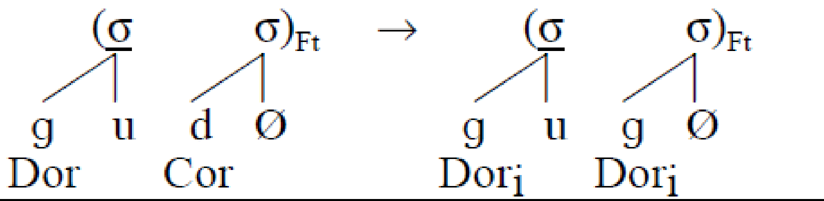

Figure 1. Consonant harmony via licensing (drawn from Goad, 2004, p. 5)

[4] The *distinctive features* (hereinafter DF) of place [DORSAL], [LABIAL] and [CORONAL] define the major articulatory areas and they are symbolized with capital letters inside brackets because they are characterized as unary / univalent, (see Kappa, (to appear), p. 75 - 76), namely, each sound characterized by one of the above categories is distinguished due to the presence of its place DF and not of its absence. When one sound is characterized in relation to a major articulatory area then it automatically implies its absence of the others. However, the univalent DF may appear with double articulation, as in the case of [k^w] which is characterized as [labio-velar] and bears as major articulatory area [DORSAL] and as secondary [LABIAL].

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In Figure 1. CH is argued to take place in a specific domain such as foot where the word [gud] is uttered by the child as [gug]. CH is used in order for a marked DF to emerge, as [DORSAL] place of consonant [g] in a weak unstressed syllable, such as the last onset of foot via its licensing by a strong stressed syllable, namely, the initial onset of foot which contains the [DORSAL] [g] (Goad, 2004).
In the present study our main question is why children use the process of CH in their speech. We will argue that it is due to prosodic reasons and in order for children to utter *extended prosodic words*. Alongside the main question, it will be shown how CH helps children acquire extended prosodic words and some properties of CH, such as its domain, direction and degree of assimilation will be discussed. The remaining of the paper is organized as follows: next the notion of extended prosodic word is defined and discussed. Section 2 includes the research methodology and the CH data of the Greek-speaking children are presented and described. Section 3 contains the analysis of data based on the theoretical model of *Optimality Theory* (hereinafter OT, Prince & Smolensky, 1993, p. 2) and the proposal of Pater & Werle's (2001, p. 122, 2003, p. 386), who count CH as *agreement* between consonants. For the variable properties of children's CH the *Multiple Parallel Grammars* model is additionally used (Revithiadou & Tzakosta 2004, p. 378). In section 4 the conclusion follows and at the end after the references, the tokens with CH of each child separately drawn for the needs of the present research are cited in appendix.

1.1. Extended prosodic word

The extended prosodic word emerges when a functional element of small word size is joined as adjunction with the prosodic word and is created one larger structure (Itô & Mester, 2009; Anderson, 2011), as illustrated in figures (2a, b).

cl	verb	verb	cl
[to	ˈeðose] (it gave)	[ˈpare	to] (take it)

Figures 2a, b. Extended prosodic word via functional element's adjunction (drawn from Tzakosta, 2004a, p. 695 - 696)

The symbol a in figures (2a, b) represents a functional element, such as a *clitic* (e.g. article, particle or pronoun), while the inner prosodic word may consist of a noun, verb or adjective. Clitics which precede the prosodic word are called *proclitics*, while these that follow *enclitics* (Halpern, 1998, p. 101).

In children's tokens with CH of the present study emerge only the first ones (figure 2a). Further, clitics come from the non lexicon group of prepositions, pronouns, particles and are considered weak elements (e.g. Halpern, 1998; Tzakosta, 2004a; Revithiadou & Spyropoulos, 2008; Anderson, 2011). They are usually monosyllabic and do not bear stress because they depend on higher prosodic structures, which act as their host, such as an adjacent prosodic word (e.g. Halpern, 1998; Tzakosta, 2004a; Revithiadou & Spyropoulos, 2008; Anderson, 2011).[5] However, clitics constitute subject of controversy regarding their phonological representation. This happens due to the fact that several researchers disagree whether the *clitic group* is included as a layer in the prosodic hierarchy (3a, b).

3a)	(e.g. Selkirk, 1996)	b) (e.g. Nespor & Vogel, 1986)
	Prosodic hierarchy	Prosodic hierarchy
	utterance	phonological utterance
	intonational phrase	intonational phrase
	phonological phrase	phonological phrase
	prosodic word	clitic group
	foot	prosodic word
	syllable	foot
		syllable

Some of them, who reject the existence of clitic group, point out that clitics are integrated into the prosodic word or in other categories of the prosodic hierarchy depending on the requirements of the respective language (e.g. Zec & Inkelas, 1991; Booij, 1996; Selkirk, 1996), while others relying on phonological processes, which are accomplished in the domain of clitic group, such as vowel deletion in word edges, consider clitics as independent prosodic elements that are not integrated in other categories and together with adjacent non clitic words constitute the clitic group (e.g. Nespor & Vogel, 1986; Hayes, 1989). In the current study the first view is adopted, as an additional layer in the prosodic hierarchy demands more effort from the children, something that is considered empirically and theoretically less economical in the acquisition of their mother tongue (Tzakosta, 2004a).

2. Methodology

2.1. Information of subjects and way of collecting material

All parents before the meetings between researcher and children provided written and verbal consent. The data collection comes from four subjects, two twin and two non twin monolingual Greek-speaking children with typical linguistic development. Children speak Standard Modern Greek despite living in Crete and do not seem to be dialectal. The parents of the subjects were also given a questionnaire, in which they were asked to fill, if they

[5] In Greek when two enclitics are integrated in the same prosodic word, then stress is presented in this located in penultimate (e.g. [ˈðo.se ˈmu to]). In this specific language, trochaic foots at the right edge of word are created when two consecutive unstressed syllables emerge with the presupposition that, regarding stress, *clash* (Anderson, 2011, p. 2003) is not provoked. This way, the trisyllabic law is satisfied, which prohibits a syllable to be stressed before the antepenultimate (Revithiadou & Spyropoulos, 2008, p. 46).

desire, whether children speak the Cretan dialect among others and the answer they gave for all the subjects is that they do not.
Basic tool for children's data recording is the professional tape recorder Marantz PMD661MKII, while the main experimental method is the naming of pictures that were presented in children via a laptop. These pictures were drawn from a research concerning child speech in Greek (Kappa & Paracheraki, 2014) with some additions and subtractions for the needs of the present research, which include everyday words, such as foods, animals, plants, professions, vehicles, buildings, household utensils and others. The pictures were designed to give the children the opportunity to utter all types of consonants and clusters in every position.[6] In addition, spontaneous child speech was recorded, which resulted through various activities either inside kindergartens or in their courtyard, such as reading books, playing with bricks, balls, dolls, cars, painting with markers, fun in slide, swings, seesaw and others. Children's speech was recorded 1 - 2 times per week. The research lasted about 15 months, while the duration of each recording ranged from 15 - 30 minutes for each of the four children separately. The age of twin children is 1;8.15 on the first recording and 2;10.9 on the last recording. The age of non twin boy is 1;7.5 - 2;7.18, while of non twin girl is 1;6.26 - 2;9.12. Regarding their tokens the four children utter in total 35.677 out of which 872 with CH (359 by twin children and 513 by non twin). Finally, the reproduction, processing and conversion of audio material into phonetic tokens were done via Audacity software, while the recording and organization of tokens via Microsoft Office Word. The transcription was done by ear only and for that reason data are included, in which there is a high degree of certainty of what the children utter. For the phonetic rendering of words the *International Phonetic Alphabet* was used.

2.2 Children's data that are excluded

In this section children's data are cited that present two processes, in which some researchers argue that they undergo CH, while others do not consider them as a result of CH. Examples containing the following processes have not been used in the children's tokens count, as there is not so far a universal view whether CH is included in these. The first is *coalescence*, which emerges when children utter from a cluster of consonants - targets a new consonant, which includes DF from both cluster's consonants that are usually unmarked (Kappa, 2004, p. 210). Below an example (4) of coalescence from the present study is provided.

Adult's Form	→ Child's Form	Child: Age
4) [ˈkra.nos]	→ [ˈta.no] (helmet)	boy (twin): 2;8

In (4) the consonant [t] of output [ˈta.no], which bears DF [CORONAL, -continuant, -voiced], arises from the coalescence of consonants of the adult's output first syllable [k] and [r] with DF [DORSAL, -continuant, -voiced] and

[6] For example each segment that belongs to a category of consonants based on its DF (e.g. [DORSAL], [LABIAL], [stop], [fricative] and so on) appears at least once in words in initial, medial and final stressed and unstressed syllable.

[CORONAL, rhotic, +voiced] respectively. In particular, consonant [t] kept the unmarked DF from consonants' cluster, namely, the [CORONAL] place from [r], while the [-continuant] manner and [-voiced] voice from [k].
Reduplication constitutes the second process, which emerges when a word is exactly repeated as it is or a part or the root or the stem of a word or even the whole sentence or phrase (Urbanczyk, 2007, p. 473). Furthermore, reduplication and CH has been argued that they look like because both include melody copy (Goad, 2001). In other researches though, reduplication has been proposed that it is realized with a syllable or foot copy (Tzakosta, 2007), as in examples (5) and (6) respectively, while CH with a DF or segment copy (e.g. Kappa, 2001; Tzakosta, 2007).

Adult's Form	→ Child's Form	Child: Age
5) [xa.mi.ˈlo.ni]	→ [xa.ˈlo.lo] ((he / she / it) lowers)	girl (twin): 2;9.18
6) [baba]	→ [babababa] (dad)	Zosia: 1;7

(Polish, Dressler, Dziubalska-Kołaczyk, Gagarina & Kilani-Schoch 2011, p. 464)

In example (5) copy of the stressed syllable [ˈlo] in the last syllable [ni] is realized resulting in a change of both its consonant and vowel, while in example (6) copy of the whole foot [baba] is realized. However, other cases as (7) are taken into account in children's data.

Adult's Form	→ Child's Form	Child: Age
7) [ɣu.ˈɾu.ni]	→ [ɣu.ˈɣu.ni] (pig, 1 / 2[7])	boy (non twin): 2;7.18

In (7), adopting the view that CH is realized with a DF or segment copy (e.g. Kappa, 2001; Tzakosta, 2007), it is not clear that the process of CH is not included in the non twin boy's output, since the vowel of the first two syllables is same and specifically [u].

2.3 Description of children's tokens with consonant harmony

Before the description of children's data it should be noted at this point that two developmental phases are distinguished, the early phase, which lasts till 2;0 years old and the intermediate, which begins after 2;0 years old. The extended prosodic words of twin and non twin children appear in the intermediate developmental stage, which is considered the transition of unmarked structures to marked ones, such as the emergence of codas, clusters, consonants characterized as [fricative], the utterance of trisyllabic and above words with faithfulness regarding the number of syllables and generally words with marked syllables as CCV, CVC, VC, V (e.g. Kappa, 2000; Tzakosta, 2003; Tzakosta & Kappa, 2008). During this stage all the

[7] The first number states the times that the output is uttered with CH and the second number how many times in total it is uttered in child's data. For instance, 1 / 2 means that the child utters the specific token two times, of which one with CH. The remaining can be a faithful utterance or to bear another process.

children utter 739 tokens with CH out of which 34 are observed in extended prosodic words after the age of 2;3 years old (examples 8 - 41)[8, 9].

[DORSAL] triggers - place change

Adult's Form	→ Child's Form	Child: Age
8) [to ko.ˈli.so]	→ [ko ko.ˈli.so] (I (will) stick it, 1 / 9)	boy (twin): 2;6.17
9) [pu ˈka.nu.me]	→ [ku ˈka.nu.me] (where we do, 1 / 2)	boy (twin): 2;8.7
10) [pu sku.ˈpi.zu.me]	→ [ku ko.ˈpi.zu.me] (where we wipe, 1 / 1)	boy (twin): 2;8.7
11) [to ˈe.vɣa.la]	→ [kxo ˈe.ɣa.la] (I took it out, 1 / 5)	boy (non twin): 2;5.16
12) [ðen ˈka.no]	→ [ɟe ˈka.no] (I do not do, 1 / 1)	boy (non twin): 2;5.23

[DORSAL] triggers - place and manner change

Adult's Form	→ Child's Form	Child: Age
13) [θa ˈka.tˢo]	→ [ka ˈka.tˢo] (I will sit, 1 / 1)	girl (non twin): 2;6.8
14) [θa ˈka.tˢu.me]	→[ka ˈka.si.a.me] (we will sit, 1 / 1)	girl (non twin): 2;7.6
15) [ta ˈçer.ʝa]	→ [ça ˈçe.ʝa] (the hands, 1 / 2)	girl (non twin): 2;9.12
16) [θa ˈka.ni]	→ [ka ˈka.ni] ((he / she / it) will do, 1 / 2)	girl (non twin): 2;9.12

[LABIAL] triggers - place change

Adult's Form	→ Child's Form	Child: Age
17) [tin ˈpi.ɾa]	→ [pi ˈpi.a] (I took her, 1 / 3)	boy (non twin): 2;3
18) [to ˈspi.ti]	→ [po ˈpi.ti] (the house, 2 / 4) (m[10])	girl (non twin): 2;6.13
19) [to ˈspi.ti]	→ [pa ˈpi.ti] (the house, 2 / 4)	girl (non twin): 2;6.13
20) [ta pe.ˈða.ca]	→ [pal pe.ˈða.ca] (the children, 1 / 1)	girl (non twin): 2;9.12

[LABIAL] triggers - place and manner change

Adult's Form	→ Child's Form	Child: Age
21) [θa ˈpe.si]	→ [pa ˈpe.si] ((he / she / it) will fall, 2 / 4)	boy (twin): 2;6.5
22) [θa ˈfi.ʝi]	→ [pa ˈpi.ʝi] ((he / she / it) will leave, 1 / 1)	boy (twin): 2;6.24
23) [θa ˈpe.si]	→ [pa ˈpe.si] ((he / she / it) will fall, 2 / 4)	boy (twin): 2;8
24) [ðe ˈbe.ni]	→ [be ˈbe.ni] ((he / she / it) does not get in, 13 / 47)	girl (non twin): 2;3.22

[8] The extended prosodic word is symbolized as: [a [b] PW] PW, for example [to ko.ˈli.so] → [to [ko.ˈli.so] PW] PW.

[9] In all the examples the age begins from the smallest to the biggest per child. In case the age is same in two or more tokens, then they are listed based on syllables number beginning from disyllabic and ending to pentasyllabic words.

[10] (m) = mimicry. As mimicry is considered the direct utterance of a token by the child either faithfully or with different DF immediately after the utterance of the same token by the adult. The strategy of adult's tokens mimicry from child constitutes a learning process. In other words, the child hears the token, processes it and utters it after having heard it again by itself. The process of information's transfer between adult and child we assume that it contributes to the in depth understanding of the information. For this reason, data that are uttered as mimicry have been included in the present study.

25) [ðe ˈbe.ni] → [be ˈbe.ni] ((he / she / it) does not get in, 13 / 47) girl (non twin): 2;4.26
26) [ðe ˈbe.ni] → [be ˈbe.ni] ((he / she / it) does not get in, 13 / 47) girl (non twin): 2;4.26
27) [ðe ˈbe.ni] → [be ˈbe.ni] ((he / she / it) does not get in, 13 / 47) girl (non twin): 2;4.28
28) [ðe ˈbe.ni] → [be ˈbe.ni] ((he / she / it) does not get in, 13 / 47) girl (non twin): 2;5.1
29) [ðe ˈbe.ni] → [be ˈbe.ni] ((he / she / it) does not get in, 13 / 47) girl (non twin): 2;5.1
30) [ðe ˈbe.ni] → [be ˈbe.ni] ((he / she / it) does not get in, 13 / 47) girl (non twin): 2;5.1
31) [ðe ˈbe.ni] → [be ˈbe.ni] ((he / she / it) does not get in, 13 / 47) girl (non twin): 2;5.1
32) [ðe ˈbe.ni] → [be ˈbe.ni] ((he / she / it) does not get in, 13 / 47) girl (non twin): 2;5.3
33) [ðe ˈbe.ni] → [be ˈbe.ni] ((he / she / it) does not get in, 13 / 47) girl (non twin): 2;5.10
34) [ðe ˈbe.ni] → [be ˈbe.ni] ((he / she / it) does not get in, 13 / 47) girl (non twin): 2;5.10
35) [ðe ˈbe.ni] → [ba ˈbe.ni] ((he / she / it) does not get in, 13 / 47) girl (non twin): 2;5.15
36) [ðe ˈbe.ni] → [ba ˈbe.ni] ((he / she / it) does not get in, 13 / 47) girl (non twin): 2;6.8
37) [θa ˈpe.si] → [pa ˈpe.ti] ((he / she / it) will fall, 3 / 8) girl (non twin): 2;7.6
38) [θa ˈpe.si] → [pa ˈpe.ti] ((he / she / it) will fall, 3 / 8) girl (non twin): 2;7.6
39) [θa ˈpe.si] → [pa ˈpe.ti] ((he / she / it) will fall, 3 / 8) girl (non twin): 2;7.6
40) [θa ˈpa.ne] → [pa ˈpa.ne] (they will go, 1 / 1) girl (non twin): 2;8.21
41) [θa ˈpa.o] → [pa ˈpa.o] (I will go, 1 / 2) girl (non twin): 2;8.28

Regarding the properties of CH, in all the cases the direction of assimilation is ascertained to be regressive, namely, a consonant located in the inner prosodic word affects the initial consonant of the extended. The unilateral development of assimilation's direction, that is, the replacement always of the initial syllable is due to the order of emergence and acquisition of elements which constitute the extended prosodic words. In other words, in cross-linguistic studies it is argued that in the early developmental stages of children functional elements are not often uttered (e.g. Brown & Bellugi, 1964; Caselli, Bates, Casadio, Fenson, Fenson, Sanderl & Weir, 1995; Kedar, Casasola & Lust, 2006; Lleó, 2012; Lidz & Perkins, 2018). In addition, it is mentioned by researchers that in language acquisition, words as nouns and verbs are acquired earlier than functional elements (e.g. Radford, 1990; Ninio, 2019). A reason for this is that the former can be learned from single-word utterances, while the latter cannot be isolated from other words and are learned from multiword sentences (Ninio, 2019). Based on the aforementioned views, we assume that the acquisition of the extended prosodic word presupposes the acquisition of the inner prosodic word. So, the segments of functional elements are more likely to be assimilated than to assign their DF to these of nouns or verbs and since they precede in all the aforementioned tokens of children, the direction of assimilation is regressive. One additional reason for the emergence of the regressive assimilation only and the replacement of segments in proclitics lies to the fact that they are considered more difficult in their acquisition than enclitics because the latter constitute post-stress constituents and as such, they are adjoined more easily to the prosodic word (e.g. [ˈðo.se mu] (give me) → [ˈðo.sem], [ˈðo.mu], Tzakosta, 2004b, p. 94). Further, in most tokens the type of assimilation is full, except for examples (11 - 12), in which partial is ascertained. The degree of assimilation seems to be connected with the place of triggers, since CH with [CORONAL] triggers is usually partial (table 1) and assimilations in extended prosodic words are observed only with [DORSAL] and [LABIAL] triggers.

Table 1
Degree of assimilation with [CORONAL] triggers

Twin children	Boy	Girl	Non twin children	Boy	Girl
Partial Assimilation	46 / 70 (65.7%)	26 / 34 (76.5%)		22 / 33 (66.7%)	136 / 246 (55.3%)
Full Assimilation	24 / 70 (34.3%)	8 / 34 (23.5%)		11 / 33 (33.3%)	110 / 246 (44.7%)

Table 1 shows the degree of assimilation in the total tokens observed in the intermediate developmental phase of the four children with CH, in which a [CORONAL] consonant participates as trigger. We assume that [CORONAL] consonants trigger mainly partial assimilation due to the fact that they are considered less marked than [DORSAL] and [LABIAL] (e.g. Menn, 1975; Cruttenden, 1978; Donahue, 1986; Pater & Werle, 2003). So, they fail to systematically assign all their DF to [DORSAL] and [LABIAL] consonants, which being more marked resist their full assimilation. As for the twin girl extended prosodic words with CH are not observed. Finally, as it is mentioned in previous section, tokens such as (8, 13 - 14, 16 - 17, 24 - 34, 40 - 41) are not considered reduplication but CH because in the present study, the view, which mentions that reduplication is accomplished with the copy of one syllable or foot is adopted (Tzakosta, 2007). One additional reason for the emergence of CH in this environment constitute several data, in which the first two syllables do not bear the same vowel (9, 11 - 12, 15, 18 - 23, 37 - 39) while in others, although they bear the same vowel, in the output of child the change of one is observed (10, 35 - 36)[11]. Therefore, CH seems to be applied regardless of the type of vowels located in syllables that participate in the assimilation.

[11] The reasons for the change of vowels in tokens of the four children are beyond the scope of the present research.

3. Findings

In OT (Prince & Smolensky, 1993) *Universal Grammar* (hereinafter UG) provides a set of universal and violable constraints ranked in a language specific way. OT in language acquisition is viewed as constraint demotion and more specifically, in the initial stages where the structures uttered by children are unmarked, markedness constraints dominate faithfulness constraints, while in the final stage faithfulness constraints dominate markedness, as in adult's grammar (e.g. Demuth, 1995; Gnanadesikan, 2004). Regarding CH, the proposal of Pater & Werle's (2001, 2003) is adopted, who based on Lombardi (1999), consider this process as agreement between consonants. So, the general markedness constraint used is AGREE, which requires two consonants to bear the same place. An advantage of the agreement is that it allows assimilation from distance in child speech (Pater & Werle, 2001, 2003), while Hansson (2010, p. 24 - 25) mentions that the same also happens in adult's speech as it is not bound by *strict locality*, which in the theory of spreading is required. For the direction of assimilation, based on McCarthy (1997) and Walker (2000), who propose in markedness constraints the addition of elements such as the place which is copied or the direction of assimilation, Pater & Werle (2003, p. 389) convert AGREE to AGREE-L-[DOR], since they observe that dominant triggers in their subject's data are [DORSAL], while the direction of assimilation is systematically accomplished leftwards. Faithfulness constraints for every category of consonants regarding place are also used, which demand faithfulness between input and output's DF and in combination with the markedness constraint of agreement predict the dominance of [DORSAL] consonants to [LABIAL] and [CORONAL], the dominance of [LABIAL] to [CORONAL] and the non application of CH from [CORONAL] consonants. The same researchers use the ranking FAITH [DOR], FAITH [LAB] >> FAITH [COR], which Kiparsky (1994, p. 1 - 3) suggests for the faithfulness constraints and it is responsible for the non participation of [CORONAL] triggers in the process of CH in adults' speech. Indicative example is cited next (table 2).

Table 2

Dominance of [DORSAL] consonant and regressive direction

(Drawn from Pater & Werle 2003, p. 389)

/dɔg/[12]	AGREE-L-[DOR]	FAITH [COR]
☞ [gɔg][13]		*
[dɔg]	*!	

The output [dɔg], as formulated in table (2), is rejected due to the fact that it violates fatally (symbolized as *!) the higher ranked constraint, while as optimal the output [gɔg] emerges, which violates the faithfulness constraint

[12] The inputs are listed in sidelines.

[13] The outputs are listed in brackets, while the optimal is indicated with ☞.

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due to assimilation, which though is the lowest ranked. The dominance of one constraint to other is indicated as AGREE-L-[DOR] >> FAITH [COR].
Before analyzing children's data it should be noted at this point that their extended prosodic words present variation to the properties of CH. So, we rely on Multiple Parallel Grammars model (Revithiadou & Tzakosta, 2004), according to which in the intermediate developmental stages children employ parallel grammars next to the core, namely, different rankings of constraints, which help them acquire the target grammar. Returning to children's data the constraint AGREE-L is drawn and for simplicity the general term IDENTITY-IO is used as a cover term for Faith (DOR), Faith (LAB), Faith (COR), which demands faithfulness between input and output form (McCarthy & Prince, 1995, p. 264). In addition, the accomplishment of the assimilation leads to the satisfaction of the faithfulness constraint INTEGRITY (McCarthy & Prince, 1995, p. 372; Tzakosta, 2004a, p. 701), which prohibits the deletion of any part of the extended prosodic word. The ranking for twin and non twin children's data is AGREE-L (DOR / LAB) >> INTEGR >> IDENT-IO (table 3).

Table 3
Analysis of extended prosodic words

[to ko.ˈli.so][14]	AGREE-L (DOR)	INTEGR	IDENT-IO
☞ [ko ko.ˈli.so]			*
[ko.ˈli.so]	*!	*	
[to ko.ˈli.so]	*!		
[pu ˈka.nu.me]	AGREE-L (DOR)	INTEGR	IDENT-IO
☞ [ku ˈka.nu.me]			*
[ˈka.nu.me]	*!	*	
[pu ˈka.nu.me]	*!		
[θa ˈka.ni]	AGREE-L (DOR)	INTEGR	IDENT-IO
☞ [ka ˈka.ni]			*
☹ ☞ [xa ˈka.ni]			*
[ˈka.ni]	*!	*	
[θa ˈka.ni]	*!		

[14] The adult's output is considered as input, namely, the linguistic stimuli that the child receives and hears from its parents, which is Modern Greek.

[ðe ˈbe.ni]	AGREE-L (LAB)	INTEGR	IDENT-IO
☞ [be ˈbe.ni]			*
☹ ☞ [ve ˈbe.ni]			*
[ˈbe.ni]	*!	*	
[ðe ˈbe.ni]	*!		

The proposal of Pater & Werle's (2001, 2003) analysis in some cases seems that it can lead to more optimal outputs in table (3) that are not uttered by the children. This happens due to the markedness constraint, which refers to the place of the harmonized segments only and in the direction of assimilation. For this reason, it can account full assimilations with the harmonized segments having the same DF regarding manner and voice before the implementation of CH. In order for the other optimal forms to emerge, in which the harmonized segments may differ from one to all their DF before the completion of the assimilation, new constraints need to be added, which can account both types of assimilation, namely, partial or full as well as the additional DF beyond place, which are required to change. So, we adopt the constraints ANCHOR-L (-CONTINUANT), ANCHOR-L (+CONTINUANT), which demand the anchoring of [-continuant] or [+continuant] manner at the left edge of word (Tzakosta, 2002, p. 641). The ranking which leads to the optimal tokens of children is AGREE-L (DOR / LAB) >> INTEGR >> ANCHOR-L (-CONT) >> ANCHOR-L (+CONT), IDENT-IO (table 4)[15].

Table 4
Extended prosodic words uttered by children with full assimilation

[θa ˈka.ni]	AGREE-L (DOR)	INTEGR	ANCH-L (-CONT)	ANCH-L (+CONT)	IDENT-IO
☞ [ka ˈka.ni]				*	*
[xa ˈka.ni]			*!		*
[ˈka.ni]	*!	*		*	
[θa ˈka.ni]	*!		*		
[ðe ˈbe.ni]	AGREE-L (LAB)	INTEGR	ANCH-L (-CONT)	ANCH-L (+CONT)	IDENT-IO
☞ [be ˈbe.ni]				*	*
[ve ˈbe.ni]			*!		*

15 Two constraints can be equal to each other occupying the same position in a hierarchical ranking symbolized with (,) or with dashed line (Kager, 1999, p. 37).

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[ˈbe.ni]	*!	*		*	
[ðe ˈbe.ni]	*!		*		

In the first example, the outputs [ˈka.ni] and [θa ˈka.ni] are rejected as non harmonic, while the optimal output [ka ˈka.ni] prevails over [xa ˈka.ni] due to the change of the required features to the target in order for full assimilation to emerge, something that is ensured with the dominance of ANCH-L (-CONT) to ANCH-L (+CONT). The optimal token of the second example arises for the same reasons as the first with the difference that the trigger bears [LABIAL] place.

In a few cases, children's productions present partial assimilation. The same constraints can deal with the properties of CH presented in them. However, these cases contain consonants in coda position and children have not yet acquired them. So, we need to add the constraint *Coda, which prohibits consonants to appear in coda positions (McCarthy & Prince, 1995, p. 267). The satisfaction of this constraint leads to the violation of MAXIMALITY-IO, which requires every segment of the input to have a correspondent in the output (McCarthy & Prince, 1995, p. 264). The relevant ranking has the form AGREE-L (DOR) >> INTEGR >> ANCHOR-L (+CONT) >> *Coda >> ANCHOR-L (-CONT), IDENT-IO, MAX-IO (table 5).

Table 5
Extended prosodic words uttered by children with partial assimilation

[ðen ˈka.no][16]	AGREE-L (DOR)	INTEGR	ANCH-L (+CONT)	*Coda	ANCH-L (-CONT)	IDENT-IO	MAX-IO
☞ [ɟe ˈka.no]					*	*	*
[ɟen ˈka.no]				*!	*	*	
[cen ˈka.no]			*!	*		*	
[ˈka.no]	*!	*	*				***
[ðen ˈka.no]	*!			*	*		

Candidates [ˈka.no] and [ðen ˈka.no] are excluded as non harmonic. In the candidate [cen ˈka.no] more DF change than required resulting in full assimilation and its rejection, while between candidates [ɟe ˈka.no] and [ɟen ˈka.no] the former is selected cause it manages to have the required

[16] In this example the adult's output [ðen ˈka.no] has already incurred assimilation, as the input is /ðeN ˈka.no/. However, it is difficult to explain via OT how child's output [ɟe ˈka.no] results from /ðeN ˈka.no/ due to the fact that this model cannot predict the cyclic evaluation of processes in a single ranking, such as for instance two assimilations (McCarthy, 2001). How OT could adequately deal with this example, as other serial derivational models do, is beyond the scope of the present research, since in all the examples the adult's output is considered as input for the tokens of children.

properties regarding degree and DF that change and simultaneously to delete consonant in coda position. So, the promotion of either ANCH-L (-CONT) or ANCH-L (+CONT) over the other and together with the other constraints used, can sufficient account the emergence of both types of assimilation and the accomplishment of the respective type of CH with change of one or two DF in the extended prosodic words of children.
Sometimes an intervening consonant is located between the harmonized segments, which could also be a potential target for assimilation, as [s] in the example [to ˈspi.ti]. However, if assimilation takes place within prosodic word then the extended one cannot be uttered with all its elements. Further, the constraints used in the previous data can resolve such situations and there is no need to add another one to force the domain of assimilation in initial syllable. The relevant ranking is AGREE-L (LAB) >> INTEGR >> ANCHOR-L (-CONT) >> ANCHOR-L (+CONT), IDENT-IO, MAX-IO (table 6).

Table 6
Assimilation with intervening consonant

[to ˈspi.ti]	AGREE-L (LAB)	INTEGR	ANCH-L (-CONT)	ANCH-L (+CONT)	IDENT-IO	MAX-IO
☞ [po ˈpi.ti]				*	*	*
[ˈfpi.ti]		*!	*		*	**
[ˈspi.ti]	*!	*	*			**
[to ˈspi.ti]	*!			*		

According to table (6), candidates [ˈspi.ti] and [to ˈspi.ti] are rejected due to non application of CH. In the candidate [ˈfpi.ti] the assimilation does not maintain all elements of the extended prosodic word violating this way the second higher constraint. As optimal emerges [po ˈpi.ti], which preserve all parts of the extended prosodic word and the assimilation arises with the features required here, namely, full assimilation with place change. So, there is no need to add a positional specific constraint in order for the assimilation to take place in the consonant of the first syllable, as this role has INTEGRITY, which penalizes all the assimilations that cannot retain the whole extended prosodic word, that is, those whose domain of application is restricted to the inner prosodic word. Finally, the extended prosodic words of children seem to not play any role if they constitute noun or verb phrase (e.g. article + noun, [to ˈspi.ti] (the house) or particle + verb [θa ˈka.t^{s}o] (I will sit), since the constraints used can lead to the optimal tokens in both categories and only the ranking need to change in some of them.

4. Conclusion

In the present study, we dealt with CH and some of its properties in Greek-speaking twin and non-twin children. Their data agree with other researches, in which it is pointed out that this process is used for prosodic reasons (e.g. Bat-El, 2009). In particular, it helps children utter extended prosodic words, in which the consonant of the proclitic is assimilated to one located in the inner prosodic word. Regarding CH properties, regressive assimilation arises in all children's tokens and full in almost all of them. Regressive assimilation emerges due to the late acquisition of proclitics in comparison to prosodic words, while full assimilation due to the specific place of triggers. For the analysis of children's tokens, we relied on OT framework (Prince & Smolensky, 1993) and we adopted Pater & Werle's (2001, 2003) proposal of agreement and the constraints AGREE-L (PLACE) and IDENTITY-IO. For the variation that properties of CH present in children's tokens we used the Multiple Parallel Grammars Model (Revithiadou & Tzakosta, 2004) and the constraints INTEGRITY, ANCHOR-L (-CONTINUANT), ANCHOR-L (+CONTINUANT), which is responsible for the preservation of all the elements in extended prosodic words and the anchoring for [-continuant] or [+continuant] manner at the left edge of word respectively (Tzakosta, 2002; Tzakosta, 2004a). The two latter can account for CH, in which partial or full assimilations with the change of one or two DF are presented. In a few cases, we added the constraints *Coda and MAXIMALITY-IO due to non utterance of consonants in coda position, which lead to the deletion of segments in the output forms of children (McCarthy & Prince, 1995). A question that remains open and we leave it for future research is why in some cases the trigger assigns only its place to the target while in others its place and manner. A bigger sample of data could address this issue. Further, children's data seem to be against the clitic group as a separate layer, since it would demand extra constraints referring to it and its relation to other layers in the prosodic hierarchy (Tzakosta, 2004a), something that is not necessary in this study as the constraints used can adequately provide a proper analysis.

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Appendix

Twin children - Boy

	Adult's Form	Child's Form	Age	Translation
1	θa ˈpe.si	pa ˈpe.si	2;6.5	(he / she / it) will fall
2	to ko.ˈli.so	ko ko.ˈli.so	2;6.17	I (will) stick it
3	θa ˈfi.ʝi	pa ˈpi.ʝi	2;6.24	(he / she / it) will leave
4	θa ˈpe.si	pa ˈpe.si	2;8	(he / she / it) will fall
5	pu ˈka.nu.me	ku ˈka.nu.me	2;8.7	where we do
6	pu sku.ˈpi.zu.me	ku ko.ˈpi.zu.me	2;8.7	where we wipe

Non twin children - Boy

	Adult's Form	Child's Form	Age	Translation
1	tin ˈpi.ɾa	pi ˈpi.a	2;3	I took her
2	to ˈe.vɣa.la	kxo ˈe.ɣa.la	2;5.16	I took it out
3	ðen ˈka.no	ʝe ˈka.no	2;5.23	I do not do

Non twin children - Girl

	Adult's Form	Child's Form	Age	Translation
1	ðe ˈbe.ni	be ˈbe.ni	2;3.22	(he / she / it) does not get in
2	ðe ˈbe.ni	be ˈbe.ni	2;4.26	(he / she / it) does not get in
3	ðe ˈbe.ni	be ˈbe.ni	2;4.26	(he / she / it) does not get in
4	ðe ˈbe.ni	be ˈbe.ni	2;4.28	(he / she / it) does not get in
5	ðe ˈbe.ni	be ˈbe.ni	2;5.1	(he / she / it) does not get in
6	ðe ˈbe.ni	be ˈbe.ni	2;5.1	(he / she / it) does not get in
7	ðe ˈbe.ni	be ˈbe.ni	2;5.1	(he / she / it) does not get in
8	ðe ˈbe.ni	be ˈbe.ni	2;5.1	(he / she / it) does not get in
9	ðe ˈbe.ni	be ˈbe.ni	2;5.3	(he / she / it) does not get in
10	ðe ˈbe.ni	be ˈbe.ni	2;5.10	(he / she / it) does not get in
11	ðe ˈbe.ni	be ˈbe.ni	2;5.10	(he / she / it) does not get in
12	ðe ˈbe.ni	ba ˈbe.ni	2;5.15	(he / she / it) does not get in
13	ðe ˈbe.ni	be ˈbe.ni	2;6.8	(he / she / it) does not get in
14	θa ˈka.t^{s}o	ka ˈka.t^{s}o	2;6.8	I will sit
15	to ˈspi.ti	po ˈpi.ti (m)	2;6.13	the house
16	to ˈspi.ti	pa ˈpi.ti	2;6.13	the house
17	θa ˈpe.si	pa ˈpe.ti	2;7.6	(he / she / it) will fall
18	θa ˈpe.si	pa ˈpe.ti	2;7.6	(he / she / it) will fall
19	θa ˈpe.si	pa ˈpe.ti	2;7.6	(he / she / it) will fall
20	θa ˈka.t^{s}u.me	ka ˈka.si.a.me	2;7.6	we will sit
21	θa ˈpa.ne	pa ˈpa.ne	2;8.21	they will go
22	θa ˈpa.o	pa ˈpa.o	2;8.28	I will go
23	ta ˈçer.ja	ça ˈçe.ja	2;9.12	the hands
24	θa ˈka.ni	ka ˈka.ni	2;9.12	(he / she / it) will do
25	ta pe.ˈða.ca	pal pe.ˈða.ca	2;9.12	the children