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Conjoined Constraints and phonological acquisition

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Abstract

Since the publication of Optimality Theory (Prince & Smolensky, 1993), research on phonological acquisition has been exploring the explicative potential of constraint theories. This study is equally based on Optimality Theory. It attempts to analyze the acquisition of CVVC syllable structure by Brazilian Portuguese children and addresses the question of the use of Local Conjunction (Smolensky, 1995, 1997) in research that deals with problems of phonological acquisition.

1. Introduction

Since Local Conjunction was proposed by Smolensky (1995, 1997), it is been basically used to analyze phonological aspects in the adult grammar. According to McCarthy (2002), local conjunction is a powerful idea, but we need limits on which constraints can be combined and we also need more explanations about their functioning.

In this paper I am going to talk about the use of conjoined constraints in phonological acquisition, considering that they are "potential constraints" activated by the child in her learning process.

The paper begins talking about constraint hierarchies and syllable acquisition in Brazilian Portuguese, according to Bonilha (2000). I then discuss the conjoined constraint schemata and I will argue that we just can talk about limits on Local Conjunction if we analyze its functioning on child language.

2. Constraint hierarchies and syllable acquisition

According to Bonilha (2000), four stages should be distinguished in the acquisition of syllable structures - CV, V, CVV, CVC and CVVC - in Brazilian Portuguese (BP). The important acquisitional fact that motivates this four-fold staging is based on the analysis of falling oral diphthong in 86 monolingual children, aged between 1:0 and 2:05:29 (years-months-days), from the INIFONO and AQUIFONO databases. Below, the relevant stages are represented in (1):

(1)
Stage I: CV-V
Stage II: CV-V-CVV
Stage III: CV-V-CVV-CVC
Stage IV: CV-V-CVV-CVC-CVVC

In Bonilha (2000) the constraints in (2) are used to explain the acquisition of the syllable structures mentioned in (1).

(2)
Onset: syllables must have an onset.
*ComplexNuc: the nucleus[1] must contain a short vowel only.
NoCoda: syllables should not have a coda.
DEP I/O (Dependency Input/Output): output segments should have input correspondents.
MAX I/O (Maximality Input/Output) input segments should have output correspondents.

In order to demonstrate how the learner acquires the successive stages given in (1), that is, which intermediate hierarchies are involved in the process of syllable structure acquisition and how each of these hierarchies is constructed, it is useful to look at the learning algorithm proposed by Tesar & Smolensky (2000). According to this algorithm, the child's confrontation with the data takes it to demote the necessary constraints in such a way that the target hierarchy is attained, as will be explained in the following sections.

2.1 Acquisition stage I

According to the OT literature on the subject of acquisition (Gnanadesikan, 1995; Smolensky, 1996), the child presents in the beginning of the process of language acquisition the H_O hierarchy, as seen in (3),

(3)

H_O={Onset, *ComplexNuc, NoCoda}>>{MAX I/O, DEP I/O}

In the initial hierarchy markedness constraints dominate faithfulness constraints, which state of affairs automatically leads to the production of CV syllable structure. According to Matzenauer (1999), Onset is the first constraint related to syllable structure that needs to be demoted in the acquisition of BP, in order to account not only for the production of CV syllables but also of V syllables. The question that must be answered is how the child knows that, to produce a V type target form, it must demote the Onset constraint? According to Tesar & Smolensky (2000), by analyzing sub-optimal/optimal pairs created by GEN, the algorithm starts the demotion of the relevant constraints, until the hierarchy that supports the optimal candidate is constructed. The amount of informative pairs used for the analysis can show the complexity of a structure. More complex structures will probably make it necessary for a greater amount of pairs to be analyzed, as a larger number of constraint demotions will be necessary account for the target forms, as is shown in Table 1:

Table I - Check out of violated constraints in *zaza<a.za* e *za<a.za*

	loser<winner	loser-marks	winner- marks
a<c	za.za<a.za	DepI/O	Onset
b<c	za<a.za	Max I/O	Onset

The analysis of sub-optimal/optimal pairs shows which constraints are violated by the loser and the winner candidates. If a constraint is violated by both elements in the pair, the *mark cancelation process* is applied**.** This process is used to 'purify' the information by cancelling out marks from the table which have no information value, so it will eliminate from the table any marks which are shared by winner and loser because what is relevant is the difference in violations of a constraint with other candidates. The relevant constraints will be demoted only after markedness cancellation. In Table I, no constraint is violated by both members of the pair, therefore, no violation mark will be deleted. Therefore, process of constraint demotion can start. According to Tesar & Smolensky (2000), in this situation, the constraint ranking must be adjusted, so that for each pair of candidates analyzed, all the constraints violated by the potentially optimal candidate be dominated by at least one constraint violated by the sub-optimal candidate. It is highlighted that only constraint violations are relevant for the demotion process, as constraint satisfaction on the potentially optimal candidate is unable to reflect its position in the hierarchy.

By analyzing the informative pair *a<c,* one observes that Onset must be dominated by DEP I/O so that candidate *c* can be selected as optimal. The hierarchy in (4) shows the first acquisition stage in Brazilian Portuguese.

(4)

Stage I - CV and V structure production

Hierarchy H_1

{ *ComplexNuc, NoCoda }>>{ Max,Dep}>> { Onset}

2.2. Acquisition stage II

As was suggested in (1), for the learner to reach the second stage of syllable structure acquisition it is necessary that a new analysis of informative pairs be carried out. It is shown in (4) that, at the first acquisition stage, only non-branching nuclei are produced. Therefore, when, at this stage, the child faces a lexical target such as *papai* [pa.´paj] 'daddy', the optimal candidate will be chosen according to the constraint ranking of this stage of acquisition. Observe the tableau in (5):

(5) Tableau 01

/papai/	*Complex Nuc	NoCoda	DEP I/O	MAX I/O	Onset
pa.paj	*!				
☞ pa.pa				*	
pa.pa.pi			*		

According to (5), the second candidate is chosen as optimal, because it does not violate *ComplexNuc, which is ranked above the faithfulness constraints. Although there is no ranking among the faithfulness constraints at this stage of development, the acquisition data in BP point to the existence of a subhierarchy involving Dep I/O and Max I/O, since children systematically prefer deletion instead of insertion.

The ranking proposed in (5), however, only allows the production of non-branching nuclei. To produce the target form [pa.paj], a ranking in which DEP/IO and MAX/IO dominate *ComplexNuc would be necessary, as shown in (6):

(6) Tableau 02

/papai/	NoCoda	Dep I/O	Max I/O	Onset	*Complex Nuc
☞ pa.paj					*
pa.pa			*!		
pa.pa.pi		*!			

The learning algorithm will guide the learner when confronted with new informative pairs in achieving the ranking proposed in (6). The application of the Algorithm will then lead to the demotion of *ComplexNuc below the faithfulness constraints. The hierarchy in (7) shows the second stage in the acquisition of syllable structure in BP, when the child is starts producing falling oral diphthongs.

(7)

Stage II – VG structure production

H_2 Hierarchy

{NoCoda}>> {MAX I/O,DEP I/O} >> {*ComplexNuc, Onset}

Taking into account that in (7) the production of falling diphthongs occurs due to the demotion of *ComplexNuc demotion, it can be stated that the child can produce CV, V and VG syllable structures only by Onset and *ComplexNuc demotion.

2.3. Acquisition stage III

The demotion of *ComplexNuc in stage II obtains that the unmarked VG structure is acquired before the relatively marked VC structure, if the NoCoda constraint is demoted in $H_{3,}$ as shown in (8).

(8)
Stage III – VC structure production
H_3 Hierarchy
{MAX I/O,DEP I/O}>>{*ComplexNuc, Onset, NoCoda}

The hierarchy in (8) predicts that, when the learner arrives at stage III, he is able to perform a CVVC syllable structure[2], i.e. a complex nucleus followed by a coda consonant. Let us next observe the tableau 03 in (9):

(9) Tableau 03

/seis/	DEP I/O	MAX I/O	Onset	*ComplexNuc	NoCoda
ses		*!			*
sej		*!		*	
☞ sejs				*	*

According to (9), candidates *a* and *b are* not chosen as optimal, because they violate MAXI/O which is ranked above the markedness constraints. The candidate *seis* [‘sejs] ‘six’ is selected as the best candidate, because it violates NotComplex(nucleus) and NoCoda, which are ranked below the faithfulness constraints.

According to the analyzed data, however, a CVVC syllable structure is not considered acquired in the acquisition stage III because of its low production percentage.

Observe Table II:

Table II - Occurrence possibility and CVVC syllable structure produced forms

Diphthongs	**Possibilities CVVC**	**Production**			
		CVVC	**CVV**	**CVC**	**Others**
[aj]	18	13	2	0	3
[oj]	23	12	7	2	2
[ew]	1	0	1	0	0
[ej]	6	3	1	2	0
Total	48	28	11	4	5
%	100	58,3	22,9	8,4	10,4

According to Table II, only 28 out of the 48 possible CVVC patterns really occurred, representing only 58,3% of the input items with that structure. Of the remaining items, 30,3% were produced as CVV or CVC syllables. Considering the fact that H_3 allows the production of syllables containing simultaneously a complex nucleus and a coda, a production percentage of the CVVC pattern superior to 58,3% is expected[3].

An OT account for the acquisition of syllable structure cannot be given with the constraints proposed in (2) alone. Bonilha (2000) proposes a Local Conjunction of the constraints NotComplex(nucleus) & NoCoda[4], which requires that syllables should not have at the same time a complex nucleus and a coda. The mechanism of Local Conjunction proposed by Smolensky (1995,1997) permits the conjunction of two simple constraints into one, including the conjunction of a constraint with itself (or local self-conjunction), may not be violated in a specific domain.

According to McCarthy (2002), the possibility of conjoining constraints somewhat mitigates the effects of the strictnes of strict domination, nevertheless it is pointed out that the conjoined constraint is also ranked with regards to the simple constraints that it contains and the conjoined constraint is also defined to apply within a local domain.

Follwing Fukazawa (2001), we illustrate the mechanism of Local Conjunction with the abstract examples in (10-11):

(10)

C>>A, B

(11)

$[A\&B]_D$>>C>>A,B

In (10), because *C* is ranked higher in the hierarchy than A and B, it cannot be violated by the optimal candidate, which can violate *A* or *B*. On the other hand, in (11), by virtue of the locally conjoined constraint, the optimal candidate can violate *C,* because the conjoined constraint $[A\&B]_D$ cannot be violated[5]. When A and B are both violated by a candidate, the conjunction of these two violations may force the violation of constraint C.

In the hypothetical languages, represented by the hierarchies in (10) and (11), the constraints *A* and *B* can be violated separately, satisfying constraint *C*, but both of them cannot be violated at the same time.

In relation to local self-conjunction, this occurs if conjoined constraint $[C1\&C2]_D$, C1=C2, i.e, a constraint is violated twice in the same domain.

Since conjoined constraints were proposed for the first time, many questions have been raised with regard to their usage:

(i) Do Local Conjunction constraints form part of UG?

(ii) How is locality established?

(iii) Is it possible to conjoin only the constraints that belong to the same family?

(iv) Which sense is family used in this case?

What regard to the question in (i), Smolensky (1997), Fukazawa and Miglio (1998) and Fukazawa (1999, 2001) suggest that conjoined constraints are language specific. According to these authors, if these constraints form part of UG, it would unnecessarily enlarge the universal set of constraints. UG only contains the "& " operator, which allows joining constraint. According to Fukazawa and Miglio (1998), this suggestion seems to be corroborated by the rareness of each particular type of local conjunction throughout the world's languages.

Smolenky (1995, 1997) suggests in relation to (ii) that conjoined constraints can only be created when violated in the same domain. Equally, Nathan (2001) assumes that the issue of locality is the heart of conjoined constraint.

As for the question raised in (iii), Fukazawa and Miglio (1998) observe that, if there are no limitations in the types of constraints that can be joined, even if UG only provides the "& " operator, the grammar of given language could still be broadened tremendously as a consequence of the conjunction of constraints. They authors propose that only constraints which belong to the same family can be conjoined. Fukazawa (1999:216) criticizes Itô and Mester (1996) for using the NoCoda & *Voice constraint, showing that devoicing in German can be explained by using single constraints. Moreover, the proposed conjunction does not obey the 'same-family' restriction. However, it is possible to interpret the conjoined constraints used by Itô and Mester (1996) as belonging to same family, if a broader definition of the concept 'family' is adopted, such that three great families are distinguished among the constraints that are part of UG, markedness, faithfulness and alignment constraints. In other words, depending on the definition of what a constraint family is, constraints such as Dep [+ ATR] and Dep [Hi] refer to the more restricted family of Dep constraints, or to the much larger family of faithfulness constraints. To conclude, although Fukazawa and Miglio (1998) try to evince the existence of a restriction in the constitution of Local Conjunction suggesting that both constraints must be of the same family, the issue regarding the proper definition of the concept "family" remains unsolved.

According to Suzuki (1998:41), although the analyses that use conjoined constraints point to the existence of some restriction on constraint conjunction that has to do with family membership, the uncertainty about exactly which constraints should be allowed to be conjoined still remains. It is therefore fruitful to reflect upon the way conjoined constraints emerge in the grammar, since it may be hypothesized that by understanding this mechanism one may gather some insight in which constraints may be conjoined.

For Fukazawa (1999, 2001) and Fukazawa and Miglio (1998) a conjoined constraint can only be used as a last resort, that is, when an analysis using single constraints is not able to explain a certain phonological process. More specifically constraint conjunction must obey the following three restrictions: last resort, locality, and same family.

In the following, the conjoined constraint *Complex (nucleus) & NoCoda suggested by Bonilha (2000) will be discussed from the perspective of these three restrictions.

From the tableau in (9), which presents the ranking of the single constraints in H3**:** {MAX I/O, DEP I/O}>>{NoComplex (nucleus), Onset, NoCoda}, it is impossible to account for the production of CVV and CVC syllables and the non-occurrence of CVVC syllables. The use of the conjoined constraint, therefore, is in accordance with the requirement that no ranking of single constraints can account for the grammatical outputs. Observe next the tableaux in (12) and (13):

(12) Tableau 04

/sei/	MAX I/O	*ComplexNuc	NoCoda
a-) se	*!		
b-) ☞sej		*	
/pas/			
a) pa	*!		
b) ☞ pas			*
/mais/			
a) maj	*!	*	
b) mas	*!		*
c) ☹ majs		*	*

(13) Tableau 05

/sei/	*ComplexNuc	NoCoda	MAX I/O
a-) ☹ se			*
b-) sej	*!		
/pas/			
a) ☹ pa			*
b) pas		*!	
/seis/			
a) ☞ sej	*		*
b) ☞ ses		*	*
c) sejs	*	*!	

The ranking shown in (12), Max I/O >> *ComplexNuc, NoCoda , although is capable of accounting for the production of CVV and CVC syllables, selects as the optimal output from a CVVC input the candidate in c, which is not produced by the child at this stage of acquisition. On the other hand, the ranking proposed in (13) – *ComplexNuc, NoCoda >> Max I/O – can account for the non-production of CVVC. At the given stage of acquisition, the selected outputs CVV and CVC are really the forms produced by the children for a CVVC input. The problem with this ranking is that it favors the candidates that violate Max I/O constraints for CVV and CVC inputs, although the children are already producing those structures in conformity with the target form. The use of *Complex (nucleus) & NoCoda is able to account for the production of words such as *pai* 'father' and *paz* 'peace' in accordance with the target form. It also predicts adequately the non-production of words such as *mais* 'more'and *seis* 'six' at the same stage of acquisition.

Another issue to be observed is the fact that the constraints that constitute *ComplexNuc & NoCoda belong to the same constraint family, obeying, therefore, the family restriction proposed by Fuzakawa & Miglio (1996). It should also be observed that the constraint proposed by Bonilha (2000) is in agreement with both the large and the narrow definition of constraint family, the narrow definition referring to the family of syllable structure constraints and the broader one to the family of markedness constraints.

Regarding the locality restriction, the tableaux in (14-15) show that, if no local domain were defined, the conjoined constraint would make the wrong predictions in some cases:

(14) Tableau 06

/seis/	*ComplexNuc & NoCoda	MAX I/O	*Complex Nuc	NoCoda
a-)☞ses		*		*
b-)☞sej		*	*	
c-) sejs	*!		*	*
/meias/				
a) ☹meas		*		*
b) ☹meja		*	*	
c) mejas	*!		*	*

(15) Tableau 07

/seis/	*ComplexNuc & NoCoda $_{(\sigma)}$	MAX I/O	*ComplexNuc	NoCoda
a-)☞ses		*		*
b-)☞sej		*	*	
c-) sejs	*!		*	*
/meias/				
a) meas		*!		*
b) meja		*!	*	
c) ☞mejas			*	*

According to the tableau in (14), the child would not only be unable to produce a CVVC syllable but also the words that have a complex nucleus and a coda in different syllables. The attribution of locality to the *ComplexNuc & NoCoda constraint in tableau (7) restricts the non production of complex nucleus and coda to the same syllable, not to the prosodic word as a whole, as was evidenced throughout the data that were used.

The proposed ranking in (15) shows the third stage of BP language acquisition. Observe the tableau in (16):

(16) Tableau 8

/sei/	NotComplex (nucleus) & NoCoda $_{(\sigma)}$	MAX I/O	*ComplexNuc	NoCoda
a-) se		*!		
b-)☞sej			*	
/pas/				
a) pa		*!		
b) ☞pas				*
/seis/				
a) ☞sej		*	*	
b) ☞ses		*		*
c) sejs	*!		*	*
/meias/				
a) meja		*!	*	
b) ☞mejas			*	*

*ComplexNuc & NoCoda$_{(\sigma)}$ >> MaxI/O >> *ComplexNuc, NoCoda, which is the ranking established in (16), accounts for the correct production of words that have CV, V, CVV and CVC syllable structures and also for the non production of a CVVC syllable structure to the extend that these occur in the target forms. For a CVVC input this grammar would not select candidate c, because it violates *ComplexNuc & NoCoda$_{(\sigma)}$ which is ranked higher than MAX I/O violated by the candidates a and b.

The ranking in (16) shows how local conjunction functions in the learner's grammar. *ComplexNuc and NoCoda are violated by the production of CVV and CVC outputs, respectively. In order to produce a CVVC output, these constraints would have to be violated simultaneously. Given the ranking in (16), an output form that violates Max I/O instead of the conjoined constraint is still better**.** The deletion of the glide or the coda consonant is therefore motivated by the high ranking of [*ComplexNuc & NoCoda]$_{(\sigma)}$ in the H_3 hierarchy. At this stage of acquisition, the simultaneous violation of the syllable structure constraints *ComplexNuc and NoCoda is much worse than the violation of just one them at the time, even if the violation of one of the simple constraints brings with it the violation of a faithfulness constraint. Observe that the hypothetical example suggested in (10) is here evidenced by acquisition data. It is worth mentioning that the grammar in (16) selects for a given CVVC input not one but two candidates as equally optimal, candidates a and b. This state of affairs suggests that there is variation in the learner's production. However, the data provided by Bonilha (2000), as summarized in Table III below, show that a CVV structure is systematically produced, not a CVC structure.

Table III – CVC and CVV syllable structures production for CVVC targets.

Words	CVC	CVV
"depois" after		[‘poj] (Marina – FE12)
"dois" two	[‘doʃ] (João II – FE09)	
dois		[‘doj] (Ivan – FE12)
dois		[‘doj] (Victória – FE12)
dois		[‘doj] (João – FE07)
dois	[‘dos] (Vinícius II – FE14)	
dois		[‘doj] (Iago – FE09)
"dois" more		[‘maj] (Ivan – FE12)
mais		[‘maj] (Luíza – FE02)
"seis" six	[‘ʃis] (Gabriela – FE10)	
seis		[‘sej] (Iago – FE09)
seis	[‘ses] (Carolina – FE09)	
TOTAL	04	08
%	33,4	66,6

The preference for the CVV syllable structure as shown in Table III can be explained by the possibility of NoCoda being ranked higher than *ComplexNuc.

2.4. Acquisition stage IV

In order to explain the acquisition of a CVVC syllable structure type it is necessary to return briefly to the learning algorithm proposed by Tesar & Smolensky (1996). First, we will consider, in table IV, for each elements of an informative pair created by GEN which constraints are violated:

Table IV – Constraints violated by the pairs ses < sejs and sej < sejs

loser < winner		loser-marks	winner-marks
a<c	ses < sejs	Max I/O - NoCoda	*ComplexNuc NoCoda – *ComplexNuc & NoCoda $_{(\sigma)}$
b<c	sej < sejs	Max I/O *ComplexNuc	*ComplexNuc NoCoda – *ComplexNuc & NoCoda$_{(\sigma)}$

The markedness cancellation process eliminates the constraints violated by both pairs *ses<sejs* and *sej<sejs*, as is illustrated in table V:

Table V- Elimination of constraints shared by ses < sejs and sej < sejs pairs

loser < winner		loser-marks	winner-marks
a<c	ses < sejs	Max I/O - ~~NoCoda~~	*ComplexNuc ~~NoCoda~~ – *ComplexNuc & NoCoda$_{(\sigma)}$
b<c	sej < sejs	Max I/O *~~ComplexNuc~~	*~~ComplexNuc~~ NoCoda – *ComplexNuc & NoCoda$_{(\sigma)}$

After markedness cancellation has applied, the constraint demotion process becomes active, based on the violated constraints given in table VI:

Table VI - ses < sejs and sej < sejs candidate pairs are ready to activate demotion

loser < winner		loser-marks	winner-marks
a<c	ses < sejs	MAX I/O	*ComplexNuc *ComplexNuc & NoCoda$_{(\sigma)}$
b<c	sej < sejs	MAX I/O	NoCoda *ComplexNuc & NoCoda$_{(\sigma)}$

Considering that, after markedness cancellation has applied, no other constraint is violated by both members of the pairs, the process of constraint demotion can apply.

Departing from the learner's current hierarchy in which {*ComplexNuc & NoCoda$_{(\sigma)}$} >> {DEP I/O, MAX I/O}>>{Onset, *ComplexNuc, NoCoda}, the analysis of the a<c informative pair shows that *ComplexNuc and [*ComplexNuc&NoCoda]$_{(\sigma)}$ should be dominated by the MAXI/O constraint for the candidate c to be chosen as the optimal form. Considering that *ComplexNuc is already located one stratum below MAX I/O in the current learner's hierarchy, only the constraint [*ComplexNuc & NoCoda] $_{(\sigma)}$ must be demoted according to (17):

(17)

H_4 {DEP I/O, MAX I/O}>>{Onset, *ComplexNuc, NoCoda, [*ComplexNuc&NoCoda]$_{(\sigma)}$}

Observe that [*ComplexNuc&NoCoda] $_{(\sigma)}$ does not constitute a new stratum in the hierarchy because the informative pair analyzed does not determine that this constraint must be ranked below Onset, *ComplexNuc and NoCoda. [*ComplexNuc& NoCoda] (σ), therefore, is ranked in the highest possible stratum of the hierarchy.

The analysis of the pair b < c will not cause any alterations to the H_4 hierarchy. Therefore, it is a non-informative pair. The analysis of b<c shows that NoCoda and [*ComplexNuc& NoCoda]$_{(\sigma),}$ which are violated by the optimal candidate, must be demoted below MAX I/O, which is violated by the suboptimal candidate. But the current learner's hierarchy H4 already demonstrates this ranking.

It is essential to observe that even by changing the order of the proposed pairs in Table IV, the H_4 hierarchy will be obtained by taking into consideration the analysis of only one of the pairs, since all analyses imply the demotion of the constraint [*ComplexNuc & NoCoda] $_{(\sigma)}$ below MAX I/O constraint. If the b < c pair is analyzed first, the child finds out that NoCoda and [*ComplexNuc& NoCoda] $_{(\sigma)}$ must be demoted below MAX I/O, which equally leads to the ranking in H_4. The only difference is that the pair b < c would become an informative pair. Consequently, it is seen here that the classification of a pair as informative or non-informative may depend on the order in the relevant pairs are analyzed. Sometimes, however, the change in the order in which pairs are analyzed involves changes in the sequence of the provisional hierarchies that the learner goes through. According to Kager (1999), the difference in the order of analysis of the pairs will mean an increase or decrease in the time span used by the learner to achieve a certain structure, however this difference will not change the final hierarchy[6].

In line with Bonilha (2000), the different hierarchies that account for the stages of acquisition in which the CV, V, CVV, VC, and CVVC structures gradually emerge, are shown in Table VII.

Table VII – Acquisition of syllable structures in Brazilian Portuguese

Stage I: CV - V	H1= {[NoCoda & *ComplexNuc]$_{(\sigma)}$, *ComplexNuc, NoCoda}>>{DEP I/O, MAX I/O}>>{Onset}
Stage II: (C)VV	H2={[NoCoda&NotComplex(nucleus)]$_{(\sigma)}$, NoCoda}>> {DEP I/O, MAX I/O}>>{Onset, *ComplexNuc}
Stage III: (C)VC	H3={[NoCoda & NotComplex(nucleus)] $_{(\sigma)}$}>>{DEP I/O, MAX I/O}>>{Onset, *ComplexNuc, NoCoda}
Stage IV: (C)VVC	H4={DEP I/O, MAX I/O}>>{Onset, *ComplexNuc, NoCoda, [*ComplexNuc& NoCoda] $_{(\sigma)}$}

3. Alternative analyses

According to Fukazawa & Miglio (1998), the use of conjoined constraints should be restricted to those cases where no other possible ranking can account for the occurrence of a given phonological phenomenon. The tableaux in (12) and (13) show the incapability of the syllable structures constraints to deal with the presence of CVV and CVC syllables and the simultaneous absence of CVVC syllables at a given stage of acquisition. One question that must therefore be asked if it is possible to account for the same pattern by the interaction of a set of constraints that does not contain the conjunction [*ComplexNuc&NoCoda] $_{(\sigma)}$. One possibility would be to consider the interaction between the constraints Binary (σ,μ) and Singly Linked (μ)[7]. The former constraint requires that the syllable has two moras**.** The family of Singly Linked constraints requires that each element be linked to an element on a higher tier. As such, the second constraint prohibits the sharing of a mora by two syllable elements. Consider the hierarchy in (18):

(18)

H_3 = {Binary (σ,μ), Singly Linked (μ) }>> {Dep I/O, Max I/O}>> {Onset, *ComplexNuc, NoCoda}

Given the hierarchy in (18) with the high ranking of Binary (σ,μ) and Singly Linked (μ), for a CVVC input – such as *sejs* 'six' the outputs indicated as optimal would be CVV and CVC structures. For the forms that contain a CVVC syllable, the form [sejs], whether presenting three moras each of them linked separately to one of the three segments in the syllable rhyme or just two, one of them linked to both the vowel and the glide – would be eliminated for violating either Binary (σ,μ) or Singly Linked(μ). In order to produce a CVVC syllable, it is necessary that at least[8] Shingly Linked(μ) be demoted below the faithfulness constraints in the hierarchy in (19), which would then account for the fourth acquisition stage of syllable structure in BP.

(19)

H_4 = {Binary(σ,μ)}>>{Dep I/O, Max I/O}>> {Onset, *ComplexNuc, NoCoda, SinglyLinked (μ)}

So what would there be against the grammars represented in (18) and (19) as a way of accounting for the acquisition of syllable structure in BP? First, it is not obvious that one should use constraints referring to mora structure in stages of acquisition in which reference to syllable structure seems enough to account for the data. According to Levelt , Schiller & Levelt (2000), other syllable types that are found to be acquired late, such as VCC, CCVC and CCVCC clearly do not all involve complex rhymes. Research carried out by the authors based on 12 Dutch children showed that the order CV, CVC, V and VC reflects the order of acquisition of all analyzed subjects. From stage IV, the subjects divide into two groups with regard to the acquisition of more complex syllable structures[9]:

(20)

Group A

CVCC, VCC, CCV, CCVC and CCVCC;

Group B

CCV, CCVC, CVCC, VCC and CCVCC.

The authors use the the mechanism of local conjunction, proposing the following conjoined constraints: [Onset&NoCoda], [*Complex Onset&NoCoda], [*Complex Onset&* Complex Coda] and [*Complex Coda & Onset]. We conclude that there are independent reasons to appeal to constraint conjunction in order to account for the acquisition of more complex syllable structures. If there is a need for conjoined constraints to account for the acquisition of CVCC, VC, VCC and CCVCC structures, why should this constraint type be prohibited to account for CVVC syllable structure? It seems also relevant to mention that the constraint [Onset&NoCoda] used by the authors to explain the late VC syllable acquisition is ranked high in the language known as Central Sentani, that admits CVC and V syllable structures but prohibits VC. A similar typological observation backs up the constraint [*ComplexNuc&NoCoda]$_{(\sigma)}$ proposed by Bonilha (2000). According to Blevins (1995), the languages Yokuts, Afar and Hausa admit CVC and CVV syllable structures, but lack CVVC syllables.

4. The use of Local Conjunction: implications for phonological acquisition

Conjoined constraints seem to be necessary as a "last resort" language-specific option. UG can make use of the "&" operator when the interaction between the constraints that are part of UG are unable to provide the grammatical output. In the language where it is active, it cannot be violated and it must always be placed higher in the ranking that the simple constraints of which it is made up. If [A&B] were ranked below the single constraints A and B, it would lose its function, which is to avoid the simultaneous violation of A and B. I therefore wish to propose that its relatively high position - relative to the constraints that it conjoins - as well as its inviolability act as restrictions on their functioning. However, the restrictions suggested here seem to create a problem for later stages of acquisition, when the complex structures are eventually acquired and the conjoined constraints are consequently violated and demoted below the simple constraints. This state of affairs may be observed in the analysis proposed by Bonilha (2000). It is also present in the analysis by Levelt, Schiller & Levelt (1999), since the [*ComplexNuc & NoCoda]$_{(\sigma)}$ constraint must be demoted below Dep I/O and Max I/O, in order to free the way for the emergence of the CVVC syllable structure. The conjoined constraint would be positioned in the same constraint stratum as the constraints of which it is made up, losing its main role in the grammar. In Levelt, Schiller & Levelt (1999), the ranking of constraints is postulated without the authors taking a stand with regard to the learning algorithm applied. Nevertheless, the proposed construction of hierarchies shows that Faithfulness constraints are being promoted throughout the phonological acquisition. For example, in order to explain the third stage of acquisition, when the child starts producing V and CV syllables, the Faithfulness constraints are ranked higher than Onset. In fact, the faithfulness constraint start to dominate the markedness constraints one by one, accounting for the different stages of acquisition. In the analysis of Levelt, Schiller & Levelt the promotion of faithfulness constraints ends up guaranteeing that the conjoined constraint remains ranked the constraints that constitute it. Observe the example in (21), which shows the acquisition of CVCC at a stage before the structure VCC is acquired.

(21a)
CVCC Production
H' = {[ComplexCoda&Onset]}>> {Faith} >>{*ComplexCoda}>>{Onset}

(21b)
VCC Production
H'' = {Faith }>> {[* ComplexCoda >>Onset]}>>{* ComplexCoda} >>{Onset}

Contrary to Tesar & Smolensky (2000), which is the proposal used by Bonilha (2000), the ranking proposed by Levelt, Schiller & Levelt authors does not position conjoined constraint in the same stratum where the constraints are located that constitute it. Nevertheless, it is still the case that the conjoined constraint loses its main role, which is to prohibit "the worst of the worst", since there is no violable constraint between the conjoined constraints and its constituting parts. Observe, to see this, the rankings in (22) and (23):

(22)

A functional Local Conjunction

A&B>>C>>A, B

(23)

A non-functional Local Conjunction

C>>A&B>>A<B (Levelt,Schiller & Levelt, 1999)

C>>A&B, A, B (Bonilha,2000)

C>>A, B>>A&B (hypothetical)

In (24-26), the hierarchies shown in (23) are illustrated with BP acquisition data.

(24) Tableau 09

/sei/	MAX I/O	NotComplex (nucleus) & NoCoda $_{(\sigma)}$	*ComplexNuc	NoCoda
a-) se	*!			
b-)☞sej			*	
/pas/				
a-) pa	*!			
b-) ☞pas				*
/seis/				
a) sej	*!		*	
b) ses	*!			*
c) ☞sejs		*	*	*

(25) Tableau 10

/sei/	MAX I/O	NotComplex (nucleus) & NoCoda $_{(\sigma)}$	*ComplexNuc	NoCoda
a-) se	*!			
b-)☞sej			*	
/pas/				
a) pa	*!			
b) ☞pas				*
/seis/				
a) sej	*!		*	
b) ses	*!			*
c) ☞sejs		*	*	*

(26) Tableau 11

/sei/	MAX I/O	*ComplexNuc	NoCoda	NotComplex (nucleus) & NoCoda $_{(\sigma)}$
a-) se	*!			
b-)☞sej		*		
/pas/				
a) pa	*!			
b) ☞pas			*	
/seis/				
a) sej	*!	*		
b) ses	*!		*	
c) ☞sejs		*	*	*

As can be seen in the tableaux in (24-26), the conjoined constraint [*ComplexNuc& NoCoda]$_{(\sigma)}$ has no role in the emergence of CVV, CVC and CVVC syllables in BP, independently of its ordering. For a CVVC input, the optimal output emerges because it does not violate the Max I/O constraint ranked higher than *ComplexNuc and NoCoda. This output would not be selected with the current constraints table, if the conjoined constraint were ranked higher than the faithfulness constraint and, therefore, also above the constraints that constitute it. Then, whether [*Complex(nucleus)&NoCoda]$_{(\sigma)}$ is positioned above the constraints that compose it, as in Levelt, Schiller & Levelt (1999) or it shares its stratum with them, as in Bonilha (2000), it has no longer a role to play in the BP grammar that allows for the production of CVVC syllables. When ranked below faithfulness constraint, the conjoined constraint become basically a mere repetition of the constraints that constitute it. Accepting the proposal by Bonilha (2000) would imply that the construction of conjoined constraints are primarily motivated by the learner's "difficulties" in language acquisition. Constraints such as [*ComplexNuc&NoCoda]$_{(\sigma)}$ would be constructed because the learner experiences some difficulty, not because the language provides evidence for their necessity. If that were the case, how many conjoined constraints could be created to solve such "difficulties"? Or, in other words, how many "inactive" constraints would end up composing the adult grammar? It would be more coherent to assume that the "&" operator may only be activated for the creation of a conjoined constraint that would really performs a function in the grammar.

Considering that conjoined constraints are language-specific constraints, one could assume their conjunction is triggered only when motivated by evidence in the adult output. Could it also be possible that it is activated independently of evidence in the output of the adult? The acquisition data in BP show that the answer is "yes". Therefore, constraint conjunction is directly related to the use of the learning algorithm, in the process of the child building up its input and demoting the constraints in order to reach the hierarchy of the target language. It might therefore be interesting to think about the "&" operator as a function of the learning algorithm, instead of it being a function of UG.

It is important to observe that conjoined constraints always refer to highly marked forms. For instance, there is no conjoined constraint that prohibits a prosodic word to consist of two CV syllables. Conjoined constraints are used in a language to avoid "the worst of the worst". Under this approach, it is possible to consider that conjoined constraints are created by the learner as a learning strategy that enables him to deal with more complex structures at a point of acquisition when the demotion of the constraints that constitute it has already occurred, thus allowing the emergence of a structure that is grammatical in terms of the grammar that does not contain the conjoined constraint, but which, because of a local accumulation of markedness, he is not yet able to produce. From this perspective, the "&" operator is activated exactly by the fact that a conjoined constraint performs a function: it prohibits the production of a marked structure that the low ranking of simple constraint already allowed.

How could one avoid the unnecessary proliferation of conjoined constrained in the learner's grammar, specifically in view of the fact that, after their demotion, their role in the grammar is canceled? Within the view of the "&" operator belonging to the learning algorithm, it makes sense to suggest that, after the demotion of a conjoined constraint to the same stratum of the constraints that constitute it – as in the hierarchy in (17) – these constraints are split. Together with the existence of the "&" conjoiner operator, there would also be a splitter operator. The conjoined constraints that not demoted below the constraints that constitute them, not suffering violation, would be kept and would remain in the grammar according to each specific language aspect. Besides having the task of discovering for their language the correct ordering of constraints provided by UG, a learner also needs to activate conjoined constraints that really have a function in his grammar or that will split by the splitter operator. It is important to highlight that the construction of conjoined constraints that do not militate in the adult's grammar would not be one more mechanism to reach the target grammar, but a resource made available by the learning algorithm to cope with difficulties in the production of complex structures. As can be seen in (27), the H_4 hierarchy (in 27b) that supports the production of a CVVC syllable structure is compared to the H_3 hierarchy in (27a) in the way their relation is understood here.

(27a)

H_3 = {[*ComplexNuc&NoCoda]$_{(\sigma)}$}>>{MAX I/O, DEP I/O}>>{*ComplexNuc, Onset, NoCoda}

(27b)

H_4 = {MAX I/O, DEP I/O } >> {*ComplexNuc, Onset, NoCoda}

Observe that the functioning of Local Conjunction constraint is different from other constraints that really compose UG, i. e. that are not conjoined, because it must always be ranked higher in the hierarchy. This can actually point out to the construction of those constraints by means of the “&” operator.

The existence of an splitting operator seems to be logical if we consider the existence of the “&” operator. If it weren’t for the “&” operator, conjoined constraints would be part of UG. According to McCarthy (2002), learners would have a modest table of innate constraints, with part of the learnability dedicated to finding out which universal constraints are conjoined in their language. Considering that OT is inherently typological and that the relation between the individual grammar and the universal grammar is a matter of constraint ranking, McCarthy’s view is completely in line with he OT logic. However, even if there is a principled way of restricting the types of constraints that can be conjoined and for providing the definition of possible domains, why should UG be overloaded with an even more excessive number of constraints?

It can be suggested that conjoined constraints work out: (i) for their existence in CON - due to intrinsic characteristics of each constraint - of limitations in the types of constraints that can be conjoined; (ii) by the activation of the “&” operator in learning algorithm. The universality of CON is kept because the same list of conjoined constraints can be potentially created in all languages, i. e. conjoined constraints are “potential constraints” that can be activated in the grammar.

However, this paper agrees with McCarthy (2002) that the different ranking of the constraints that are part of Universal Grammar explain the differences among grammars of different languages. Therefore, before conjoined constraints are added to a given grammar, it should first be clear that no possible ranking of simple constraints can account for the data.

5. Conclusion

According to the present research, we need to posit the grammar [*ComplexNuc & NoCoda] (σ) >> Max I/O, Dep I/O >>*ComplexNuc, Onset, NoCoda to account for the third stage in the acquisition stage of BP syllable structure, when CVV and CVC syllables are part of the child's grammar, but CVVC syllables are not. This grammar crucially contains a conjoined constraint. We have suggested that the way in which conjoined constraints emerge in language acquisition may shed some light on the function and the status of this constraints in a theory of language. In the present study, I have reflected on the function of conjoined constraints in the phonological acquisition process. More in particular I have shown the following facts:

a) Local conjunction loses its role in the constraint ranking when a hierarchy C>> [A&B] >>A,B changes into C >> [A&B] , A, B or C>>A,B>> [A&B];

b) The "&" operator is a function of the learning algorithm. Although there is the operator, the universality of CON is maintained, since the same setting of conjoined constraints can be potentially created in all languages.

c) The "&" operator is not activated by the existence of specific structures in the adult grammar only, but may also be triggered by the learner whenever he faces specific difficulties in the process of acquisition. This was argued specifically on the bases of the data presented in Bonilha (2000) and Levelt, Schiller & Levelt (2000);

d) As conjoined constraints always refer to marked forms in a given language, it seems possible to consider that they are created by the learner as a way to cope with highly marked structures, when the demotion of the constraints of which it is composed has already occurred.

e) After demotion of a conjoined constraint to the same constraint stratum that contains the corresponding 'simple' constraints, the former are split because they have lost their role in the grammar;

f) The conjoined constraints that are not demoted, and which, consequently cannot be violated, will be maintained and will remain in the grammar according to the particular needs of each language.

The phonological acquisition according to this proposal could be seen as a reordering of constraints and the building of conjoined constraints that will actually perform a role in the target language.

Footnotes

[1] Bonilha (2000) places the glide in a complex nucleus in Brazilian Portuguese based on Câmara Jr. (1977), Cristófaro Silva (1999) and Lee (1999). In this research some evidences were found in the acquisition data, what suggests the nuclear position of the glide. It is possible to find more evidences about the glide position in Brazilian Portuguese in Bonilha (2001).

[2] Considering different views in literature dealing with the syllable position of fricative /s/ in words such as "mais", "dois", "perspectiva" e "solstício" - more, two, perspective and solstice -, it is shared with Lee (1999) and Cristófaro Silva (1999) that the fricative /s/ is in a syllable coda position in BP. It is placed in the first coda position in words in which /s/ is followed by a falling diphthong as the glide is in a nuclear position in these analyses.

[3] The late acquisition of CVVC syllable structure is also observed by other researchers (cf. Fikkert (1994) for Dutch; Freitas (1997) for European Portuguese; Fikkert & Freitas (1997) for Dutch and European Portuguese; Bernhardt & Stemberger (1998) for English).

[4]Levelt, Schiller & Levelt (2000) use constraints such as Onset & NoCoda and *Complex-O & No Coda.

[5] Although Hewitt and Crowhurst (1995) postulate that the conjoined constraint must be considered violated when at least one of the constraints that compose it is violated, in the model originally proposed by Smolensky (1995, 1997), which is the one used here, a conjoined constraint is violated only when both constraints that compose it are violated.

[6] When the hierarchy is totally ranked, that is, when each stratum presents only one constraint, the acquisition will have taken place. Tesar & Smolensky (2000) classify this stage as "total ranking"

[7] The use of Binary (σ,μ) and Singly Linked (μ) constraints for the current work was suggested by Paul Stemberger in a personal e-mail.

[8] Singly Linked (μ) is justified by the possibility that literature to analyse a CVVC syllable as constituted by two moras sharing association lines . If that possibility did not exist , the use of Binary(σ,μ) would be enough to testify the production of a CVVC syllable – constituted of three moras - , considering its demotion below faithfulness constraints. As the present study does not attempt to define under which theorethical approach a CVVC

syllable structure is to be fit in BP, two possibilities are used: Single Linked (μ) demotion for CVVC production – shared moras; Binary (σ,μ) demotion for CVVC production – constituted of three moras.

[9] According to Van Vjiever the diphthongs were not considered in the analysis, then the authors classified CVV syllable as a CV one. Such information was passed on through personal e-mail.

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