

## Biologically Based Universality of Merge in Wh-questions

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**Abstract:** This thesis deals with the merge operation in the four types of languages in the world, namely internal merge of displaced wh-words or wh-phrases in Single Filled Spec Languages, Multiply Filled Spec Languages, and Non-multiply Filled Spec Languages, and external merge of in situ wh-words and wh-phrases in Null Spec Languages. The universality of merge in the wh-questions proves that merge is a biologically based operation.

**Keywords:** Merge, universality, wh-questions, biolinguistics.

### INTRODUCTION

Biolinguistics regards the study of language as part of the human organ. It, in its strong sense, refers to "attempts to provide explicit answers to questions that necessarily require the combination of linguistic insights and insights from related disciplines (evolutionary biology, genetics, neurology, psychology, etc.) [1]. Biolinguistics focuses on the research on the relationship between human biology and the features of language faculty. As a newly developed and lively discussed research field, it deals with the origin of language, the properties of language in the animal kingdom as well as the biological basis of the human language capacities. Language should and can be studied as an organ of the mind/brain. The study of language faculty is actually a branch of biology. The central goal of biolinguistics is to seek answers for the following five questions [1]:

- (1) What is knowledge of language?
- (2) How is that knowledge acquired?
- (3) How is that knowledge put to use?
- (4) How is that knowledge implemented in the brain?
- (5) How did that knowledge emerge in the species?

As Grohmann [2] points out, the first question is Humbolt's question about the role of universal grammar and the faculty of language; the second question is Plato's question about language acquisition, that is to say, why a person's experience is so little but his knowledge is so much; the third question is Descartes' question about innateness of language; the fourth question is Broca's question about linguistic comprehension and the relationship of the brain/mind and language; the last question is Darwin's question about language evolution. In order to investigate on the faculty of language, three questions must also be answered [3]:

- (6) What is the nature of language?
- (7) How does it function?
- (8) How has it evolved?

The recent task of biolinguistics program is to capture the basic property of the faculty of language, as Chomsky [4] put, "There is substantial evidence that the human language capacity (LC) is a species-specific biological property, essentially unique to humans, invariant among human groups, and dissociated from other cognitive systems", which provides "the means for a language to yield a digitally infinite array of hierarchically structured expressions with systematic interpretations at interfaces with two other internal systems, the sensorimotor system for externalization and the conceptual system for inference, interpretation, planning, organization of action, and other elements of what is informally called 'thought'" [5]. This basic property of human language is an operation called merge as the human language phenotype yielded by the key evolutionary novelty. "Merge builds a discrete infinity of structured expressions that are interpretable in a definite way by the conceptual-intentional system of thought and action, and by a sensory-motor system for externalization-in short, thought with sound/sign" [6, 7] Merge, as the basic property of human

language, “gives rise to the language faculty: the ability for any person to acquire any human language” [7]. The ability to process human language hierarchy is human specific and the merge computation is the fundamental mechanism creating linguistic hierarchies [8]. “Merge may constitute an essential requisite supporting the uniqueness of human language and is proven to be localized in the ventral anterior portion of BA 44”, which, “with its strong neural connection to the posterior temporal cortex, provides a recent evolutionary neurobiological basis for the unique human faculty of language” [8].

Merge, as the basic property of language, is defined and exemplified in the following [9]:

“Merge is a (dyadic) operation that takes two syntactic objects, call them X and Y, and constructs from them a single new syntactic object, call it Z. X, Y can be building blocks that are drawn from the lexicon or previously constructed objects. Put simply, Merge (X, Y) just forms the set containing X and Y. neither X nor Y is modified in the course of the operation Merge” [9].

“If X and Y are merged there are only two logical possibilities. Either X and Y are distinct, and neither one is a term of the other, or else one of the two elements X or Y is a term of the other, where Z is term of W if it is a subset of the other or the subset of a term of the other. We call the former operation ‘External Merge’: two distinct objects are combined.

(i) Merge (read, that book) $\Rightarrow$ {read, that book}

If alternatively X is a term of Y or vice versa and X and Y are merged we call this ‘Internal Merge’. So for example, we can (internal) Merge which book and John read which book, yielding the following:

(ii) Merge (which book, John read which book) $\Rightarrow$  {which book, John read which book}

In this case, the result of merging X and Y contains two copies of Y. Following further operations, this structure will surface in (iii), under a constraint to externalize (‘pronounce’) only the structurally most prominent copy of which book:

(iii) (Guess) which book John read

This sentence may be understood as (iv):

(iv) (Guess) for which book x, John read the book x

Internal merge is a ubiquitous property of language, sometimes called displacement. Phrases are heard in one place but they are interpreted both there and somewhere else” [9].

“Human language syntax can be characterized via a single operation that takes exactly two (syntactic) elements a and b and puts them together to form the set {a, b}. We call this basic operation ‘merge’. The Strong Minimalist Thesis (SMT) holds that merge along with a general cognitive requirement for computationally minimal or efficient search suffices to account for much of human language syntax” [10]

However natural languages can be classified into four types according to the different behavior of wh-movement in wh-questions: Null Spec Languages, Single Filled Spec Languages, Multiply Filled Spec Languages, and Non-multiply Filled Spec Languages [11-19]. In the first type of languages, there is no overt wh-movement in the wh-questions [20-24], the wh-words or wh-phrases remain in situ [25-28]. In the second type of languages, there is overt wh-movement and only one wh-word or wh-phrase is moved into the sentence initial position of Spec CP. In the third type of languages, all the wh-words or wh-phrases are moved into the sentence initial position of Spec CP. In the fourth type of languages, only one wh-word or wh-phrase is moved into the sentence initial position of Spec CP, while other wh-words or wh-phrases are moved into the Spec IP position. Apparently displacement is not ubiquitous as there is no wh-movement in the wh-questions in the first type of languages. In fact in the first type of languages the wh-word or wh-phrase remains in situ. Then how to explain the different behavior of wh-movement in these four types of languages?

### **Internal Merge and External Merge of Wh-words in Wh-questions Chinese**

Chinese is the first type of language. In the Chinese wh-questions, the wh-words do not need to move to the front position of the sentence, instead all of the wh-words in this language remain in situ.

(9) Zhangsan du le na ben shu?

Zhangsan read Part. which cl. book

“Which book did Zhangsan read?”

(10) Shei du le zhe ben shu?  
Who read Part. this cl. book  
“Who read this book?”

(11) Shei du le na ben shu?  
Who read Part. which cl. book  
“Who read which book ?”

In (9), the wh-phrase in Chinese “na ben shu” (which book) is not raised to the front position of the sentence, and it is merged with the verb “du” into “du na ben shu”. This operation is called external merge. The merging process can be shown below:

(12) Merge (du, na ben shu) => { du, na ben shu }

In sentence (10), the wh-word “shei” is external merged with the verb phrase ‘du le zhe ben shu’, and this external merging operation can be illustrated as below:

(13) Merge (shei, du le zhe ben shu) => { shei, du le zhe ben shu }

In sentence (11), the wh-phrase in Chinese “na ben shu” is external merged with the verb “du” into “du na ben shu” and formed a VP “du le na ben shu”, and this VP is also external merged with the wh-word “shei” into “shei du le na ben shu”. The process of merge is demonstrated below:

(14) a. Merge (du, na ben shu) => { du, na ben shu }  
b. Merge (shei, du le na ben shu) => { shei, du le na ben shu }

In modern Chinese wh-questions an optional wh-question particle can be attached to the sentence final position without changing the meaning of the wh-question in (9-11) as it is shown below:

(15) Zhangsan du le na ben shu ne?  
Zhangsan read Part. which cl. book Part.  
“Which book did Zhangsan read?”

(16) Shei du le zhe ben shu ne?  
Who read Part. this cl. book Part.  
“Who read this book?”

(17) Shei du le na ben shu ne?  
Who read Part. which cl. book Part.  
“Who read which book ?”

The question particle “ne” should not be considered as a complementizer for it is not the head of the sentence. This wh-question particle instead is attached to the end of the sentence as a sentential affix [22, 17].

This reveals that in nominal Chinese wh-questions, wh-word or wh-phrase is external merged with other relevant constituents to form a new phrase or sentence. Different from wh-movement in other languages, displacement does not occur in Chinese wh-questions. However internal merge occurs in topic structures of the wh-questions in (9-11) when the nominal element or the wh-word or wh-phrase in the object position is topicalized and moved to the initial position of the sentence as shown below:

(18) na ben shu, Zhangsan du le?  
which cl. book Zhangsan read Part.  
?“Which book, Zhangsan read?”

(19) zhe ben shu, shei du le?  
this cl. book who read Part.  
?“This book, who read?”

(20) na ben shu, shei du le?  
which cl. book who read Part.

?“Which book, who read ?”

In the above examples, the fronted topic phrase is internal merged with respectively the sentence in (9-11), and yields the following sentences respectively:

(21) na ben shu, Zhangsan du le na ben shu?

(22) zhe ben shu, shei du le zhe ben shu?

(23) na ben shu, shei du le na ben shu?

The topicalized elements in the sentences of (21-23) are pronounced in the sentence initial position like the moved wh-word or wh-phrase in English and interpreted both there and in the object position of the sentence. In (21), merge “na ben shu” and “Zhangsan du le na ben shu” yields “na ben shu, Zhangsan du le na ben shu” with two copies of “na ben shu”. The last copy is not pronounced. Sentence (21) fully explains why (9) or (18) means something like “duiyu na ben shu x, Zhangsan du le na ben shu x” (“for which book x, Zhangsan read the book x”). The copy property of internal merge also occurs in (22), when “zhe ben shu” is merged with “shei du le zhe ben shu” which yields the sentence “zhe ben shu, shei du le zhe ben shu”. The first copy of the topic in the sentence initial position is pronounced while the last copy of “zhe ben shu” is not pronounced. The copy property of (22) exactly explains why (19) instead of (10) means something like “duiyu zhe ben shu x, na ge ren y du le zhe ben shu x” (“for this book x, which person y read the book x”). In (23) the topic “na ben shu” is merged with “shei du le na ben shu” and yields “na ben shu, shei du le na ben shu” with two copies of “na ben shu”. The first copy of “na ben shu” at the topic position of the sentence is pronounced while the second copy of “na ben shu” at the object position is silent. This copy property of internal merge explains why sentence (11) or (20) can be understood as “duiyu na ben shu x, na ge ren y du le zhe ben shu x” (“for which book x, which person y read the book x”). As it is shown in the above examples, internal merge in Chinese occur in topic structures, and the displaced elements are not restricted to wh-words or wh-phrase as it is the case in English language. As in example (22), the moved element is an ordinary NP instead of wh-word or wh-phrase.

Topicalization is different from wh-movement in that after the topicalized element the topic marker “ne” can be attached as illustrated in the sentences (24-26) respectively.

(24) na ben shu ne, Zhangsan du le?  
which cl. book Part. Zhangsan read Part.  
?“Which book, Zhangsan read?”

(25) zhe ben shu ne, shei du le?  
this cl. book Part. who read Part.  
?“This book, who read?”

(26) na ben shu ne, shei du le?  
which cl. book Part. who read Part.  
?“Which book, who read ?”

As it is illustrated in the above examples, in nominal wh-questions in Chinese, no wh-movement occurs in the derivation of the sentence. The wh-word or wh-phrase in Chinese wh-questions is external merged, but in topic structures the topicalized wh-word or wh-phrase is internal merged.

### English

In the Single Filled Spec Languages such as English, normally there is only one wh-word or wh-phrase which is raised to fill in the position of Spec CP. In (24), the wh-phrase “which book” is originally generated in the object position after the verb “read”, and as the head C in CP is strong in English, the spec CP position must be filled in order to check the strong [+wh] feature of the head C. Thus this strong [+wh] head feature of C attracts the [+wh] feature of the wh-phrase to move to the spec CP position and the formal features of the wh-phrase pied-pipe with the [+wh] feature of the wh-phrase. And when the wh-phrase is moved into spec CP, the strong [+wh] feature of the head C is checked and therefore the sentence is interpreted as a wh-question.

(27) Which book did John read?

According to the copy theory, there are two copies of which book in (27), one is in Spec CP and another in its original object position, as illustrated in (28). The first copy of the wh-phrase is pronounced and the last copy of the wh-

phrase in object position is not pronounced and then deleted. The copy property of internal merge fully accounts for the semantic interpretation of the wh-phrase: “for which book x, John read the book x”.

(28) Which book did John read which book?

The wh-phrase “which book” in (28) is internal merged with the yes-no question “did John read which book” into the wh-question “Which book did John read which book”. The merge operation is therefore demonstrated in (29) below:

(29) Merge (which book, did John read which book) => { which book, did John read which book }

In (30), the sentence shows that the wh-question in (27) can be embedded in a sentence.

(30) I wonder which book John read.

If we write out all the copies of the wh-phrase, (30) will be written as (31):

(31) I wonder which book John read which book.

The wh-phrase “which book” in (28) is internal merged with the sentence “John read which book” into the wh-question “which book John read which book”. The merge operation is therefore illustrated in (32):

(32) Merge (which book, John read which book) => { which book, John read which book }

The first copy of the wh-phrase is pronounced and the last copy of the wh-phrase in object position is not pronounced. The copy property of internal merge fully accounts for the meaning of the wh-phrase: “for which book x, John read the book x”.

In (33) there are two wh-elements in the sentence, the first wh-word is the subject “who” and the second wh-element is “which book” in the object position.

(33) Who reads which book?

In the wh-question in (33), the wh-phrase “which book” is external merged with the verb “reads” into a VP “reads which book”, while the wh-word “who” is internal merged with the sentence “who reads which book” into “who who reads which book” as it is illustrated in (34). The copy property of the wh-word can be pronounced in one place and explained in both places of the two copies. Thus (34) can mean “for which person x, which book y, x reads y”.

(34) Who who reads which book?

The first copy of “who” is pronounced, while the second copy of “who” is silent and erased. The merge operation is shown in (35):

(35) Merge (who, who reads which book) => { who, who reads which book }

As it is shown in the above example the IP “who reads which book” is merged with “who” and therefore it cannot be further merged with “which book” into “which book who reads which book” Therefore, (36) is ungrammatical.

(36) \*Which book does who read?

In English wh-questions, the displaced wh-word or wh-phrase is internal merged with IP, and the in situ wh-word or wh-phrase is external merged with a local element.

### **Bulgarian**

In the third type of languages of Multiply Filled Spec languages such as in Bulgarian, all the wh-words or wh-phrases must move to the sentence initial position of the sentence [29].

(37) koj kakvo kupuva

Who what bought  
“Who bought what?”

In (377) each of the wh-words “koj” and “kakvo” has two copies: one in the spec CP position and the other in its original generated position as shown in (38):

(38) koj kakvo koj kupuva kakvo  
Who what who bought what

The internal merge operation of the sentence, we may hypothesize, may take a two step process: first the wh-word “koj” is internal merged with an IP “koj kupuva kakvo” into “koj, koj kupuva kakvo”. The first copy of “koj” is pronounced, while the second copy is not pronounced and thus deleted. The merging operation is shown in (39):

(39) Merge (koj, koj kupuva kakvo) => {koj, koj kupuva kakvo}

After the second copy of “koj” is deleted, the second wh-word “kakvo” is merged with a CP “koj, kupuva kakvo” into “koj kakvo, kupuva kakvo”. The first copy of “kakvo” is pronounced and the second copy of “kakvo” is silent and thus deleted. The merge operation is shown in (40):

(40) Merge (kakvo, koj, koj kupuva kakvo) => {koj kakvo, koj kupuva kakvo}

The copy property of the wh-words in (38) can account for the semantically interpretation of the sentence as “for which person x, which thing y, x bought y”.

In (41), three wh-words are all moved to the front of the sentence [30].

(41) a. koj kogo kak e tselunal  
Who whom how Aux kissed  
“Who kissed whom how?”  
b. koj kak kogo e tselunal  
who how whom Aux kissed  
“Who kissed whom how?”

Each of the wh-words in sentence (41) has one copy of wh-word in the sentence initial position, and the other copy at its original generated position as shown in (42) below:

(42) a. koj kogo kak koj e tselunal kogo kak  
Who whom how who Aux kissed whom how  
b. koj kak kogo koj e tselunal kogo kak  
Who how whom who Aux kissed whom how

The internal merge in (42a) undergoes a three step process. First the wh-word koj is merged with koj e tselunal kogo kak into koj koj e tselunal kogo kak as in (43). Later the wh-word kogo is merged with koj koj e tselunal kogo kak into koj kogo koj e tselunal kogo kak as in (44). Finally the wh-word kak is merged with koj kogo koj e tselunal kogo kak into koj kogo kak koj e tselunal kogo kak as in (45). In (42b), the wh-word kak in the left periphery moves across another wh-word kogo, and wh-island is not a problem in Bulgarian.

(43) Merge (koj, koj e tselunal kogo kak) => { koj, koj e tselunal kogo kak }

(44) Merge (kogo, koj, koj e tselunal kogo kak) => { koj kogo, koj e tselunal kogo kak }

(45) Merge (kak, koj kogo, koj e tselunal kogo kak) => { koj kogo kak, koj e tselunal kogo kak }

In (42) each of the internal merged wh-words in the left periphery position is pronounced, while the second copy of koj in the specifier position of VP, the second copy in complement position of VP and the second copy of kak in the adjunct position of VP is unpronounced and therefore deleted. Thus (41) is derived.

To sum up, in Bulgarian language, the displaced wh-word is internal merged with an IP or CP.

### Czech

In the fourth type of Non Multiply Filled Spec languages such as in Czech, there is only one wh-word raised to the spec CP position and all the other wh-words are moved inside the IP as shown in (46) [29]:

- (46) a. kdo ho kde videl je nejasne  
who he where see is difficult-to-understand  
“I do not understand who saw him where?”  
b. \*kdo kde ho videl je nejasne  
who where he see is difficult-to-understand

The sentences in (46) shows that in Czech there is only one wh-word which is moved to the left periphery of CP. After the raised wh-word no other wh-word is allowed to move into the sentence initial position in the left periphery. Another constituent is following the moved wh-word. And if another wh-word follows the moved wh-word into the Spec CP position in the sentence, it is ungrammatical as shown in (46b). The two copies of each of the wh-words are listed in (47).

- (47) kdo kdo ho kde videl kde je nejasne  
who who he where see where is difficult-to-understand

The internal merge of kdo and kde is respectively shown below in (48) and (49):

- (48) Merge (kdo, kdo ho kde videl kde je nejasne) => {kdo, kdo ho kde videl kde je nejasme}

- (49) Merge (kde, videl kde je nejasme) => {kde, vedel kde je nejasme}

The first copy of kdo at the spec CP position in the left periphery of CP is pronounced, and the second copy of kdo is not pronounced and then deleted. The first copy of kde at the spec IP position in the left periphery position of IP is pronounced while the second copy of kde in the adjunct position of VP is silent and thus deleted.

To summarize, in Czech, only one wh-word is moved to the spec CP position in the left periphery of CP and all other wh-words are moved inside the IP. The displacement of the internal merge of wh-words is different from the third type of languages such as Bulgarian in which all wh-words are moved to the sentence initial spec CP position.

### Biological Based Universality of Merge

As it is shown in the literature, merge is classified into two kinds: external merge and internal merge. External merge of X and Y into simply X and Y is shown in the following as in (50):

- (47) Merge (X, Y) => {X, Y}

Merge an adjective with a noun into an adjective and a noun and form a noun phrase. This computation can be shown as in (51):

- (51) a. Merge (Adj, N) => {Adj, N}  
b. Merge (interesting, book) => {interesting, book}

Merge a determiner with a noun or noun phrase into a determiner and a noun and form a determiner phrase. This operation is illustrated as in (52):

- (52) a. Merge (D, N/NP) => {D, N/NP}  
b. Merge (a/an, book/interesting book) => {a/an, book/interesting book}

Merge a verb with a determiner phrase into a verb and a determiner phrase and form a verb phrase. The operation of merge is demonstrated as in (53):

- (53) a. Merge (V, DP) => {V, DP}  
b. Merge (read, an interesting book) => {read, an interesting book}

Merge an infinitival marker or an auxiliary I and a verb phrase into an infinitival marker or an auxiliary I and a verb phrase and form an inflectional phrase IP. This process can be exemplified as in the following:

- (54) a. Merge (I, VP) => {I, VP}  
b. Merge (to/will, read an interesting book) => { to/will, read an interesting book }

Merge a head complementizer C with an IP into a complementizer and an IP and thus form a complementizer phrase CP. This derivation can be illustrated as in (55):

- (55) a. Merge (C, IP) => {C, IP}  
b. Merge (that, you will read an interesting book) => {that, you will read an interesting book}

Merge a verb with a CP into a verb and a CP and thus form a VP. This operation can be shown as in (56):

- (56) a. Merge (V, CP) => {V, CP}  
b. Merge (know, that you will read an interesting book) => {know, that you will read an interesting book}

This VP can also merge with an inflectional marker or an auxiliary I into an IP, and IP merged with C can form a CP, and the CP merged with another verb can form a VP. This recursive nature of merge guarantees the universality of the operation and the infiniteness of the hierarchical structure.

Notice that if we ask a question about “an interesting book”, the interrogative sentence should be written as in (57):

- (57) What will you read?

The displacement of “what” is merged with the IP “will you read what” into “what, will you read what” as is shown in (58):

- (58) What will you read what?

The internal merging process of the displaced constituent is illustrated as in (59):

- (59) Merge (what, will you read) => {what, will you read}

Another interrogative wh-question can be formed as shown in the following:

- (60) Who knows that you will read an interesting book?

If the object in the embedded question is also questioned, then the sentence can be written as in (61). The first wh-word is moved and internal merged, while the second wh-word remains in situ and external merged with the verb “read”.

- (61) Who knows that you will read what?

Notice that in (61) the wh-word “what” cannot be moved across the subject wh-word in the main clause. (62) is not acceptable.

- (62) \*What does who know that you read?

From the above examples we can arrive at the conclusion that merge is the basic property of language. The basic property of language gives rise to the faculty of language.

There is biological evidence to show that merge is localized in Brodmann Area 44 [8]. BA 44, known as pars opercularis (of the inferior frontal gyrus), as a part of the front cortex in the human brain, a subdivision of the cytoarchitecturally defined frontal region of cerebral cortex, is located at anterior to premotor cortex and on the lateral surface, inferior to BA 9. Thus, it is bounded caudally by the inferior precentral sulcus and rostrally by the anterior ascending limb of lateral sulcus. It surrounds the diagonal sulcus. In the depth of the lateral sulcus it borders on the insula. Cytoarchitectonically it is bounded caudally and dorsally by the agranular frontal area 6, dorsally by the granular frontal area 9 and rostrally by the triangular area 45 [31]. BA 44 comprises Broca's area a region involved in semantic tasks.



The biological basis of merge in BA 44 can account for the universality of the merge operation, either internal merge or external merge.

## CONCLUSION

Although there have been diverse opinions on what language is and how language may be studied, most linguists unanimously agree that the human capacity to acquire and use language is a part of human biology, and that it can be studied from a biological perspective [32-36]. Chomsky's recent study of the mind mainly foci on the minimalist approach to syntactic representations as language is beautiful and perfect just as nature is beautiful and perfect. The minimalist efforts for a principled explanation for the nature of language and language faculty are based on an understanding that human language is a highly non-redundant species-specific system. The mechanism of external merge of lexical items to combine into argument structures and of internal merge of moved/displaced constituents to form structures within a larger unit exhibits human capacity to combine words into infinite strings of constituents. The recursive nature of merge, as we have shown in section 3, has much to do with the principles underlying mental recursion. This research matches with the objective of biolinguistics, which is to discover as much as possible about the principles underlying mental recursion.

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