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## From Phylogenetic Diversity to Structural Homogeneity: On Right-branching Constituent Order in Mesoamerica<sup>1</sup>

### Abstract

In this article it is claimed that language contact has led to structural homogeneity in the languages of Mesoamerica. Mesoamerican languages are demonstrated to be structurally homogeneous insofar as they tend to be consistently right-branching. This tendency can naturally be explained in terms of Hawkins' (1994, 2004) theory of Early Immediate Constituents (EIC), which predicts that uniform branching facilitates online processing. Adopting an evolutionary model of language change proposed by Kirby (1999), it is argued that Mesoamerican languages have become structurally homogeneous as a result of the adaptive interplay between the generation of structural variation on the one hand, and the process of selection from among existing variants on the other: Language contact acts as a source and amplifier of variation and therefore feeds the evolutionary mechanisms of change. It offers speakers a choice and allows for the selection of those structures which optimize Early Immediate Constituent recognition best.

### 1. Introduction: The Mesoamerican linguistic area

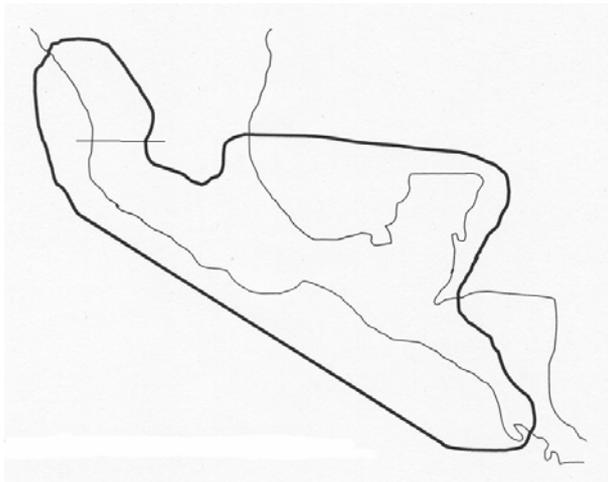
#### 1.1 The boundaries of Mesoamerica

The term 'Mesoamerica' was coined by the anthropologist Paul Kirchhoff (cf. Kirchhoff 1943). It refers to an area that covers large parts of Mexico,

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<sup>1</sup> This paper, whose origins date back to a talk given at the 22. Annual Meeting of the *Deutsche Gesellschaft für Sprachwissenschaft* in 2000, was finished during a research visit of the author at the *Center for Grammar, Cognition and Typology* (University of Antwerp) in autumn 2006. Financial support from the Alexander von Humboldt foundation and the University of Antwerp is gratefully acknowledged. I would like to thank Sebastian Drude, Daniel Hole, Peter Siemund and two anonymous reviewers for critical discussion and helpful comments. Any remaining inaccuracies are my own.

Guatemala and El Salvador, and extends southwards on to the Pacific coast of Costa Rica (cf. Figure 1). Kirchhoff (1943) characterizes Mesoamerica as a *kulturbund* which manifests itself in a number of features from different areas of cultural life (agriculture, religion, garment, architecture, etc.). The cultural convergence that can be observed is undoubtedly the result of long-term coexistence. With the exception of the Uto-Aztecan groups that migrated into Mesoamerica around 1000 AD, Mesoamerican peoples have co-existed for several millennia (cf. Coe et al. 1986 as well as references cited there). Migration in the area has, for the most part, been either internal or inwards. To a certain extent, this can probably be attributed to the fertile soils and rich fresh water resources that are characteristic of the region (cf. West 1964). The northern border of Mesoamerica corresponds approximately to the dividing line between the dry lands in northern Mexico and the more fertile soils in the centre and the south. The south-eastern border does not have any topographical significance.



**Figure 1.** Mesoamerica as a *kulturbund* (Kirchhoff 1943)

It is by now generally accepted that Mesoamerica is “a particularly strong linguistic area” (Campbell et al. 1986: 530; cf. also Stolz & Stolz 2001). It should be noted, however, that the boundaries of Mesoamerica as a linguistic area do not coincide entirely with its boundaries as a *kulturbund* according to Kirchhoff (1943). On the basis of linguistic evidence, Campbell et al. (1986) argue that Mesoamerica is bounded in the north by a dividing line that corresponds approximately to the tropic of cancer (cf. the thin straight line in Figure 1). Some of the languages spoken in north-west Mexico are thus excluded (in particular, Cora, Huichol, Southern Tepehuan

and Northern Tepehuan; note that these languages were included in some previous work on the Mesoamerican *sprachbund*, e.g. by Kaufman 1973).<sup>2</sup> By and large, anthropological and linguistic evidence nevertheless converge, bearing witness to the fact that Mesoamerican peoples have co-existed and been in contact with each other for several millenia.

The identification of boundaries for the Mesoamerican linguistic area has been approached in terms of a quantitative model by van der Auwera (1998). Van der Auwera assumes that linguistic areas generally have fuzzy boundaries, and that membership is a matter of degree. The degree of membership depends on the number of areal traits that a given language exhibits. Consequently, some of the peripheral Mesoamerican languages—for instance, Cora—are considered only “partly Mesoamerican” (van der Auwera 1998: 266). This means that they exhibit a few but not all of the traits that characterize the Mesoamerican *sprachbund*. As will be seen, the present approach is quantitative, very much like van der Auwera’s, and therefore does not rely on the assumption of categorical membership or non-membership of any given language to the Mesoamerican *sprachbund*. In tables and surveys, the languages of the ‘north-western peripheral area’ (Cora, Huichol, Northern Tepehuan, Southern Tepehuan) will be regarded as non-Mesoamerican, i.e. I adopt the boundaries assumed by Campbell et al. (1986). It should be borne in mind, however, that these languages clearly have an intermediate status. In maps, the north-western peripheral area will be separated from both the (genuine) Mesoamerican languages in central Mexico and the (clearly) non-Mesoamerican languages in the north. A map of the Mesoamerican languages mentioned in this article is provided in Figure 6 in the Appendix.

## 1.2 Linguistic features of Mesoamerica

Mesoamerica has been characterized in terms of the following areal traits (cf. Campbell et al. 1986; Campbell 1997; van der Auwera 1998; Stolz & Stolz 2001):<sup>3</sup>

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<sup>2</sup> More recently, Avelino (2006) has argued that Pamean languages—Northern Pame, Central Pame and Southern Pame (or ‘Jiliapan Pame’), which are often regarded as varieties of the same language, i.e. Pame—exhibit Mesoamerican traits to varying degrees (in particular, in their numeral systems). He assumes that the boundary between Mesoamerican and non-Mesoamerican languages cuts across these languages or varieties.

<sup>3</sup> A list of glosses is given in the appendix.

- (1) a. VO word order;  
 b. possessive constructions of the type [POSS-N<sub>PSR</sub> NP<sub>PSM</sub>], e.g. Tzotzil [s-tot [li Šun-e]] ‘Šun’s father’ (lit. ‘his-father the Šun-CL’);  
 c. relational nouns which precede their complement<sup>4</sup> and which are typically associated with the semantics of spatial relations, e.g. Classical Nahuatl *i-nawak i-kal* ‘close to his house’ (lit. ‘its-closeness his-house’);  
 d. (certain features characteristic of) vigesimal numeral systems;  
 e. loan words from Nahuatl (e.g. Totonac *kuluutl* < Nahuatl *kolootl* ‘turkey’) and semantic calques (e.g. ‘stone’ for ‘egg,’ cf. Nahuatl *tetl* ‘stone, egg’ and Tzotzil *ton kašlan*, lit. ‘stone hen,’ i.e. ‘egg’).

None of these traits is exhibited by all Mesoamerican languages. Still, they represent a sample of features that are extremely widespread in, and characteristic of, the region. In all cases, it can be demonstrated (via comparative evidence) that the features have spread through language contact. Most of the traits are logically independent. However, VO word order, preposed relational nouns (which are akin to prepositions) and the genitive construction illustrated in (1b) are closely related both conceptually (the head or non-branching node precedes the complement or branching node) and empirically (they tend to co-occur in the languages of the world, as has been shown in word order typology in the tradition of Greenberg 1966). These three features can be considered symptoms of two salient typological properties of Mesoamerican languages: Mesoamerican languages tend to be HEAD-MARKING and RIGHT-BRANCHING. The latter of these features will be central to the argument made in this paper.

### 1.3 Structural homogeneity and phylogenetic diversity

It will be demonstrated that Mesoamerican languages are structurally highly homogeneous, in the sense that the order of branching and non-branching nodes in surface syntax is invariant across phrasal constituents. More specifically, Mesoamerican languages are rather consistently right-branching, i.e. smaller constituents tend to precede larger ones. This high degree of ‘structural homogeneity’<sup>5</sup> is surprising if one considers that (a)

<sup>4</sup> In terms of Nichols (1986), relational nouns of this type can be called ‘head-marking prepositions’.

<sup>5</sup> I use the term ‘structural homogeneity’ as referring to the extent to which the order of branching and non-branching nodes is invariant across different types of categories. There are two extremes of structurally homogeneous languages, i.e. consistently right-branching languages and consistently left-branching languages.

the Mesoamerican linguistic area exhibits a high degree of “phylogenetic diversity” (Nettle 1999), and (b) two of the four major families represented in the area (Uto-Aztecan and Mixe-Zoquean) were formerly basically left-branching. Instead of developing a mixed-type syntax—as one might be led to expect on the basis of the naive assumption that mixing languages leads to structural disorder—Mesoamerican languages seem to have ‘opted for’ right-branching constituent structure and uniform surface syntax. This fact is in need of an explanation since it is not *a priori* expected that phylogenetic diversity and inter-family language contact should lead to structural homogeneity. I will argue that the development of a homogeneous constituent structure in Mesoamerican languages is predicted by Hawkins’ (1994) theory of ‘Early Immediate Constituents,’ embedded into a Neo-Darwinian model of language change as developed by Croft (1996, 2000) and Kirby (1999), among others: Syntactic diversity in a situation of intensive language contact gives rise to structural homogeneity because the existence of structural variation feeds the evolutionary process based on the interplay between variation and selection. On the assumption that structural homogeneity facilitates language processing, this process can be regarded as adaptive, responding to the cognitive needs of speakers taking part in a situation of intensive language contact.

The paper starts with an explication of the notion ‘branching direction’ in Section 2. An indicator of the ‘branching tendency’ of a language (right-branching or left-branching) is defined: the ‘branching index’. In Section 3, branching indices are determined for 40 Mesoamerican and 15 (adjacent) non-Mesoamerican languages. The results are interpreted in terms of their areal distribution and checked against genetic relationships. It is shown that Mesoamerican languages are structurally highly homogeneous (heavily right-branching), and that this homogeneity cannot be attributed to genetic relatedness. Section 4 offers an explanation for the observed homogeneity in terms of processing ease, referring to Hawkins’ (1994, 2004) theory of Early Immediate Constituents and Kirby’s (1999) elaboration of it in terms of an evolutionary model. Section 5 summarizes the conclusions.

## 2. Homogeneous constituent order in Mesoamerica

### 2.1 On the notion of ‘branching direction’

One of the central claims made in this paper is that Mesoamerican languages are ‘structurally homogeneous’. More specifically, they are claimed to be ‘predominantly right-branching’. This claim calls for clarification in two respects: first, it should be made explicit what exactly ‘right-branching’ means; and second, the qualifying adverb ‘predominantly’ should be translated into a more precise notion. These issues will be addressed in this section.

I will adopt the concept of branching direction that is commonly used in word order typology (e.g. Dryer 1992; Hawkins 1983, 1994; Kirby 1999). In this research tradition, branching direction refers to the order of shorter (lexical, non-branching) elements and larger (phrasal, branching) sister constituents in a surface constituent analysis. For example, the order VO is a right-branching structure because the verb is (usually) lexical and the object phrasal. The reverse order OV, by contrast, is left-branching since here, the phrasal constituent (NP) precedes the lexical head (V). Thus, branching direction is regarded as a PROPERTY OF THE CONSTRUCTIONS OF A GIVEN LANGUAGE.<sup>6</sup>

If we assume that the branching direction of a constituent is a function of the order of phrasal and non-phrasal elements in surface syntax, we obviously have to make some basic assumptions about constituent structure. Constituent structure will be represented using a simple version of X-bar theory in the tradition of Chomsky (1970) and Jackendoff (1977). Pronominal possessors, numerals, and adjectives are assumed to adjoin to N’. Lexical genitives are taken to be sisters of N’ when they are modifiers and sisters of N when they are complements. The hierarchical structure of a (consistently right-branching) NP is thus assumed to be as shown in (2a) (the order of DET, POSS, and NUM may of course vary from one language to another). German examples are given in (2b) and (2c).

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<sup>6</sup> Note that Dryer’s (1992) ‘branching-direction theory,’ on which Hawkins’ (1994) theory is based, does not say anything about what is the ‘head’ and what is the ‘dependent’ in a phrasal node. I will assume that the non-phrasal node is generally the ‘head,’ but this is basically an abbreviation and does not have any theoretical implications.

- (2) a. [<sub>NP</sub> DET [<sub>N'</sub> POSS [<sub>N'</sub> NUM [<sub>N'</sub> A N]]]]  
 b. [<sub>NP</sub> *diese* [<sub>N'</sub> *meine* [<sub>N'</sub> *zwei* [<sub>N'</sub> *kleinen* *Töchter*]]]]]  
     those      my            two      little      daughters  
     lit.: 'those my two little daughters'  
 c. [<sub>NP</sub> *diese* [<sub>N'</sub> *zwei* [<sub>N'</sub> *kleinen* [<sub>N</sub> *Töchter* [<sub>NP</sub> *meines* *Bruders*]]]]]]]  
     those      two      little      daughters      my.GEN brother.GEN  
     lit.: 'those two little daughters of my brother'

Word order typology in the tradition of Greenberg (1966) sometimes fails to distinguish between categorical and relational notions. For example, a statement such as “in language L the verb precedes the object” is, strictly speaking, inaccurate because ‘verb’ is a lexical category and ‘object’ a syntactic relation. More accurately, we should say that ‘in language L, a verbal predicate (regularly) precedes a nominal object.’ Technically, the order of verbal predicate and nominal object could be represented by the formula ‘[V]<sub>PRED</sub>-[NP]<sub>O</sub>,’ where category labels are represented by capitals and relational notions by subscripts. For the sake of brevity, however, subscripts indicating syntactic relations will be used only when ambiguity may arise. For example, ‘V-[NP]<sub>O</sub>’ will stand for the traditional shortcut ‘VO,’ since a verb is typically a predicate, whereas an NP is not always an object. In informal discussion, ‘VO’ will continue to be used as an abbreviation for ‘the verbal predicate precedes the nominal object.’ Likewise, ‘NG’ will stand for ‘the head noun precedes the genitive (NP).’

In order to determine the overall tendency of a language towards either right-branching or left-branching syntax, I will use a sample of six phrasal categories: (i) monotransitive VPs (verb and direct/primary object; e.g. [*saw* [*the man*]]), (ii) Adpositional Phrases (AdP, prepositions [*in* [*two hours*]] vs. postpositions [[*two hours*] *ago*]), (iii) combinations of a genitive NP and a head noun/N'-constituent ([<sub>NP</sub>[<sub>NP.GEN</sub> *your father's*] [<sub>N</sub> *son*]]), (iv) combinations of a pronominal possessor and N' ([*my* [*old friend*]]), (v) combinations of demonstratives and N' ([*this* [*old man*]]), and (vi) combinations of numerals and N' ([*three* [*young boys*]]).

This sample of categories as indicators of the general ‘branching tendency’ of a language is intended to represent phrasal nodes at different levels of the clause, two of them above NP (VP, PP) and four of them within NP (NG, PRO<sub>POSS</sub>-N', DEM-N', NUM-N'). While higher-level constituents have a stronger impact on the overall branching tendency of a language (which will be captured by a ‘heaviness coefficient,’ cf. Section 2.2.2), lower-level constituents tend to be more stable diachronically. Taking into account different levels of clause structure is meant to ensure

that both more recently acquired structural properties of languages (usually at the higher level of syntax) and more conservative traits are reflected (in lower-level syntax). The choice of constituents within NP has been governed by obvious restrictions of data availability: the NP-internal categories chosen in my sample (genitive NPs, pronominal possessors, demonstratives, numerals) are typically represented in either reference grammars or dictionaries of Mesoamerican languages. There is, thus, a certain arbitrariness or at least convenience in the choice of categories contained in the sample. Still, the sample does seem to contain the most frequently occurring phrasal categories, as is also reflected in the very fact that these categories figure prominently in reference grammars, at least of Mesoamerican languages and other languages of Mexico and Central America.<sup>7</sup>

The constructions dealt with in this paper are summarized in Table 1. The first column assigns an ID to each construction for the sake of future reference. The rightmost columns specify which order of constituents corresponds to which ‘branching type’ (right-branching or left-branching). Prepositions and postpositions are subsumed under ‘Ad(position)’.

<i>C<sub>n</sub></i>	order of . . .	branching type	
		right-branching	left-branching
C1	verb and object	V – [NP] <sub>O</sub>	[NP] <sub>O</sub> – V
C2	adposition and NP	Ad – [NP]	[NP] – Ad
C3	head noun and genitive NP	N – [NP] <sub>GEN</sub>	[NP] <sub>GEN</sub> – N
C4	pronominal possessor and N’	PRO <sub>POSS</sub> – [N’]	[N’] – PRO <sub>POSS</sub>
C5	demonstrative and N’	DEM – [N’]	[N’] – DEM
C6	numeral and N’	NUM – [N’]	[N’] – NUM

**Table 1.** Order of elements and branching types

<sup>7</sup> Note that a more comprehensive investigation would have to be based on natural discourse, rather than abstractions thereof (grammatical descriptions). Such an investigation has been carried out by Hawkins (1994) for English, but is, for obvious reasons, beyond the scope of this paper: We would need a parallel corpus comprising data from 45 languages, which is inconceivable even for much better documented languages than those of Mesoamerica, e.g. European ones. At some point it may be possible to carry out such an investigation on the basis of bible texts.

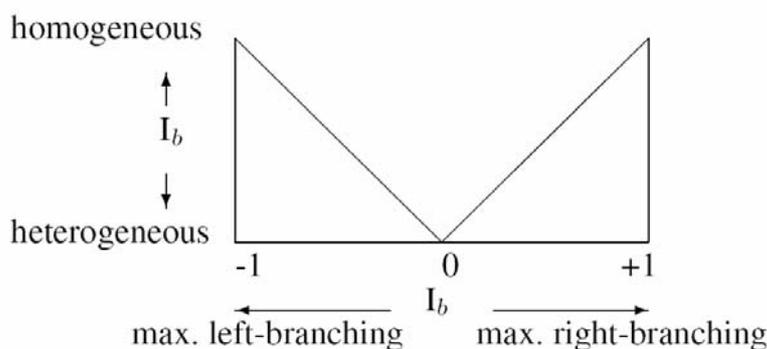
## 2.2 The branching index

### 2.2.1 Towards an operationalization

If branching direction is regarded as a property of constructions or phrasal constituents in surface syntax, it probably becomes apparent what it means for a language to be ‘predominantly right-branching’: it means that the language in question has right-branching constituent structure in most of its phrasal constituents. For example, Mixtec is right-branching in VPs since it is VO; it is right-branching in lexical genitive constructions since it is NG; it is right-branching in PPs since it has prepositions. Mixtec NPs headed by a demonstrative, by contrast, are left-branching since demonstratives follow N’ (for example,  $[_{NP}[_{N'} \text{ iža sɨʔa}] \text{ žaʔa}]$  ‘this goddess,’ lit. ‘[[god female] this]’). Thus, in most but not all of its phrasal constituents, Mixtec is right-branching; it is ‘predominantly right-branching’. Otomí, on the other hand, is right-branching in all of the constructions mentioned above. We could say that it is ‘very heavily right-branching’ and ‘more right-branching than Mixtec.’ However, such impressionistic statements are hardly of any use in a cross-linguistic study claiming a certain degree of falsifiability. I will therefore propose a metric that is intended to indicate the branching tendency of a given language: the BRANCHING INDEX, represented as ‘ $I_b$ ’. I would like to emphasize from the outset that the calculation of a numerical value representing the branching tendency of a language can only be an approximate heuristic device and obviously requires a certain fuzzy tolerance. Within a reasonable extent of tolerance, however, the branching index may be a useful tool which allows us to (quantitatively) compare languages in terms of their branching tendencies.

The branching index is calculated on the basis of the sample of constructions listed in Table 1. The simplest way of calculation would be to work out the ratio of right-branching and left-branching constructions to the total of constructions for each language. For example, we could say that Mixtec is 4/6, or 67%, right-branching and only 2/6, or 33%, left-branching, since four of the six constructions in the sample are right-branching. However, the procedure applied in this paper will be slightly different. First, the structural complexity of the different constructions  $C_n$  will be taken into account by assigning a ‘heaviness coefficient’ to them. This is intended to allow for a direct association between the concept of branching direction and Hawkins’ (1994) theory of ‘Early Immediate Constituents’. Second, I will use a mode of calculation that delivers results

between -1 (for maximally left-branching) and +1 (for maximally right-branching). The reason is that I would like to avoid the impression of a fundamental conceptual difference between right-branching and left-branching structure. For example, the statement that Mixtec is 67% right-branching while Otomí is 100% right-branching gives the impression that the two languages are arranged on a scale of ‘right-branchingness’. The claims made below, however, are intended to apply to right-branching and left-branching languages alike. If the branching indices range from -1 to +1, this allows us to abstract away from the degree of either right-branchingness or left-branchingness, and to introduce the more general concept of STRUCTURAL HOMOGENEITY: the ABSOLUTE VALUE of the branching index (i.e.,  $|I_b|$ ) can be regarded as a metric of structural homogeneity, irrespective of the specific branching direction. Consider, for instance, the cases of Otomí and Mískitu. Otomí is right-branching in all six constructions under consideration, while Mískitu is left-branching in all constructions. What both languages have in common is that they are structurally homogeneous. The absolute values of their branching indices are both ‘1’. Figure 2 provides a graphical illustration of the branching indices and their absolute values.



**Figure 2.** Absolute values of branching indices

The branching index is calculated as follows: let  $C_n$  be the right-branching member of any of the six constructions of our sample, and let  $L_r$  be a given language. The two-place function  $U$  stands for ‘. . . is the canonical construction in . . . ,’ and takes construction  $C_n$  and language  $L_r$  as its arguments. The predication  $U(C_n, L_r)$  thus translates as ‘ $C_n$  is the canonical construction in  $L_r$ .’ The function  $U$  has either the value ‘1’ (for true) or ‘0’ (for false). Let us suppose that  $C_n$  is the construction  $C_1$  (i.e., V-[NP]<sub>o</sub>), and that  $L_r$  is Chalcatongo Mixtec. The value of  $U(C_1, \text{Mixtec})$  is ‘1,’ since VO

is the canonical order in information-structurally neutral sentences of Mixtec.  $U(C_5, \text{Mixtec})$ , by contrast, has the value ‘0’ since in Mixtec, demonstratives follow the noun phrase. In this way, the  $U$ -values are determined for each of the six constructions  $C_1$ – $C_6$ . This is illustrated for Mixtec in Table 2.

	Construction	$U(C_n, \text{Mixtec})$
$C_1$	V-[NP] <sub>0</sub>	$U(C_1, \text{Mixtec}) = 1$
$C_2$	Ad-[NP]	$U(C_2, \text{Mixtec}) = 1$
$C_3$	N-[NP] <sub>GEN</sub>	$U(C_3, \text{Mixtec}) = 1$
$C_4$	PRO <sub>PSR</sub> -[N’]	$U(C_4, \text{Mixtec}) = 0$
$C_5$	DEM-[N’]	$U(C_5, \text{Mixtec}) = 0$
$C_6$	NUM-[N’]	$U(C_6, \text{Mixtec}) = 1$

**Table 2.**  $U$ -values of Mixtec

### 2.2.2 Early Immediate Constituents and the heaviness coefficient

In a next step, the  $U$ -values are multiplied by a ‘heaviness coefficient.’ The heaviness coefficients are intended to reflect the approximate average length (measured in words) of the phrasal part of a branching node. They are meant to relativize the  $U$ -values to the impact that the relevant constructions have in terms of processing efficiency. In order to understand their relevance, I will anticipate some of the discussion presented in Section 4. I will follow Hawkins (1994, 2004) in assuming that uniform branching facilitates language production and comprehension, whereas the co-occurrence of right-branching and left-branching constituents gives rise to processing difficulties (and sometimes to garden-path structures). The degree of processing (in)efficiency of a structure crucially depends on the complexity of the constituents involved. Therefore, the (average) length of each constituent needs to be taken into account in the calculation of the branching index.

Let us consider an example: a (right-branching) verb-initial VP that dominates a (left-branching) postpositional phrase is relatively difficult to process, since the most important information about the higher level constituent structure ( $VP \rightarrow V + [_{\text{AdP}} NP \text{ Ad}]$ ) is available only at the end

of the linear input—the postposition heading the AdP is the last word of the VP. Thus, the (higher-level) constituent tree cannot be constructed by the parser until the whole VP has been processed. Hawkins (2004) refers to the minimal part of a phrase that must be available to the processor in order to construct the immediate constituent structure as the “Phrasal Combination Domain” (PCD): “The PCD for a mother node M and its I(mmediate) C(onstituent)s consists of the smallest string of terminal elements (plus all M-dominated non-terminals over the terminals) on the basis of which the processor can construct M and its ICs” (Hawkins 2004: 107). In a VP such as [<sub>VP</sub> *met* [<sub>NP</sub> *the man*] [<sub>AdP</sub> [<sub>NP</sub> *two years*] *ago*]], the PCD extends over the whole VP (six words). The three immediate constituents V, NP and AdP cannot be processed until the postposition *ago* becomes available. In the VP [<sub>VP</sub> *met* [<sub>NP</sub> *the man*] [<sub>AdP</sub> *in* [<sub>NP</sub> *the library*]]], by contrast, the immediate constituent structure (under VP) can be constructed as soon as the preposition *in* has been uttered or parsed. Thus, only four of the six words must be processed in order to recognize the highest nodes that are immediately dominated by VP.

In a first attempt at quantifying the difference in ‘user-friendliness’ or ‘efficiency’ between the two structures, we can calculate the ratio of immediate constituents to the number of words contained in the PCD. Hawkins refers to this ratio as the “IC-to-word ratio” (cf. Hawkins 1994: 69ff., 2004: 106). In the first example given above, the PCD stretches six words, while in the second one it contains only four words. The first example therefore exhibits an IC-to-word ratio of .5 (=3/6, six words must be processed in order to recognize three immediate constituents), while the second has an IC-to-word ratio of .75 (=3/4). The parsing efficiency of a construction is optimal to the extent that its IC-to-word ratio approaches 1.

The details of Hawkins’ theory are much too far-reaching to be discussed here. Some more information and illustration will be provided in Section 4. For the time being, suffice it to say that uniform branching facilitates language processing, and that the length of a constituent is in direct proportion to its impact on the processing (in)efficiency of a structure. When the branching direction of a two-word constituent does not match the overall sentence structure, the IC-to-word ratio of that sentence decreases only slightly. By contrast, when a longer segment – for example, a relative clause – does not match the rest of the sentence, the IC-to-word ratio may decrease dramatically. Translated into the present framework, this means that longer (higher-level) constituents are better indicators of the branching tendency of a language than shorter (lower-level) constituents.

Therefore, the length of the relevant constituents needs to be taken into consideration in the calculation of the branching index, by including a ‘heaviness coefficient’ in the calculus.

How are the heaviness coefficients calculated, then? The six constructions listed in Table 1 can be divided into two groups, according to the structural complexity of their branching constituents: in the first group (C<sub>1</sub>–C<sub>3</sub>), the branching nodes are NPs, while in the second group (C<sub>4</sub>–C<sub>6</sub>), they are N’-constituents. Table 3 illustrates this.

	non-branching node	branching node
C <sub>1</sub>	V <i>meet</i>	NP <i>a good friend</i>
C <sub>2</sub>	Ad <i>for</i>	NP <i>a good friend</i>
C <sub>3</sub>	N <i>son</i>	NP <sub>GEN</sub> <i>a good friend’s</i>
C <sub>4</sub>	PRO <sub>PSR</sub> <i>your</i>	N’ <i>good friend</i>
C <sub>5</sub>	DEM <i>this</i>	N’ <i>good friend</i>
C <sub>6</sub>	NUM <i>three</i>	N’ <i>good friends</i>

**Table 3.** Structural complexity of branching and non-branching nodes

The branching nodes of C<sub>1</sub>–C<sub>3</sub>, which are NPs (or even higher-level constituents, e.g. PPs in the case of English prepositional genitives), are structurally more complex than those of C<sub>4</sub>–C<sub>6</sub> (which are N’-constituents). Consequently, the branching directions of C<sub>1</sub>–C<sub>3</sub> have a stronger impact on the overall architecture of a sentence than those of the (lower-level) constructions C<sub>4</sub>–C<sub>6</sub>. The heaviness coefficient assigned to each construction is intended to reflect the approximate average length of the phrasal part of the constructions. I will assume that, on an average, N’-constituents consist of two words (A+N, NUM+N, etc.), while NPs contain one word more – namely, the determiner. Therefore, C<sub>1</sub>–C<sub>3</sub> are multiplied by the heaviness coefficient ‘3,’ while C<sub>4</sub>–C<sub>6</sub> are multiplied by the heaviness coefficient ‘2’.

We are now in a position to determine branching indices. The various *U*-values, each of them multiplied by the appropriate heaviness coefficient, are added up and then divided by 7.5. From the result of this operation, 1 is

subtracted. This is the mode of calculation that delivers results between -1 and +1. As is illustrated in (3) and (4), the branching index of Mixtec is 0.47:

$$(3) \quad I_b(L_r) = \frac{3(U(C_1, L_r) + U(C_2, L_r) + U(C_3, L_r)) + 2(U(C_4, L_r) + U(C_5, L_r) + U(C_6, L_r))}{7.5} - 1$$

$$(4) \quad I_b(\text{Mixtec}) = \frac{3(1+1+1) + 2(0+0+1)}{7.5} - 1 = 0.47$$

Branching indices allow us to compare languages in terms of their branching tendencies. For example, we can now say that the branching index of Otomí – which is ‘1’ – is higher than the branching index of Mixtec (.47). This is a more falsifiable form of saying that ‘Otomí is more right-branching than Mixtec’. Furthermore, the branching indices enable us to make statements about the STRUCTURAL HOMOGENEITY and consequently PROCESSING EFFICIENCY of a language. Assuming that Hawkins’ (1994) theory of Early Immediate Constituents’ is correct, languages are efficient in terms of processing to the extent that the absolute values of their branching indices approach 1. The branching index relates to the IC-to-word ratio insofar as the average IC-to-word ratio in a text of a given language is expected to approximately correlate with the branching index of that language.

### 3. Structural homogeneity in Mesoamerica

#### 3.1 The data

The sample of languages used for the present investigation comprises members of all families that are represented in Mesoamerica. In addition to the major Uto-Aztecan, Otomanguean, Mayan, and Mixe-Zoquean languages the following smaller families and isolates have been included: Lenca, Totonac-Tepihua, Tarascan, Cuitlatec, Oaxaca Chontal, Xinca, and Huave. As for the Mayan languages, some of them have been subsumed under major stocks (Greater Tzeltalan, Central Branch, K’iche’an, Mamean), since the languages of these stocks are very similar and do not exhibit much variation with regard to word order. Of the neighbouring non-Mesoamerican languages only a smaller sample has been examined, since the main focus of this paper is on the internal structure of Mesoamerica.

Table 4 shows the results.<sup>8</sup> The languages are ordered according to their branching indices. The column ‘MesAm’ indicates whether a language belongs to Mesoamerica or not, according to the boundaries established by Campbell et al. (1986) (cf. Figure 6 in the Appendix). As pointed out above, the languages of the ‘north-western periphery’ are classified as non-Mesoamerican, but the relevant minus sign is put in parentheses because these languages have an intermediate status. Pame—another language (group) whose status as Mesoamerican or non-Mesoamerican is disputed—is here represented by Southern Pame (or ‘Jiliapan Pame’) as described by Manrique Castañeda (1967), which does seem to form part of the Mesoamerican *sprachbund*.<sup>9</sup>

Ib	Language(L <sub>r</sub> )	Language family	MesAm	U(C <sub>n</sub> , L <sub>r</sub> )					
				C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>
1	Nahuatl	Uto-Aztecan	+	1	1	1	1	1	1
	Nahual	Uto-Aztecan	+	1	1	1	1	1	1
	Pipil	Uto-Aztecan	+	1	1	1	1	1	1
	Cora	Uto-Aztecan	(-)	1	1	1	1	1	1
	Otomí	Otomanguean	+	1	1	1	1	1	1
	S. Pame	Otomanguean	+	1	1	1	1	1	1
1	Matlazinca	Otomanguean	+	1	1	1	1	1	1

<sup>8</sup> The data has been drawn from the major reference grammars and dictionaries available. There is a large collection of grammars published by the Mexican branch of the SIL (or ILV, i.e. *Instituto Lingüístico de Verano*; cf. also the ‘SIL-bibliography’ provided in the Ethnologue for each language [<http://www.ethnologue.com>], and the references given by Campbell 1997). Where available, other grammars have also been consulted. Given that there is hardly any disagreement between the grammars consulted as far as the order of elements dealt with in this paper is concerned, I refrain from indicating the sources for each language individually.

<sup>9</sup> Campbell (1997: 344) remarks that “[t]he constituents of this linguistic area [Mesomerica] are: Aztecan (the Nahua branch of Uto-Aztecan), Mixe-Zoquean, Mayan, Xincan, Otomanguean (except Chichimeco-Jonaz and some varieties of Pame north of the Mesoamerican boundary)...”. Avelino (2006) has shown that Southern and Central Pame exhibit certain Mesoamerican traits (in particular, in their numeral systems) which Northern Pame lacks and thus assumes that “Northern Pame represents the northern limit of Mesoamerica as a linguistic area” (Avelino 2006: 508). Once again, it should be kept in mind that membership to a linguistic area is here regarded as a gradient concept. Cf. also Note 2.

<i>Ib</i>	Language( $L_r$ )	Language family	MesAm	$U(C_n, L_r)$					
	Mazahua	Otomanguean	+	1	1	1	1	1	1
	Chiapanec	Otomanguean	+	1	1	1	1	1	1
	Mangue	Otomanguean	+	1	1	1	1	1	1
	Oluta Popoluca	Mixe-Zoquean	+	1	1	1	1	1	1
	Sayula Popoluca	Mixe-Zoquean	+	1	1	1	1	1	1
	Sierra Popoluca	Mixe-Zoquean	+	1	1	1	1	1	1
	Greater Tzeltalan	Mayan	+	1	1	1	1	1	1
	Huastec	Mayan	+	1	1	1	1	1	1
	Itzá	Mayan	+	1	1	1	1	1	1
	K'iche'an	Mayan	+	1	1	1	1	1	1
	Mamean	Mayan	+	1	1	1	1	1	1
	Mopan	Mayan	+	1	1	1	1	1	1
	Chortí	Mayan	+	1	1	1	1	1	1
	Yucatec	Mayan	+	1	1	1	1	1	1
	Huave	isolate	+	1	1	1	1	1	1
	Oaxaca Chontal	isolate	+	1	1	1	1	1	1
	Totonac	Totonac-Tepehua	+	1	1	1	1	1	1
.73	Central Mayan	Mayan	+	1	1	1	1	0	1
	Chinantec	Otomanguean	+	1	1	1	0	1	1
	Mazatec	Otomanguean	+	1	1	1	0	1	1
	Popoloc	Otomanguean	+	1	1	1	0	1	1
	Subtiaba	Otomanguean	+	1	1	1	1	0	1
	Xinca	isolate	+	1	1	1	0	1	1
	Garífuna	Arawak	-	1	1	1	1	0	1
	Cuitlatec	isolate	+	1	1	1	0	1	1
.60	Sthn. Tepehuan	Uto-Aztecan	(-)	1	1	0	1	1	1
	Mixe	Mixe-Zoquean	+	1	0	1	1	1	1
	Chiapas Zoque	Mixe-Zoquean	+	1	0	1	1	1	1
	Tarascan	isolate	+	1	1	0	1	1	1
.47	Mixtecan	Otomanguean	+	1	1	1	0	0	1
	Zapotecan	Otomanguean	+	1	1	1	0	0	1

<i>I<sub>b</sub></i>	Language( <i>L<sub>r</sub></i> )	Language family	MesAm	<i>U(C<sub>n</sub>, L<sub>r</sub>)</i>					
	Amuzgo	Otomanguean	+	1	1	1	0	0	1
	Chatino	Otomanguean	+	1	1	1	0	0	1
	Cuicatec	Otomanguean	+	1	1	1	0	0	1
	Tlapanec	Otomanguean	+	1	1	1	0	0	1
	Trique	Otomanguean	+	1	1	1	0	0	1
.2	Huichol	Uto-Aztecan	(-)	1	0	0	1	1	1
	Nrth. Tepehuan	Uto-Aztecan	(-)	1	0	0	1	1	1
-0.2	Lower Pima	Uto-Aztecan	-	0	0	0	1	1	1
	Tarahumara	Uto-Aztecan	-	0	0	0	1	1	1
-0.47	Chichimec	Otomanguean	-	0	0	0	0	1	1
	Lenca	isolate	-	0	0	0	1	1	0
	Rama	Chibchan	-	0	0	0	1	1	0
	Matagalpa	Misumalpan	-	0	0	0	0	1	1
	Sumu	Misumalpan	-	0	0	0	0	1	1
	Tol	isolate	-	0	0	0	1	1	0
-0.73	Paya	Chibchan	-	0	0	0	0	1	0
-1	Mískitu	Misumalpan	-	0	0	0	0	0	0

**Table 4.** Branching indices of 40 Mesoamerican and 15 non-Mesoamerican languages

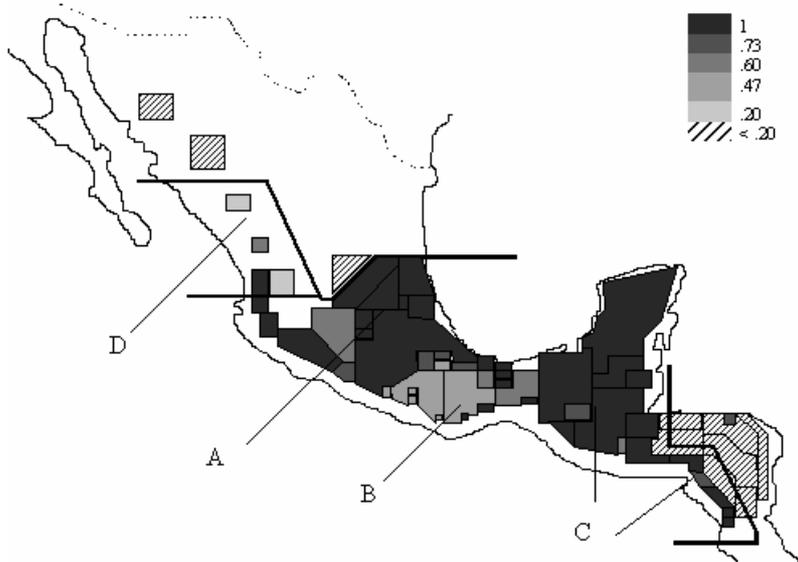
### 3.2 Areal distribution of branching indices in Mesoamerica

Some remarkable facts can be seen from Table 4. First, it is interesting to note that the branching indices cut across language families. Uto-Aztecan ranges from -0.2 (Lower Pima, Tarahumara) to 1 (Nahuatl), Otomanguean from -0.47 (Chichimec) to 1 (e.g. Otomí), and Mixe-Zoquean from .60 (Mixe, Chiapas Zoque) to 1 (Popoluca). Only Mayan languages show little variation. With the exception of some members of the Central branch, they score 1. Still, we can conclude that the branching tendency of a language cannot be predicted from its genetic affiliation.

Second, branching indices are clearly higher inside Mesoamerica than outside of it. The Mesoamerican average is .86, and the lowest score of a Mesoamerican language is .47 (some Otomanguean languages). Most of the southern neighbours show a tendency towards left-branching

constituent structure, with an average score of  $-0.42$ . With the exception of the “partly Mesoamerican” languages Cora, Huichol, Northern Tepehuan and Southern Tepehuan, the northern neighbours likewise have branching indices below zero. These numerical results illustrate the claim that Mesoamerican languages are predominantly right-branching, and that this feature sets them apart from their non-Mesoamerican neighbours.

However, the implications of the data presented in Table 4 reach even farther. Figure 3 demonstrates the areal distribution of branching indices in Mesoamerica (for a language key, cf. Figure 6 in the Appendix).<sup>10</sup> The first remarkable fact about Figure 3 is that certain branching indices cluster geographically. In the Central Highlands around the Valley of Mexico (A), there are a number of languages scoring 1. In the region around the so-called “Mesa del Sur” (B; in the following ‘the Oaxaca Region’), we find a couple of contiguous languages scoring .47. Languages spoken in the eastern part and in the south-eastern periphery of Mesoamerica (C) score 1 or .73. Only in the north-western periphery (D) can considerable variation be observed, especially if the ‘partly Mesoamerican’ languages are taken into account.



**Figure 3.** Areal distribution of branching indices

<sup>10</sup> The maps are intended to approximately reflect the geographical distribution of the languages at the time of contact prior to the conquest, based on the map provided by Moseley & Asher (1994, Map 13).

A further striking observation can be made when we check Figure 3 against the data shown in Table 4: there are clear implicational relations in the areal distribution not only of branching indices, but also of specific word order patterns. This means that adjacent languages with identical branching indices generally have identical word order patterns too. If adjacent languages have different branching indices, the set of right-branching constructions of the language with the lower branching index is a subset of the set of right-branching constructions of the language with the higher branching index. In central Mesoamerica (A), all languages are consistently right-branching. Some of the languages located at the south-eastern periphery of this central area (e.g. Chinantec, Mazatec, Popoloc) differ only in one construction ( $C_4$ ). In the Oaxaca Region (B), most languages are furthermore left-branching in  $C_5$ . In eastern and south-eastern Mesoamerica, most languages are consistently right-branching again. Adjacent Mixe-Zoquean languages deviate from that pattern only in  $C_2$  (i.e. they are postpositional).<sup>11</sup>

### 3.3 Branching indices and archaeological evidence

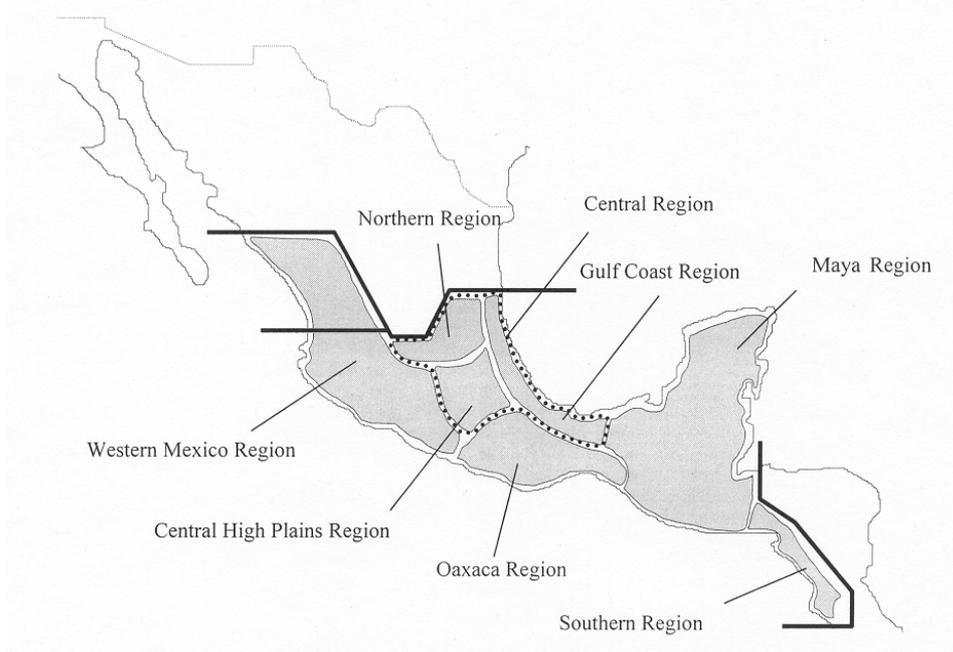
The areal patterns displayed in Figure 3 are certainly no coincidence. They closely parallel traditional archaeological sub-divisions of Mesoamerica, which are displayed in Figure 4. Among the seven regions that are distinguished in Figure 4, three can reasonably be grouped together from a historical perspective: the Northern Region, the Central High Plains Region, and the Gulf Coast Region can be regarded as representing a unit within the larger historical context of Mesoamerica. I will refer to this area as the “Central Region” in the following (cf. the dotted line in Figure 4).<sup>12</sup> The Central Region has been a centre of political power and the target of migration movements throughout the history of Mesoamerica. Consequently, it has been a focus of language contact. The archaeological divisions shown in Figure 4 reflect settlement and migration patterns and can be used as an approximate indicator of regional coexistence. The match

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<sup>11</sup> Note that some grammatical descriptions of Chiapas Zoque describe that language as GN (e.g. Harrison et al. 1981), but during my own field work in 2002 I got the impressions that NG has by now become prevalent.

<sup>12</sup> The Central Region corresponds approximately to the core of the Aztec empire at the end of the XVth century. From a linguistic point of view, it is characterized by widespread devoicing of final sonorants and prefixal reflexivization strategies, among other features.

between Figure 3 and Figure 4 is a further indication that the regional clustering of branching indices is due to language contact.



**Figure 4.** Archaeological sub-divisions of Mesoamerica

The correspondences between the areal distribution of branching indices (Figure 3) and the archaeological sub-divisions shown in Figure 4 are summarized in Table 5. This table also indicates the areal distribution of language families relative to the regions of Mesoamerica and typical word order patterns. Note that Mixe-Zoquean languages cannot clearly be assigned to any particular region. They are located in the peripheral parts of the Central Region, the Oaxaca Region, and the Maya Region. This is reflected in their branching indices (.84, on an average), which range between those of the Central Region and Maya Region (1) on the one hand, and those of the Oaxaca Region (.47) on the other.

Regions of MA	$I_b$	Typical word order patterns	Language families/phyla
Western Mexico Region	1	various	Uto-Aztecan, Otomí enclaves, Tarascan
Central Region	1	V-O, Ad-NP, N-G, POSS-N', DEM-N', NUM-N'	Uto-Aztecan (Nahuatl), Maya (Huastec), Totonac-Tepehua, Otomanguean (Otomí etc.), Mixe-Zoquean (Sierra Popoluca)
Oaxaca Region	0.47	V-O, Ad-NP, N-G, N'-POSS, N'-DEM, NUM-N'	Eastern Otomanguean
Maya Region	1	V-O, Ad-NP, N-G, POSS-N', DEM-N', NUM-N'	Maya, Nahuatl enclaves
Southern Region	1	V-O, Ad-NP, N-G, POSS-N', DEM-N', NUM-N'	Tlapanec-Mangue (Otomanguean), Nahuatl enclaves

**Table 5.** Regions, branching indices, constructions, language families

### 3.4 Phylogenetic diversity and structural homogeneity

The rightmost column of Table 5 shows that the Central Region is distinguished from the other regions of Mesoamerica by a particularly high degree of “phylogenetic diversity” (cf. Nettle 1999 for this term). The ratio of language families to languages is remarkably high in this area. While each of the other regions is associated with a preponderance of languages from a specific family, in the relatively small Central Region<sup>13</sup> languages from at least five different families are spoken: Uto-Aztecan (Nahuatl), Otomanguean (Otomí, Southern Pame, Matlazinca, Mazahua), Mixe-Zoquean (Popoluca), Totonac-Tepehua, and Mayan (Huastec).

Considering this high degree of phylogenetic diversity, it is remarkable that the languages of the Central Region are structurally so similar, and so homogeneous. This homogeneity is even more remarkable in view of the fact that at least two of the families involved—Uto-Aztecan and Mixe-Zoquean—were formerly heavily left-branching and have adopted right-branching structure only as a consequence of language contact. Campbell et al. (1986: 555) notice that “Proto-Uto-Aztecan is sufficiently well-known to make clear when Nahuatl has changed to

<sup>13</sup> The Central Region corresponds to approximately a fifth part of the Balkans in size.

become more MA [Mesoamerican, VG]”. Langacker (1977) demonstrates that Proto-Uto-Aztecan was OV, GN, and postpositional. In Popoluca, right-branching structure is also probably a consequence of language contact. Proto-Mixe-Zoque was predominantly left-branching, and verb-initial word order, genitive constructions of the type NG, and prepositions are relatively recent developments in Mixe-Zoquean (for a comparative survey of Mixe-Zoquean, cf. Wichmann 1995).

As far as the other languages of the Central Region are concerned, no safe information is available about their former branching tendencies. All Otomanguean languages spoken in the Central Region belong to the Otopamean branch of Otomanguean. It is thus difficult to decide whether their right-branching structure is to be attributed to a common ancestor language (Proto-Otopamean), or whether it is an areal feature of the Central Region. In the case of Totonac-Tepehua, we cannot say anything about its former branching tendency because we lack comparative evidence. Huastec Maya has inherited its right-branching structure from Proto-Mayan.

The central question that arises when we consider the facts presented in this section is: Why have Mesoamerican languages, in particular the languages of the Central Region, become structurally so homogeneous?

The answer to this question must obviously be sought in the realm of language contact. We should not, however, expect the sociolinguistic aspects of language contact to be particularly revealing in this context. Political dominance, prestige, and social networks cannot tell us anything about long-term areal convergence, since they are subject to change in the course of time. Mesoamerica has witnessed the hegemony of several different cultures and languages in the last two thousand years. I will therefore assume that the principles underlying structural homogeneity in the languages of Mesoamerica are of a different kind: they are functional, not social, in nature. By functional aspects of language use I refer to those factors that relate to the efficiency of language as a medium of communication. Unlike social factors, they do not change with time; they are a constant of language change.<sup>14</sup>

The explanation put forward in the next section is based on Hawkins’ (1994, 2004) theory of Early Immediate Constituents (EIC) or, more generally, on his Performance-Grammar Correspondence Hypothesis. Hawkins (1994) has demonstrated that consistency in branching direction

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<sup>14</sup> For the role of functional factors in convergence, cf. Bisang (1998, 2001) and Croft (1999, 2000), among others.

improves the processing efficiency of languages, and that consequently, languages tend to be structurally homogeneous in the sense outlined above. I would like to argue that this tendency can explain why contact between structurally diverse languages should lead to homogeneity rather than heterogeneity, and why the relevant processes of change should happen relatively quickly, in comparison with purely language-internal developments. The argument starts with a brief survey of Hawkins' (1994) theory of Early Immediate Constituents. Drawing on Kirby (1999), it is demonstrated how Hawkins' theory can be implemented into an evolutionary model of language change: language change is conceived of as a product of the interaction between VARIATION and SELECTION. In linguistic areas, so the argument goes, this adaptive process is particularly productive because language contact multiplies language-internal structural variation. Structural variation, in turn, offers speakers a choice and allows for the selection of those structures that optimize Early Immediate Constituent recognition best.

#### **4. Towards an explanation**

##### **4.1 Early Immediate Constituents**

Hawkins (1994, 2004) has demonstrated that, in grammar and in performance, languages and speakers tend to arrange constituents in such a way that the human parser is able to recognize the higher-level constituent structure as early as possible (cf. also Wasow 1997, 2002). His theory correctly predicts both the cross-linguistic correlations found by Dryer (1992) and performance-driven rearrangement rules in single languages such as heavy-NP shift in English. As pointed out in Section 2, one of the most important corollaries of Hawkins' theory is the fact that consistency in branching direction yields Early Immediate Constituent recognition optimal. Structurally homogeneous languages are 'user-friendly' insofar as they facilitate online-processing.

Hawkins' (1994) theory is based on the assumption that the linear linguistic input is immediately transformed into hierarchical structures by the human parser. Each segment of speech is automatically analyzed with regard to the information it contains about the higher-level constituent structure. In this process, specific segments uniquely identify their "mother nodes". For example, the occurrence of a verb gives the parser the

instruction to construct a VP (over V); a determiner uniquely identifies its mother node as an NP; prepositions identify their mother nodes as PPs. Hawkins refers to these prominent segments as “mother node constructing categories” (MNCC, cf. Hawkins 1994: 62). Any segment that does not uniquely identify its mother node is, according to Hawkins, immediately attached to a higher projection that is available in the syntactic environment. Thus, all segments of speech will be specified with regard to their position in the hierarchical sentence structure as quickly as possible. Those segments that cannot be assigned a structural position are stored in a “look-ahead buffer” and will be attached as soon as a structural position becomes available.

In Hawkins (2004), the idea of ‘parsing efficiency’—a principle which benefits the hearer—has been generalized to ‘processing efficiency,’ i.e. a concept which applies not only to language comprehension but also to languages production. In other words, Hawkins assumes that the principles of efficiency governing language production are identical to those governing language comprehension. Even though this is certainly plausible, it is probably not beyond doubt. Given that a purely hearer-based explanation has been shown to be feasible by Kirby (1999), I will focus on comprehension/parsing in the following, but nothing really hinges on this.

## 4.2 Early Immediate Constituent recognition and language change

In order to illustrate how language change has actually optimized Early Immediate Constituent recognition in Mesoamerica, let us briefly consider an example: the introduction of prepositions into the grammar of Nahuatl. Comparative evidence clearly shows that Proto-Aztecan was postpositional (cf. Langacker 1977). In the XVth century postpositions were still very common in Nahuatl and represented the canonical choice as opposed to relational nouns, which gradually started to replace them. Example (5) illustrates the use of the postposition *nawak* ‘close to’<sup>15</sup> in the Madrid Codex:

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<sup>15</sup> Some Nahuatl specialists may prefer analyzing *nawak* as a suffix since it is closely attached to the noun in phonological terms. Semantically, however, it takes scope over the DP. The most accurate term would probably be ‘phrasal suffix’.

## (5) Classical Nahuatl

*kinnetšikoa in ikal nawak*

kin-netšikoa	in	i-kal	nawak
3PL.OBJ-gather	DET	3POSS-house	close.to

‘He gathers them close to his house.’ Sullivan (1992: 149)

Example (5) has the hierarchical structure [<sub>VP</sub> *kinnetšikoa* [<sub>ADP</sub> [<sub>NP</sub> *in ikal*] *nawak*]]. The Phrasal Combination Domain (or ‘Constituent Recognition Domain,’ in terms of Hawkins 1994) extends over the whole VP. Considering *ikal nawak* as two words, example (5) has an IC-to-word ratio of .5 (=2/4; four words must be processed in order to recognize two immediate constituents). The PP immediately dominated by VP cannot be constructed until the postposition *nawak* has been processed. Meanwhile, the parser is exposed to a garden-path structure, since *ikal* could also be considered an immediate constituent of VP, in which case it would be interpreted as a direct object ([<sub>VP</sub> *kinnetšikoa* [<sub>NP</sub> *ikal*]], ‘he gathered his house[s]’).

After the conquest, Nahuatl gradually lost its postpositions. Forms like *nawak* were reanalyzed as relational nouns and increasingly used as (head-marking) prepositions in combination with person markers (e.g. *i-nawak i-kal*, lit. ‘its-closeness his-house’; this construction mirrors common genitive NPs). In most contemporary varieties of Nahuatl (e.g. Tetelcingo Nahuatl, cf. Tuggy 1979), the form *nawak* has been lost, and the semantically more general form *-pa* (formerly also a postposition) is used. Moreover, the third person form *i-pa* has been generalized to the first and second person, so *ipa* is now used as an invariant preposition (cf. Tuggy 1979: 62). (6) is the (contemporary) Tetelcingo Nahuatl translation of (5):

(6) *kinsentlōlia ipa ika*

kin-sentlōlia	ipa	i-kal
3PL.OBJ-gather	PREP	3POSS-house

‘He gathers them at his house.’

From the perspective of processing ease, (6) is more efficient than (5). The VP [<sub>VP</sub> *kinsentlōlia* [<sub>ADP</sub> *ipa* [<sub>NP</sub> *ikal*]]] allows for the recognition of all immediate constituents after the preposition *ipa* has been processed. The verb form *kinsentlōlia* constructs the VP, and *ipa* constructs the AdP/PP, which immediately attaches to the VP. (6) thus has an (optimal) IC-to-word ratio of 1 (=2/2; two words for two immediate constituents). The innovative

construction illustrated in (6) is therefore more ‘user-friendly’ than the conservative one illustrated in (5).

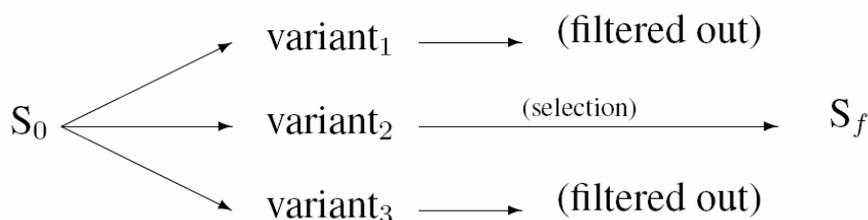
Developments such as the introduction of prepositions into the grammar of Nahuatl have occurred pervasively in the history of Mesoamerican languages, and are still occurring. For example, Zoquean languages have witnessed a partial loss of postpositions at the expense of prepositions that have been borrowed from Spanish. At the same time, some of the Zoquean languages have shifted from GN to NG word order. Both developments improve Early Immediate Constituent recognition, since probably all Mixe-Zoquean languages are VO by now. Likewise, Tarascan has enlarged its inventory of prepositions, for the most part by borrowing from Spanish (for instance, *para*).

### 4.3 Variation and Selection in Natural Language

Hawkins’ (1994, 2004) theory offers a natural explanation for why languages should tend to have a homogeneous surface syntax. It does not, however, fully account for the actual processes that lead to structural homogeneity from a diachronic perspective, since there is wide consensus that language is not in general actively shaped by languages users (and Early Immediate Constituent recognition is probably not a principle that speakers are even aware of). In order to explain how and why Mesoamerican languages have developed a homogeneous constituent order, it is thus necessary to consider the specific processes of change at the micro-level as well.

Kirby (1999) has demonstrated how Hawkins’ theory of Early Immediate Constituents can be implemented into a model of language change by adopting an evolutionary approach. His analysis is based on Hawkins’ (1994) hearer-based account of processing efficiency. The main question that needs to be addressed is, as Kirby puts it, “the puzzle of fit”, i.e. the question of how a *parsing* preference for certain structures can result in a modification of the grammar. Evolutionary models of language change such as the one advocated by Kirby rely on the assumption that language change is “based on the interplay between variation and selection” (Keller 1994: 144). This means that language change occurs in two steps: first, variation is generated, and second, specific variants are selected at the expense of others. This process is usually regarded as ADAPTIVE, i.e. as responding to specific environmental circumstances, and as improving the interaction of an organism with these circumstances. This

model of language change is illustrated in Figure 5. The initial state  $S_0$  represents a certain ‘source grammar’. As a result of innovation, (lexical or grammatical) variants are introduced into the language. In a next step, some of these variants are filtered out, while others are selected. This leads to the final state  $S_f$ . The process is cyclic, so that  $S_f$  is at the same time  $S_0$  of a successive adaptive process.



**Figure 5.** Variation and selection in language change

Kirby assumes that structures with optimal EIC metrics are preferentially accepted as “trigger experiences” in language acquisition, and that “the probability of a particular utterance being used for acquisition will be proportional in some way to its EIC metric” (Kirby 1999: 36f.). This is designed as a process of (functional) selection. The learner filters the raw linguistic input and separates out dysfunctional variants. One of the examples provided by Kirby is the selection of prepositions at the expense of postpositions in VO languages. This example is compatible with the development of Nahuatl from a postpositional language to a prepositional language outlined above:

First, imagine a language with basic VO order and postpositions. According to Hawkins, such a language would suffer from a suboptimal EIC metric in structures such as  $VP[V PP[NP P]]$ , since the CRD [Constituent Recognition Domain] for the verb phrase stretches across the noun phrase. Now, if a minor variant – prepositions – were introduced into that language, perhaps through language contact, then we would expect it to be preferentially selected from the arena of use by hearers because of its improved EIC metric. (Kirby 1999: 45)

Kirby’s model focuses on how linguistic variants are (functionally) selected in language acquisition. But then, selection requires the existence of at least two competing variants, i.e. two linguistic forms that may be used interchangeably to designate one and the same concept. In other words: *selection presupposes variation*. In order to fully account for the adaptive “interplay between variation and selection” (Keller 1994: 144), we must consequently also address the question of how variation arises. Kirby gives

us a first clue as to possible sources of variation. In his example, he conjectures that in his imaginary language, prepositions were introduced “through language contact”. When considering the languages of Mesoamerica, this is indeed a likely scenario: language contact led to the use of novel structures in the languages involved and gave rise to the type of structural variation that is necessary for selection to work. In other words: language contact acted as a source and amplifier of structural variation, thus feeding the evolutionary process. Consequently, those structures which optimize Early Immediate Constituent recognition best could be selected via functional selection.

Note that this simplified model of ‘EIC optimization’ will certainly not be accepted by all “evolutionary linguists”. Not all linguists subscribing to an evolutionary model—for instance, W. Croft—accept the role of functional factors in selection as assumed by Kirby (1999) and argue that the process of selection is primarily governed by social factors (see also Haspelmath 1999, 2000 for discussion). However, my basic claim that language contact should lead to structural homogeneity is not really affected by this controversy. Croft (1999, 2000) assumes that functional factors of language use are operative in the production of novel variants, that is, in the process of innovation. If innovations are constrained by functional factors, there should be a preponderance of functional variants vis-à-vis dysfunctional variants in the “lingueme pool” of a language (i.e. the pool of linguistic entities such as phonemes, morphemes, rules, etc.). If selection is indifferent to the functionality of a linguistic feature, there is simply an arithmetic probability that more functional variants will be selected. As Croft himself puts it:

If functional constraints operate to determine the frequency of innovations, and the novel variants undergo social selection, then the end result is going to be a preponderance of optimal variants in the long run. (Croft 1999: 207)

## 5. Conclusions

The present study started from the empirical observation that Mesoamerican languages are structurally very similar. Adopting a standard representation of constituent structure in terms of X-bar theory, it was argued that Mesoamerican languages display a high degree of structural homogeneity insofar as they tend to be consistently right-branching. For

illustration, a metric indicating the branching tendency of a language was proposed (the ‘branching index’  $I_b$ ). This metric allows us to make numerical statements about the branching tendencies of languages, thus providing a means of comparison.

The tendency of Mesoamerican languages to show homogeneous surface structure has been explained in terms of Hawkins’ (1994, 2004) theory of Early Immediate Constituents. An evolutionary model of language change has been adopted in order to account for the instantiation of parsing principles in actual language (Kirby 1999). It has been argued that an evolutionary model along these lines can also explain why phylogenetic diversity has led to structural homogeneity in Mesoamerican languages: Language contact is a source of structural variation and feeds the evolutionary process based on variation and selection by offering speakers a choice.

## Appendix

### List of glosses

POSS	possessive pronoun or prefix
PSR	possessor
PSM	possessum
CL	clitic
DET	determiner
NUM	numeral
PRED	predicate
Ad	adposition (preposition or postposition)
GEN	genitive
PRO	pronoun
PL	plural
OBJ	object
P(REP)	preposition

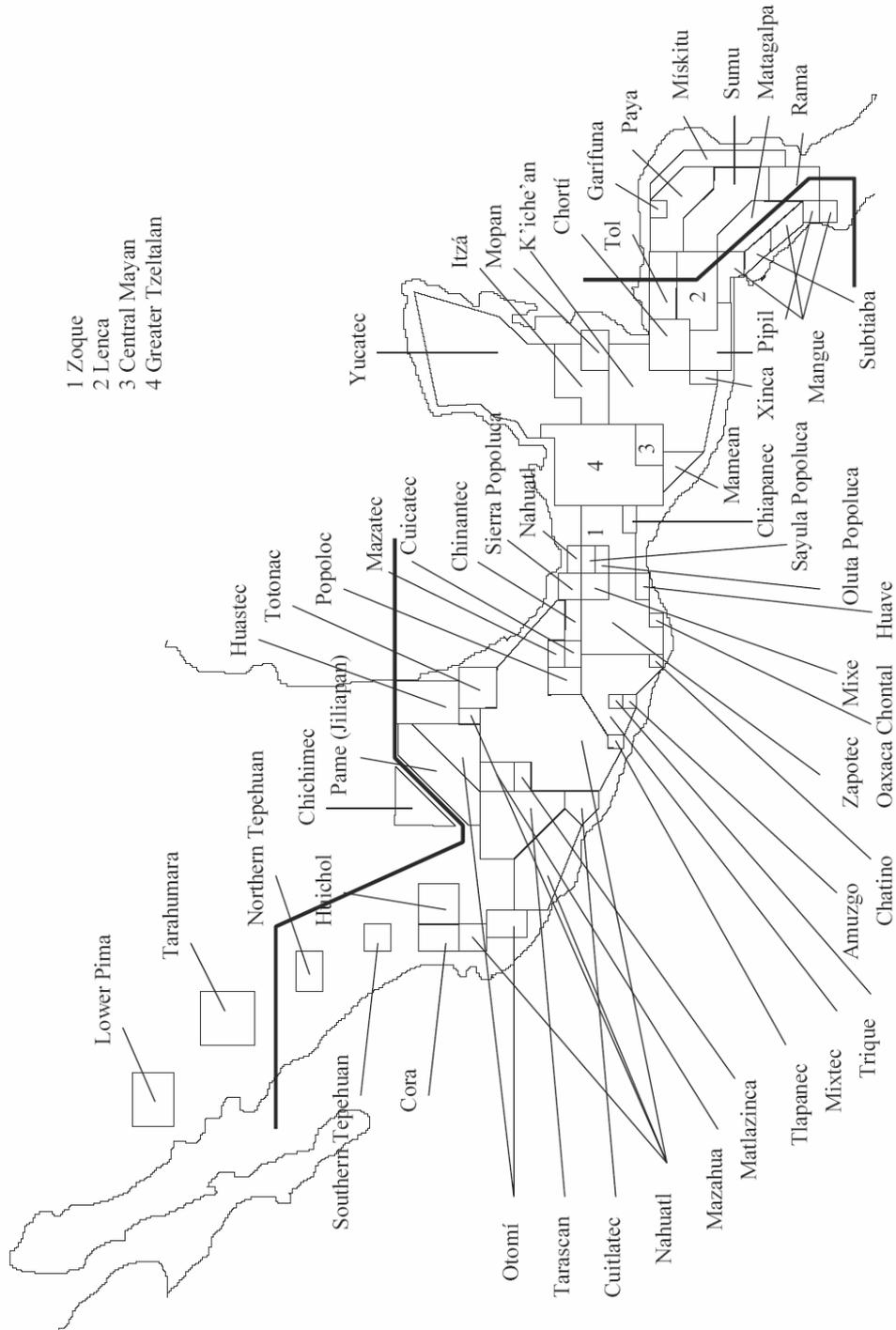


Figure 6. Sample of Mesoamerican languages used for the study

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