

In Search of the Origins of Merge, Labeling (, and the Lexicon) in the Evolution of the Faculty of Language: A Neo-Lennebergian Approach

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1. Introduction

Concerning the nature of the faculty of language (FL), Hornstein (2009: 4) remarks that:

[I]t is of recent evolutionary vintage. A common assumption is that language arose in humans in roughly the last 50,000—100,000 years. This is very rapid in evolutionary terms. I suggest the following picture: **FL is the product of (at most) one (or two) evolutionary innovations which, when combined with cognitive resources available before the changes that led to language, delivers FL.**¹ (the emphasis by K.H.)

(1) Darwin's Problem/Wallace's Problem:

How did the faculty of language (FL) emerge in the species?

(cf. Boeckx 2009, Hornstein 2009, Chomsky 2010, Bickerton 2014, Berwick & Chomsky 2016)

(2) Chomsky's Strong Minimalist Thesis (SMT):

SMT: Merge + Interfaces = Language

(Chomsky 2010: 52)

To be more specific and correct:

(3) Decomposition of SMT:

Merge + "atomic conceptual elements" (of the lexicon) + labeling + (mappings to) the interfaces with the C-I system and the SM system = (the capacity for) human language (= FL)

Chomsky (2005: 4) expresses the following view (see also Bickerton 2007 for virtually the same view):

"... at least two basic problems arise when we consider the origins of the faculty of language and its role in the sudden emergence of the human intellectual capacity: **first, the core semantics of minimal meaning-bearing elements, including the simplest of them; and second, the principles that allow infinite combinations of symbols,**

¹ Berwick & Chomsky (2016) speculate that the faculty of language emerged between 200,000 and 60,000 years ago in light of recent archaeological/paleoanthropological evidence. Ike-uchi (2016) makes a more specific claim that the faculty of language emerged as early as 130,000 to 150,000 years ago on the basis of recent archaeological/paleoanthropological and genetic evidence.

hierarchically organized, which provide the means for use of language in its many aspects.” (the emphasis by K.H.)

Also, Chomsky et al. (to appear: 19) clearly state that “M[erge] and the inventory of lexical atoms it operates over must be part of UG and as such represent evolutionary innovations specific to the human linguistic mind.”

(4) The Biolinguistic Questions on the Evolution of the FL to Be Addressed:

- (i) What is the origin of Merge?
- (ii) What is the origin of the requirement of labeling?
- (iii) What is the origin of the “atomic conceptual elements” of the lexicon?

*In terms of **evolutionary adequacy** (Fujita 2009) or **evolvability** (Bolhuis et al. 2014, Berwick & Chomsky 2016), it would be more interesting if all the three in (i)-(iii) are somehow systematically interrelated in the evolution of FL. The main purpose of this paper is to suggest a possibility that this might be indeed the case.

2. On the Origin of Merge

2.1. Previous Proposals

2.1.1. No Precursor to Merge (Chomsky 2004, 2005, 2011 *inter alia*.)

Chomsky has been consistently holding the view that Merge emerged as a result of slight re-wiring of the brain presumably due to some small genetic mutation without any obvious precursor (Chomsky 2004, 2005, 2011 *inter alia*.) See Berwick & Chomsky 2016 for a concrete proposal to the effect that the emergence of the whole neural fiber “ring” connecting the dorsal and ventral pathways in the neocortex is responsible for the rise of Merge). See also Hickok & Poeppel (2007) and Friederici (2017a,b) *inter alia*. for more on the dorsal and ventral pathways.

← Fujita’s (2012, 2014) criticism: To the extent that a biological trait, such as the faculty of language, is a descent with modification, Merge should have its evolutionary precursor, though.

I agree with Fujita’s (ibid.) point and at the same time I agree in part with Chomsky (ibid.) in thinking that there must have been some genetic mutation for giving rise to Merge.

2.1.2. Motor Control Origin of Merge (Fujita 2014, 2016 *inter alia*.)

Fujita (2014, 2016 *inter alia*.) put forth the motor control origin hypothesis of Merge on the basis of Greenfield’s (1991, 1998) theory of Action Grammar (Action Merge in his term).

- (8) a. Pairing Strategy: Pa, Pb => (Pb (Pa))
- b. Pot Strategy: Pa, Pb, Pc => Pa, (Pc (Pb)) => (Pc (Pb (Pa)))

c. Subassembly Strategy: $P_a, P_b, P_c \Rightarrow (P_b (P_a)), P_c \Rightarrow (P_c (P_b (P_a)))$

Furthermore, Fujita (2014, 2016) notes that chimpanzees' sequential action for cracking nuts with a stone anvil and a stone hammer can be described by means of Merge as follows:

- (9) a. Merge (NUT, ANVIL) \Rightarrow {NUT, ANVIL}
b. Merge (HAMMER, {NUT, ANVIL})
 \Rightarrow { HAMMER, {NUT, ANVIL}}

2.1.3. Possession Origin of Merge (Ike-uchi 2010)

Ike-uchi (2010), on the other hand, put forth the hypothesis of the possession origin of Merge, which claims that the precursor to Merge is the action of physical possession and management of valuables and its underlying concept of possession and mental manipulation. In this hypothesis, it is assumed that valuables were grouped into sets with labels with a hierarchical structure. Observe (10).

- (10) a. $\{\{v1, v2, v3\} = A's\}$
b. $\{\{\{\{v1, v2, v3\} = A's\}, \{\{v4\} = W's\}\} = A's\}$
c. $\{\{\{\{\{v1, v2, v3\} = A's\}, \{\{v4\} = W's\}\} = A's\}, \{\{v5, v6\} = B's\}\} = A's\}$

2.2. Some Considerations on the Motor Control Origin Hypothesis and the Possession Origin Hypothesis

2.3. New Proposal: A Neo-Lennebergian Approach

2.3.1. Lenneberg (1967)

Lenneberg (1967: 374) makes the following conjecture on the relation between categorization and the cognitive function underlying language in the context of evolution of language.

(11) Lenneberg's Conjecture on the Evolution of the Capacity for Language

"The cognitive function underlying language consists of an adaptation of a ubiquitous process (among vertebrates) of categorization and extraction of similarities. The perception and production of language may be reduced on all levels to categorization processes, including the subsuming of narrow categories under more comprehensive ones and the subdivision of comprehensive categories into more specific ones. The extraction of similarities does not only operate upon physical stimuli but also upon categories of underlying structural schemata." (p.374) (the emphasis by K.H.)

"This capacity [= the capacity for language--- K.H.] may be due to structural innovations on a molecular level." (p.72)

(12) Neo-Lennebergian thesis on the biological evolution of the FL:

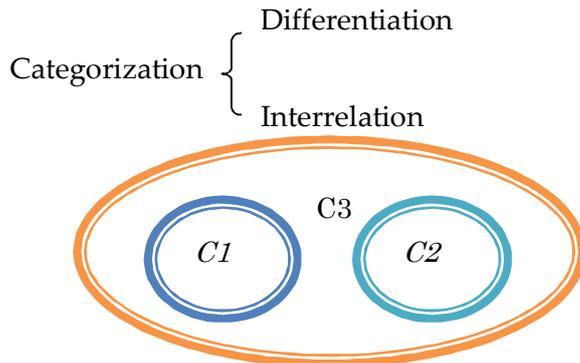
In the course of evolution of language, Merge, labeling and the lexicon in human

language all derived from categorization with a certain modification in connection with the C-I system.

2.3.2. Comparison between Merge and Categorization

(13) Merge $(X, Y) = \{X, Y\}$ (X, Y is either a lexical item or a SO already formed by Merge) (Chomsky 2013a, 2015 *inter alia*.)

(14) Differentiation & Interrelation: Two Aspects of Categorization (Lenneberg 1967)



Syntax: Phrase-structure rules \leftarrow differentiation

Transformational rules \leftarrow differentiation & interrelation

(cf. Chomsky's (1965) Standard Theory)

If κ is a label, it can be taken as a sort of characteristic function that applies to any element indicated by x that either "satisfies" the label or not, as defined as (15):

$$(15) \kappa(x) = \begin{cases} 1 & \text{if } x \in \kappa \\ 0 & \text{if } x \notin \kappa \end{cases}$$

I will assume that Categorize as the operation of categorization is an n -ary unordered set-formation under a particular label specified by κ as follows (see Tallerman 2009 for the point that labeling is significant for categorization):

(16) Categorize $^{\kappa}(x_1, \dots, x_n) = \{x_1, \dots, x_n\}$ ($x_i \in \kappa$)

(x_i is a target element for categorization and κ is a label, where the n -ary sequence in the set uniformly contains either a series of entities or a series of sets as the value of x)

It is to be noted that the operation Categorize can target either n -ary of entities or n -ary of sets already constructed by Categorize.

(17) Category Formation Patterns with Merge and Interrelational Categorization:

[i] Merge:

a binay unordered set is formed \rightarrow the label is determined

\rightarrow a new category is formed

[ii] Interrelational Categorization:

the label is determined → an n-ary unordered set is formed

→ a new category is formed

(cf. Cohen & Lefebvre (2005) for detailed overview and discussion of categorization in a variety of cognitive domains.)

(18) Crucial Properties of Merge and Interrelational Categorization (Int.Cat):

(The differences are in red and the similarities are in black.)

	Merge	Int.Cat
(a) <i>input cardinality</i>	binary/dyadic	n-ary/n-adic
(b) <i>output cardinality</i>	unary	unary
(c) <i>output set</i>	unordered set	unordered set
(d) <i>labeling</i>	unlabeled	labeled
(e) <i>recursivity</i>	recursive	recursive
(f) <i>external/internal availability</i>	Both	only external

Under this scenario, it is conceived that the well-known characteristic properties of Merge listed in (18) was derived from interrelational categorization as follows:

[i] unordered set-formation: inherited from interrelational categorization

[ii] recursivity: inherited from interrelational categorization. Note, however, the recursivity in Merge is completely unrestricted, while the recursivity in interrelational categorization is restricted by availability of labels for categorization.

[iii] output singularity and input binarity: the former stems from the output singularity of interrelational categorization, but the latter does not follow from it *per se* (note the n-ary input nature of interrelational categorization). While the boundary condition that $n > 1$ should come from the very nature of interrelational categorization (you need more than one element for interrelation in the first place), the binarity $n = 2$ should be due to computational minimality in the third factor (Chomsky 2008), which was presumably imposed upon Merge, when it was derived from categorization in evolution. The mutation in question might not have necessarily involve the coding DNA, but might well have been related to the non-coding DNA, which regulates expressions of the coding DNA (see Berwick & Chomsky 2016 and references cited therein).

[iv] label-free nature & internal option: I will point out later on a possibility that a particular change in the nature of interrelational categorization would have led to the label-free nature of Merge, opening up a novel potential for the

“internal” option in Merge.

2.3.3. Re-capturing Lenneberg’s Conjecture from the Perspective of Minimalism.

(19) a. On the Origins of Merge and the Necessity of Labeling:

In the course of language evolution, Merge emerged based on the C-I system by reversing the order of labeling and set-formation in the **interrelating aspect of categorization**, due to the effect of a small genetic mutation along with the imposition of binarity and minimal search for identification of labels by the third factor principle of minimal computation (MC).

b. On the Origin of (the Initial State of) the Lexicon:

In the course of language evolution, atomic conceptual elements (gradually) emerged based on the C-I system by **differentiating aspect of categorization** along the line of the Disintegration Hypothesis (Fujita & Fujita 2016, Fujita et al. forthcoming), presumably due to the increase of cognitive power of differentiation and distancing from the immediate, direct sensory-perceptual environmental influence (Hurford 2007, Bouchard 2013). With respect to the emergence of the atomic conceptual elements in the human lexicon, it does not seem to be realistic to assume sudden appearances in the event of the evolution of the FL, unlike Merge. Given that those elements are input elements for Merge, they should have evolved prior to the emergence of Merge (Chomsky 2010, 2012a,b, Berwick & Chomsky 2016. See also Bickerton 2007).

Criticizing Miyagawa et al.’s (2013) Integration Hypothesis (IH) (see also Miyagawa et al. 2014, Nóbrega and Miyagawa 2015, Miyagawa 2017), Fujita & Fujita (2016) and Fujita *et al.* (forthcoming) propose an alternative called Disintegration Hypothesis (DH) (see also Fujita 2016, Narita *et al.* 2014 and Tallerman 2017 for a critique of the IH).

(20) The Disintegration Hypothesis (DH) (Fujita & Fujita 2016, Fujita et al. forthcoming):

- a. In animal communication, E(xpressive) and L(exical) systems are not separated.
- b. Human language came into existence by the disintegration into E and L systems.
- c. This disintegration enabled human language to possess the creativity independent of mind-external materials.

(adapted from (26) in Fujita et al. forthcoming,

with the translation by K.H.)

They assert that the disintegrated two systems have evolved into functional categories and lexical categories (or root elements) in the biological evolution in the hominin lineage. I agree with this view and will incorporate this idea later in section 4.

2.3.4. How Would Interrelational Categorization Have Yielded Merge and How Would It Have Changed the Nature of Categorization in Humans: A Speculation

Since the cognitive ability of categorization continue to exist in humans as well, even if Merge was derived from categorization, the latter function must be somehow preserved in the event of evolution of the FL.

Bouchard (2013: 53) notes the following point:

“Biological systems evolve through a mix of introducing redundant duplication in the organism’s structure and losing bits of structure. Duplication provides a safety net for the system, but it also provides an opportunity for change. A gene optimized for a particular function may remain stable, but its copy may undergo random variations which turn out to be advantageous for adaptation and give rise to a new function (Gould & Lewontin 1979, Dawkins 1986, Sterelny *et al.* 1996, Sterelny 2001, to name but a few).”

(21) A Speculation on the Relevant Change:

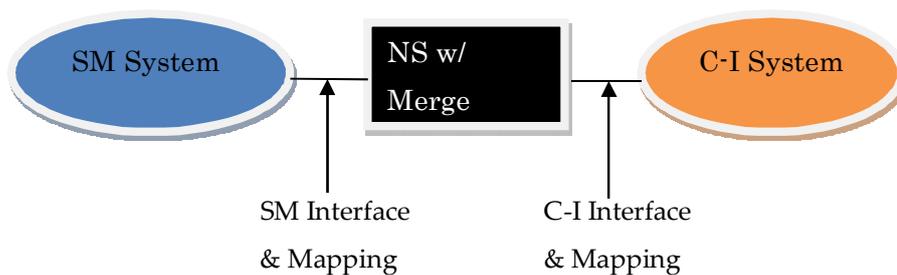
Some genetic change via duplication (in either the coding or the non-coding DNA?) occurred in our hominin ancestor, which resulted in reversing the ordering of labeling and set-formation in interrelational categorization with involvement of the third factor principle(s), leading to creating a re-wired new neural circuitry in the human brain.

3. The Architecture of the Faculty of Language Reconsidered

3.1. Standard Model of the Architecture of the Faculty of Language (FL) in the Minimalist Program (Chomsky 1995 *et seq.*)

(22) Standard Model of the Architecture of the Faculty of Language (FL) in the Minimalist Program²

² See Chomsky *et al.* (2002) proposed to divide the whole system of language-related cognitive competence into two sub-systems called the faculty of language in the narrow sense (FLN) and the faculty of language in the broad sense (FLB) (see also Fitch *et al.* 2005 for further clarifications on the distinction.)



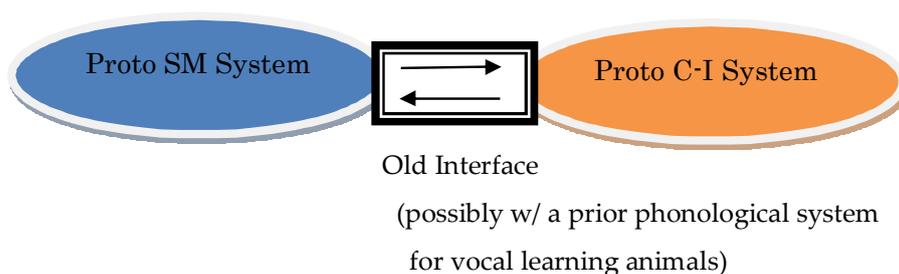
3.2. An Alternative View of the Architecture of the FL

3.2.1. Architecture of the Precursor for the Language Faculty in Animal/Non-human Primate Cognition and Behavior

With respect to animal communication systems, Chomsky (2013a: 44) states as follows, citing Gallistel (1990):

[I]t appears to be the case that animal communication systems are based on a one-one relation between mind/brain processes and “an aspect of the environment to which these processes adapt the animal behavior.”

(23) The Architecture of the Precursor to the Faculty of Language



Bouchard (2013)

(24) **Level 1:** the level of the mapping from reality to the mental processes involved in sensory perception (hearing, vision, smell, touch, taste).

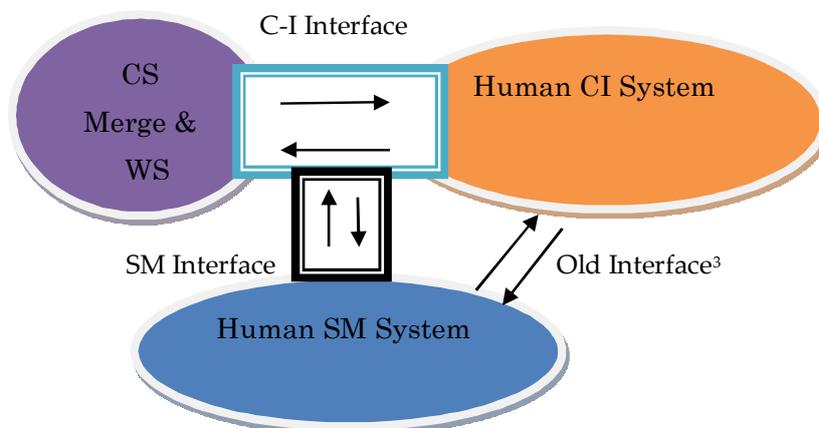
Level 2: the level of the mapping from sensory perception to categorization.

(= close to Hurford’s (2007) notion of proto-concepts, classes of input stimuli.)

Level 3: the level of the mapping from categorization to the formation of concepts, being “abstracted from any sensory input or immediacy.”

See Chomsky (2013b) for recent discussion on the non-referential nature of words of human language in a philosophical context.

(25) **The New Proposal on the Architecture of the FL**



4. Further Biolinguistic Considerations

4.1. Chomsky's (2013a, 2015) Analysis Reconsidered

(26) **Chomsky's (2013a, 2015) Labeling Algorithm and Its Miscellaneous Nature of the Labeling System**

- (i) $\{H, XP\} \rightarrow$ Label of $\{H, XP\}$ is H.
- (ii) $\{<XP>, YP\}$ (without agreement; either XP or YP in the set will undergo IM) \rightarrow Label of $\{<XP>, YP\}$ is Y.
- (iii) $\{XP, YP\}$ (with agreement between X(P) and Y(P) in the set) \rightarrow Label of $\{XP, YP\}$ is $\langle\phi, \phi\rangle$ or $\langle Q, Q\rangle$, depending on the agreement relation.

- (i) illustrates cases of categorial labels of the head elements such as v, n, a, p, D, T, C in the head-complement structure.
- (ii) illustrates the cases of the categorial labels for the subject-predicate construction $\{<DP/nP>, vP\}$ (in English) and for the intermediate landing-site $\{Wh-DP/nP, CP\}$ of successive-cyclic wh-movement.
- (iii) illustrates the cases of the non-categorial labels for the final landing-site $\{Wh-DP/nP, CP\}$ of successive-cyclic wh-movement.

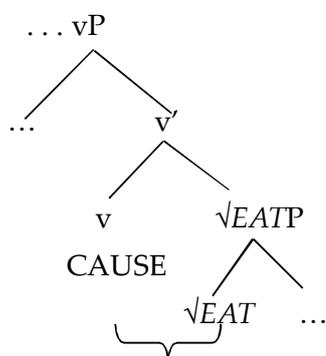
← From the perspective of symmetry, it seems rather undesirable to have miscellaneous types of labels for interpretation of syntactic objects (SOs) at the C-I and SM interfaces in Chomsky's (2013a, 2015) labeling algorithm. This "disjunctive" state of affairs in labeling of SOs suggests that the statuses of "categorial labels" and "agreement-related labels" need to be re-examined from the perspective of minimalism.

³ I assume that the neural connection realizing the "old interface" Interface 1 between the C-I system and the SM system still remains in the modern human brain, given the fact that Broca's aphasics display a finite-state linear grammatical behavior, due to the operational unavailability of Merge (Fujita 2016).

4.2. The Revision of the Notion of Label(ing)

4.2.1. Anti-lexicalism

(27)



eat [i:t] (← *eat* as a “word”

with its morpho-phonological realization)

(see Marantz 1997, Harley & Noyer 2000, Embick & Noyer 2007, Embick & Marantz 2008, Borer 2005a,b, 2013, 2017, Harley 2014 *inter alia*.)

The important biolinguistic question to be posed is this: are syntactic labels such as verbal, nominal, and adjectival, etc. biologically primitive as has been standardly assumed in the literature?

In fact, as Chomsky (2001) himself remarks, from the perspective of minimalism, it would be more desirable if we could eliminate language-specific notions such as grammatical categorial features from linguistic theory. To the extent that functional elements such as *n*, *v*, *a*, *p* virtually encode such categorial information, they should be eliminated from the theory of the FL as well in terms of minimalist desideratum.

Furthermore, Leivada (2017) argues that grammatical categories such as noun and verb (and hence those categorial features as well) do not exist, following the lead in Lenneberg’s (1967, 1975) claim that syntactic categories of syntactic objects are definable only contextually, and on the basis of Barner & Bale’s (2002) neurolinguistic evidence that case studies of apparently category-specific impairments in aphasia and other pathological phenotypes do not demonstrate any relevance of categorial features *per se*, favoring “lexical underspecification.”

Baker (2003: 294): “the lexical category distinctions correspond not so much to ontological distinctions in the kinds of things that are out there in the world, but rather to the different perspectives we can take on those things, the different ways our linguistic capacities give us of describing them.”

Panagiotidis (2011, 2015) characterizes categorizers such as *n* and *v* as “perspective”-providing elements (sortal and entending-into-time perspectives, respectively) for typing the root materials in their complement, postulating categorial

features like [N] and [V] in n and v.

(28) Labeling by Minimal Search of a Relevant Function as a Head at the C-I Interface:

At the C-I interface, if minimal search of a syntactic object (SO) finds a relevant function F specified by a head H, it is counted as serving the purpose of determining the label of the SO.

(29) The Relevant Mappings via Function-application in the “Lexical Domain”:

Following, extending and modifying Baker’s (2003) and Panagiotidis’s (2011, 2015) ideas, I propose the following mappings in the lexical domain.

The function F’s in the lexical domain as atomic perspective concepts

- i) $F_{[entity-concept]} (root-concept \surd R) = “nominal”$
- ii) $F_{[eventuality-concept]} (root-concept \surd R) = “verbal”$
- iii) $F_{[property-concept]} (root-concept \surd R) = “adjectival”$
- iv) $F_{[temporal/spatial/causal relation-concept]} (root concept \surd R) = “adpositional”$
e.g.) $F_{[entity-concept]} (\surd BOOK) = book(n) “book as a nominal”$

(30) The Relevant Mappings via Function-application in the “Functional Domain”:

- i) $F_{[(definite/indefinite-concept]} (“nominal SO”) = “definite/indefinite nominal SO”$
- ii) $F_{[finite/non-finite tense-concept]} (“eventuality SO”) = “finite/non-finite eventuality SO”$
- iii) $F_{[force-concept]} (“finite/non-finite eventuality SO”) = “finite/non-finite propositional SO with a force”$

4.3. Other Implications

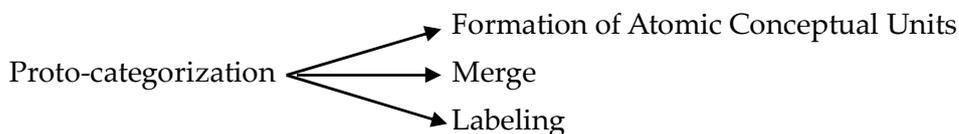
4.3.1. Chomsky (2013a, 2015)

4.3.2. Saito (2014, 2016)

4.3.3. Oku (2017)

5. Summary & Conclusion

(31) Answers to the Biolinguistic Questions in (4)



→ Human-unique categorization was enabled by formation of atomic conceptual units, emergence of Merge & human-unique labeling.

(32) The Drastic Two Changes of the Nature of Labels of Categorization in Evolution

(33) Methodological Implication

Others:

(34) Human Language Has Functions All the Way Up and All the Way Down!

Merge is a “super-meta” binary recursive function that takes two functions as its arguments, generating SOs, which are “functions” themselves.

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