★ FORUM ★

Merge and Labeling as Descent with Modification of Categorization: A Neo-Lennebergian Approach

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1.   Introduction

The problem concerning the emergence of the faculty of language (FL) in our species is sometimes referred to as *Darwin's Problem* in the literature, as stated in (1) (see e.g. Boeckx 2009 and Hornstein 2009):

(1)   *Darwin's Problem*

How did the faculty of language emerge in our species?

Regarding the nature of FL and its evolution, Hornstein remarks the following:[1]

> [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.   (Hornstein 2009: 4)

Without touching upon the important issue on the evolutionary vintage of the emergence of FL in our species in the following discussion, I will only focus

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

on a possible origin of the syntactic structure-building operation Merge and its related labeling operation in the evolution of FL. Particularly, I will address what sort of Darwinian descent with modification would be at least theoretically conceivable on the basis of a biologically plausible precursor in the emergence of Merge and its related labeling.

At the outset, I would like to emphasize that the current contribution is intended as more of an opinion piece rather than a research article. As such, since I will propose a particular hypothesis on the origin of Merge and its related labeling in the evolution of FL purely at a theoretical level, it remains to be tested empirically in the field of comparative cognitive neurobiology in the future (see Fitch 2011 for the significance of the role of comparative research in testing evolutionary hypotheses).

With this caveat in mind, I would like to suggest re-visiting Lenneberg's (1967) conjecture on the evolution of the capacity for language as cited below as a point of departure, while revising it from the perspective of modern linguistic theorizing to give it a new lease of life. Lenneberg makes the following conjecture on the relation between categorization and the cognitive function underlying language in the context of evolution of the capacity for language (see Bickerton 1990: Chap. 4 for very informative discussion on categorization in animals; see also papers in Zentall & Smeets 1996 for more recent discussion on categorization in humans and animals):

(2)   *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.[2]   (Lenneberg 1967: 374)

The organization of this opinion piece is as follows. Section 2 compares categorization and Merge/labeling in an attempt to highlight similarities and differences between the two. Section 3 proposes a neo-Lennebergian approach to the origin of Merge and its related labeling in the evolution of FL. Section 4 concludes this work with some remarks.

2.   Comparison of Categorization and Merge/Labeling

2.1.   *Two Modes of Categorization*

In properly comparing categorization with Merge/labeling, it is of necessity to differentiate two modes of categorization, as discussed in Lenneberg (1967).

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[2]   In connection with (2), it is instructive to note that Lenneberg (1967: 72) points out that "[t]his capacity may be due to structural innovations on a molecular level". Thus, he had already conceived the relevant "adaptation" in (2) as due to some structural changes on a DNA molecular level.

Crucially, Lenneberg (1967) notes that there are two modes of categorization, namely differentiation and interrelation, as shown in (3):

(3) *Two Modes of Categorization: Differentiation & Interrelation*

Categorization { Differentiation
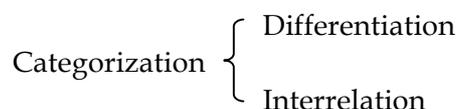
Interrelation

As an illustration, let us consider a simple hypothetical situation:
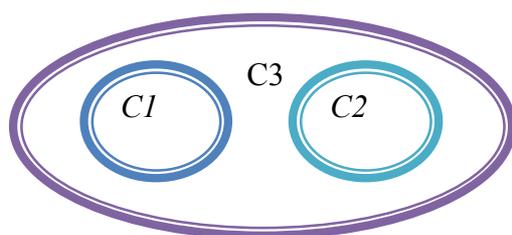
Figure 1: Differentiational Categorization vs. Interrelational Categorization

Suppose that there are two sub-sets with the category labels C1 and C2, respectively, and there is one super-set with the category label C3.[3] In *Figure 1*, if the comprehensive super-set C3 has been sub-divided, or *differentiated*, into the two sub-sets C1 and C2 by categorization, the differentiational mode of categorization is at work; whereas, if the two narrower sets C1 and C2 have been subsumed, or *interrelated*, under the super-set C3 by categorization, the interrelational mode of categorization is in operation. Therefore, the two modes of categorization reflect two possible 'directions' of the operation of categorization.[4]

2.2. *Interrelational Categorization vs. Merge/Labeling*

Ever since Chomsky (1995), the formulation of Merge has been reduced to the bare minimum, with the simplest form as stated in (4) (e.g., Chomsky 2013, 2015):

(4) Merge (X, Y) = {X, Y} (X, Y is either a lexical item or a syntactic object (SO) already formed by Merge)

When X and Y are independent of each other and do not contain each other, such Merge is called 'external Merge'. On the other hand, when either X or Y is part of the other, such Merge is referred to as 'internal Merge'. It is not the case that

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[3]   'Labels' of categories are brain-internal representations, which can be regarded as concepts in the sense of Carey (2009). On the origin of concepts, see Carey (2009) for comprehensive, in-depth discussion.

[4]   Differentiational categorization seems to be relevant to *Disintegration Hypothesis* (DH) proposed by Fujita & Fujita (2016) in accounting for the emergence of human lexicon with lexical items (both lexical and functional category) in the evolution of human language. Though dealing with the issue of evolution of human lexicon is one of the most important agenda in biolinguistics, I will not address differentiational categorization in this opinion piece (see also Lenneberg 1975 for insightful discussion on the notion of differentiation in the development of human lexicon).

there are two types of Merge. They are just two different modes of a single operation of Merge (see Chomsky 2004). Labeling of SOs (= set-structures) formed by Merge is the process of providing the information as to what kind of object such set-structures are in order for them to be interpreted properly at the conceptual-intentional (C-I) and sensorimotor (SM) interfaces (see Chomsky 2013, 2015). Note that the operation of Merge *per se* has nothing to do with labeling.

Considering the similar combinatorial property of Merge and interrelational categorization, I will take it that the proper comparison should be between Merge and interrelational categorization rather than differentiational categorization.[5] For expository purposes, let us define interrelational categorization as follows as a first approximation (see Cohen & Lefebvre 2005 for in-depth overview and discussion on categorization in a variety of cognitive domains). Suppose that κ is a label for interrelational categorization, then 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 in (5):[6]

$$(5) \qquad \kappa(x) = \begin{cases} 1 \text{ if } x \in \kappa \\ \\ 0 \text{ if } x \notin \kappa \end{cases}$$

I will name the operation for interrelational categorization *IntCat* for expository purposes and formulate it as an unordered set-formation under a particular label specified by κ as follows:

(6) $IntCat^{\kappa}(x_1, \ldots, x_n) = \{x_1, \ldots, x_n\} \ (x_i \in \kappa, 1 \leq i \leq n)$

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

Next, let us take a close look at the similarities and differences between Merge and IntCat with respect to their crucial properties, which are summarized in Table 1:

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[5]   Thornton (2016) discusses the case of what he calls *hierarchic concept-combination* (HCC) in connection with Merge, such as a family that consists of a mother and a child with the concept *family* serving as the "accommodating concept for providing the root" for the hierarchic concept [**family** mother child] in his notation. One possible reinterpretation of HCC is that it is a particular case of interrelational categorization in the C-I system, in which the label of the set for the categorization here is something like "concepts that make up the concepts of *family*". Note that, unlike Merge, which is binary, interrelational categorization is not limited to binarity, in principle, which is exactly needed for HCC in general as well, as shown by the possible hierarchic concept [**family** mother father child pet dog], etc.

[6]   Here, I am making a sort of idealization with respect to the characteristic function in question for categorization. In reality, as is well-known in the fields of psychology and cognitive linguistics, membership determination/identification for categories on the basis of extraction of similarities among set members is nuanced and complicated (see among others Rosch 1973, Lakoff 1987, and Taylor 2003).

	Merge	IntCat
(a) *input cardinality*	n = 2	n ≥ 2
(b) *output cardinality*	n = 1	n = 1
(c) *output set*	unordered set	unordered set
(d) *labeling*	label-free	labeled
(e) *recursivity*	fully recursive	partially recursive
(f) *availability*	both external and internal	external only

Table 1: Crucial Properties of Merge and IntCat

First, concerning input cardinality, while Merge is standardly taken as binary, IntCat is equal to or more than binary. Note that IntCat *interrelates* target objects, so the input cardinality should be minimally 2 by nature. Second, as for output cardinality, both of them are unary. Third, both Merge and IntCat form an unordered set as output. Fourth, Merge is label-free, whereas IntCat is labeled due to the very nature of categorization. Fifth, Merge is fully recursive, while IntCat is only partially recursive (see the discussion below; see also Watumull *et al.* 2014 for a thorough discussion on recursion in general). Finally, in principle, Merge permits both an 'external' and an 'internal' option, IntCat only allows for an 'external' option, excluding an 'internal' one (see the discussion below).

With respect to the first point, as Fujita (2017) rightly points out, appealing to the third factor such as the principle of efficient computation/minimal computation (Chomsky 2005) to account for the binarity of Merge (Chomsky 2008) is not convincing enough. This is because nothing would prevent the third factor from applying to other cognitive domains equally as well and the combinatorial operations in the other cognitive domains would also be strictly binary, given that the third factor is not specific to FL (Chomsky 2005). Similarly, a reviewer for *Biolinguistics* also correctly warns me that, given that the third factor is a general one not limited to language, it cannot account for why IntCat is not strictly binary, too. Therefore, there must be a principled reason for the binarity of Merge within the nature of FL itself, independent of the third factor.

One possibility suggested by Fujita (2017) is that binary branching structure is less costly than multiary branching structure in determining linear ordering of elements by linearizing hierarchical syntactic structures along the line of Linear Correspondence Axiom (LCA) interpreted as a linearization principle (see Kayne 1994, Chomsky 1995, Moro 2000). If this is basically on the right track, then it must be the case that linearization of hierarchical syntactic structures is always required in FL even when articulation of the linearized elements by speech or sign is not actually occurring externally in an individual, as in silent monologues.

In order to understand the fifth point, it is first necessary to consider the final point: the asymmetry of external/internal availability between Merge and IntCat. While Merge permits both external and internal option, IntCat only allows for external option. Note that to the extent that a label for IntCat is determined, you could put any number of relevant independent elements into

the category set by interrelating them (= external option). What would the putative internal option of IntCat be like?

Here, terminological clarification seems to be required in order to avoid confusion in the following discussion. I will use the names "lemon", "tangerine", "citrus fruits", and so on as labels for categories, just for ease of exposition. Strictly speaking, I distinguish between *labeling of categories* and *naming of categories*. The former refers to identification/specification of categories by some brain-internal representations corresponding to 'concepts' (see fn. 3). This is what I intend to mean when I informally use "lemon", "tangerine", and "citrus fruits" in what follows. On the other hand, the latter refers to pairing of labels of categories with some brain-internal 'forms' for externalization such as particular phonological representations of sound sequences in speech or signs in sign language in the case of human language, in the sense of Saussure (1916) (see also Bouchard 2013 for interesting discussion on Saussurean signs in the context of evolution of language). Alarm calls in animal communication systems may be regarded as a kind of 'naming' of categories (= proto-concepts in the sense of Hurford 2007) in stimulus-response behavior (see e.g. Bickerton 1990 for discussion on the different nature of labeling of categories between animal communication systems and human language).

Now, imagine a concrete interrelational categorization case. Suppose you have a category with the label "lemon" and another category with the label "tangerine". Next, you interrelate the two category sets under a super-category set with the label "citrus fruits". Suppose further that you have a category with the label "apple" and another category with the label "pear". Next, you interrelate the two category sets under a super-category set with the label "pome fruits". Furthermore, suppose that you interrelate the two super-sets with the labels "citrus fruits" and "pome fruits" to form a more inclusive super-set, presumably with the label "fruits". Now, you 'extract' the "lemon" category set from the "citrus fruits" category set by the putative internal option of IntCat and try to categorize the extracted 'copy' of the "lemon" category set together with the inclusive super-set containing the "citrus fruits" category set and the "pome fruits" category set. Is this kind of operation possible in the first place? I do not think so. Notice that, because of the 'status difference' between the extracted "lemon" subset and the inclusive super-set containing the "citrus fruits" category set and the "pome fruits" category set, in principle, you could not possibly determine any appropriate label for the whole would-be category set created by such putative internal option of IntCat. Hence, I conclude that an internal option of IntCat is not available in general. By contrast, Merge freely enjoys an internal option (= internal Merge) because there would be no 'status difference' between internally Merged X and Y due to lack of labeling in the operation of Merge *per se*.

Accordingly, and with regard to the fifth point, since Merge permits both external and internal options, it is fully recursive. On the other hand, since IntCat only allows for the external option in that it can only take independent category sets or independently created super-category sets as its input, it is partially recursive.

2.3.   *More on Labeling for Interrelational Categorization (IntCat) and Merge*

A reviewer points out that labeling of categorization, or categorial labeling, is inherently exocentric, while syntactic labeling is endocentric as well as exocentric. With this remark as a point of departure, it seems to be worthwhile to closely examine the nature of labeling for IntCat and Merge as well as its relation to the notions of endocentricity and exocentricity commonly utilized in linguistics in order to build the foundation for the hypothesis on the emergence of Merge/labeling that I will propose in the next section.

Let us first take stock of the nature of labeling for interrelational categorization. Notice that, in general, labeling of categories comes with two types:[7] One category labeling pattern is such that the label of a category set is determined, more or less, on the basis of some inherent relevant property shared by all the members in the set. Another category labeling pattern, on the other hand, corresponds to the case where the label of a category set is not specified by such an inherent common property of all the members but is supplied by some external/contextual condition. Thus, the category set {John, Bill, Tom, …} with the label, say, 'boy' illustrates the former, while the category set {scissors, a German dictionary, a coffee cup, a bill, a printer, …} with the label, say, 'what exists on that desk' represents the latter. In either case the labeling pattern for categorization is 'exocentric' in that there is no single element that can serve as the 'head' for determining the label of the whole category set.

Now, what about labeling for Merge in syntax? Although Merge *per se* is independent of labeling, it typically involves two kinds of unordered set-structure: {H, XP} and {XP, YP} (e.g. Chomsky 2013, 2015).[8] In the case of {H, XP}, where a lexical item is merged as a head H with a syntactically complex object XP already formed by Merge independently (e.g., *eat* is merged with *that apple* to form {*eat* {*that apple*}}).[9] In the tradition of generative grammar (Chomsky 1970), it has been standardly assumed that the syntactic structure corresponding to {H, XP} is 'endocentric' because it is 'headed' by the lexical item H in it (e.g., the verb phrase *eat that apple* is endocentric due to its being headed by the verb *eat*).

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[7]   I owe the observation that, generally, there are two modes of labeling for category sets to Satoshi Oku (personal communication).

[8]   Chomsky (2013, 2015) proposes the following *labeling algorithm* (LA) that applies to set-structures created by Merge:

(i)   {H, XP}
       ➔ Label of {H, XP} is H.

(ii)   {<XP>, YP} (without agreement; either XP or YP in the set will undergo internal Merge)
       ➔ Label of {<XP>, YP} is Y.

(iii) {XP, YP} (with agreement between X(P) and Y(P) in the set)
       ➔ Label of {XP, YP} is <ϕ, ϕ> or <Q, Q>, 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 a head–complement structure. (ii) illustrates cases of categorial labels for the subject–predicate construction {<DP/*n*P>, *v*P} (in English) and for the intermediate landing site {*Wh*-DP/*n*P, CP} of successive-cyclic *wh*-movement. (iii) illustrates cases of non-categorial agreement-based labels for the final landing-site {Wh-DP/*n*P, CP} of successive-cyclic *wh*-movement.

[9]   In what follows, I will abbreviate set representations for SOs by ignoring some internal sets just for expository simplicity.

The question that I would like to pose at this juncture is whether there is an alternative view to this standard doctrine. Note that the unordered set formed by Merge has two members, H and XP (such as *eat* and *that apple*), which do not share any inherent common property. Therefore, it may be taken on a par with the category set {scissors, a German dictionary, a coffee cup, a bill, a printer, …} with the label 'what exists on that desk,' which is provided externally/contextually. Let us take {*eat* {*that apple*}} as a concrete example.[10] If the similarity is close enough, then you might be able to hypothesize that the label for {*eat* {*that apple*}} is in fact supplied externally/contextually, such as 'what makes up an event(uality),' within a larger configurational context with functional projections including tense and force information.[11] This assumption seems to be quite natural, provided that at least the tense element semantically/conceptually necessitates the presence of an event(uality). If this were to be the case, the {H, XP} configuration would be 'exocentric' in that its labeling is determined externally/contextually, much the same as the case of labeling of categorization. At the same time, it appears to be 'endocentric' in that it contains an event(uality)-denoting element *eat*, which would be compatible, as a 'prominent element', with the externally/contextually supplied label 'what makes up an event(uality)' of the whole set {*eat* {*that apple*}}. How could we make sense of this situation? One possibility is to assume that the set {*eat* {*that apple*}} is in fact solely exocentric and the label 'what makes up an event(uality)' of the set semantically/conceptually requires an event(uality)-denoting element like *eat* as its obligatory pivotal member, which is intuitively taken as the 'head' of the set. If this reasoning holds, 'endocentricity' in the {H, XP} structure might be an epiphenomenon.

Next, consider the exemplar exocentric structure of {XP, YP}, where two SOs of the same 'size' status are merged. This case may be regarded as comparable with the category set {John, Bill, Tom, …} with the label 'boy,' mentioned above. Let us take {{*the boy*} {*will eat that apple*}} as a concrete example, where DP {*the boy*} has been internally merged with TP {*will eat that apple*}. Here, the two elements, the DP {*the boy*} and the TP {*will eat that apple*}, share an inherent common property of ϕ-features for agreement, and the label <ϕ, ϕ> (Chomsky 2013, 2015) will be attached to the whole set {{*the boy*} {*will eat that apple*}}, just like the shared inherent common property 'boy' is attached to the category set {John, Bill, Tom, …}.

If this line of analysis is on the right track, it might be reasonable to think that not only categorial labeling but also syntactic labeling is invariably exocentric, contrary to the standard assumption. The conclusion on the parallelism between categorial labeling and syntactic labeling is crucial in putting forth a new proposal on the origin of Merge/labeling in the evolution of FL.

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[10] Strictly speaking, it is currently assumed in the minimalist program that the underlying structure for *eat that apple* should look like {v^* {$\sqrt{EAT}$ {*that apple*}}}, where v^* is an abstract causative verb, to which the root element $\sqrt{EAT}$ will be moved (see Chomsky 2013, 2015). I will abstract away from this detail in the text.

[11] In fact, Lenneberg (1967, 1975) proposes that the specification of syntactic categories is determined on the basis of modes of functioning within a larger context of syntactic structure. Furthermore, Leivada (2017) argues that there are no inherent syntactic categorial labels such as noun and verb in human language on the basis of Lenneberg (1967, 1975) and Barner & Bale (2002).

3. A Neo-Lennebergian Approach to the Origin of Merge/Labeling

In view of the similarities and differences between Merge and IntCat in *Table 1* and the similar nature of labeling for the two cognitive processes, I will propose the following hypothesis in (7) on the origin of Merge and its related labeling in the biological evolution of FL by re-interpreting Lenneberg's (1967) conjecture in (2) in the light of the discussion in section 2:

(7)   *On the Origin of Merge and Its Related Labeling*

In the event of biological evolution of FL, Merge (= set-formation) derived from interrelational categorization IntCat (= labeling + set-formation) as descent with a certain modification, while preserving the capacity for IntCat *per se*. The modification in the brain of our ancestor that underwent a relevant genetic mutation, accompanied by its adaptive value, was such that Merge came into existence as a result of detachment of the set-formation component from IntCat, hence separating it from labeling, while the remaining labeling component came to be employed for labeling SOs formed by Merge.[12]

The modification in question can be represented as follows in *Figure 2*:
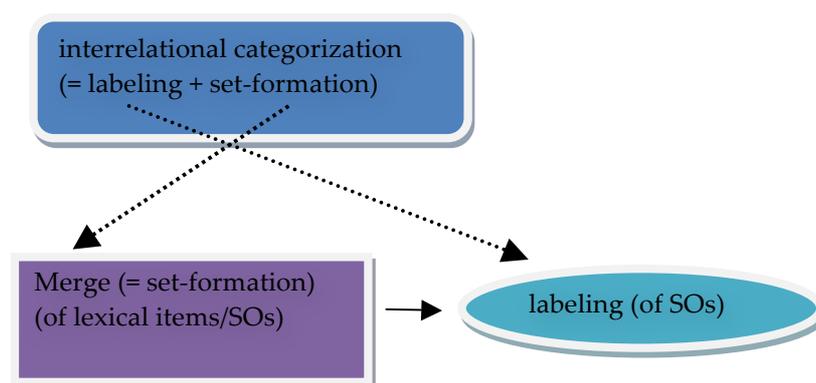
Figure 2: Merge & Labeling as Descent with Modification of Interrelational Categorization

Notice that even if Merge and its related labeling are originally due to the two components of interrelational categorization, both of them are now adapted to the use in the faculty of language (FL) in human language: they have to apply to lexical items (= conceptual atoms) and/or SOs formed by Merge. Furthermore,

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[12]   It has been widely discussed in the literature that natural language syntax and action grammar (motor planning) are parallel in that both involve hierarchical structures of some sort (see Greenfield 1998, Jackendoff 2007, Fujita 2009, Pulvermüller 2014, Stout 2010, Arbib 2012, Knott 2012, among others, but e.g. Moro 2014 for a different view). Since (interrelational) categorization is at work both in the sensori-motor domain and in the conceptual-intentional domain (e.g., Lenneberg 1967), one possibility is that those hierarchical structures claimed in action grammar might well be characterizable in terms of (interrelational) categorization, from which Merge was derived, if my hypothesis in the text is on the right track. Whether this conjecture is valid or not should be tested empirically, which I have to leave to future research.

upon the emergence of Merge, lexical items as conceptual atoms must have come to be combined by Merge to create various SOs, which in turn served as complex labels (e.g., '*gifted pre-school child who is good at playing chess*') for further categorization (both differentiational and interrelational) in human cognition. I surmise that this led to "the qualitative distinctness of both modern symbolic cognition and language" (Tattersall 2017: 64).

Now, how would the pertinent modification to yield Merge and its related labeling from interrelational categorization have possibly been implemented biologically in the course of evolution of our species? Given the fact that the ability of (both interrelational and differentiational) categorization has continued to exist in our species, even if Merge and its related labeling were derived in the course of phylogeny as decent with modification of interrelational categorization, both Merge/labeling and (interrelational) categorization have to develop biologically in the course of ontogeny as well. Then, what kind of biological evolutionary story would be the most plausible?

In this connection, it is very informative to note the well-established fact on biological evolution that Bouchard (2013) touches on in the following remark:

> 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 2001, to name but a few).   (Bouchard 2013: 53)

As concisely put in this quote, it is well-known in biology that gene duplication permits one copy of a duplicated DNA region to become free from selectional pressures and to undergo genetic mutation at random (e.g., Ohno 1970, Zhang 2003). Thus, one possibility for the descent with modification in (7)/*Figure 2* is that gene duplication in either coding or noncoding DNA areas played a role for the presumed genetic mutation for yielding Merge/labeling out of interrelational categorization in the evolution of FL in our species.

While it is true that genomics, including research on the areas of chromosome 7, which is related to language, has made a significant progress so that we can address specific genes (e.g., Benítez-Burraco 2013, Boeckx & Benítez-Burraco 2014a, 2014b, Fisher & Vernes 2015), in order to test my hypothesis in (7)/*Figure 2* empirically and eventually pin down the relevant genes related to (interrelational) categorization, Merge, and labeling, collaborative in-depth investigation into the genetic underpinnings of (interrelational) categorization among vertebrates, particularly primates, would be clearly called for in comparative genomics and comparative neuroscience (see e.g. Fitch 2005, 2017 for detailed discussion on the significance of empirical and interdisciplinary comparative approaches to the study of language evolution), given that categorization can be ubiquitously observed among vertebrates (e.g., Lenneberg 1967).

Also equally important to empirically corroborating my hypothesis on the origin of Merge/labeling in FL is to construct a linking theory at the dynome-level, accounting for how (interrelational) categorization (= labeling + set-form-

ation) and Merge (= set-formation) and its related labeling are implemented in terms of brain oscillations (see Murphy 2015, 2016, Benítez-Burraco & Murphy 2016, and Murphy & Benítez-Burraco 2016, among others, for discussion on the relation between brain oscillations and language). It is hoped that future research would shed a new light on this issue.

Finally, let me make a brief remark on recursivity of Merge. With respect to recursivity in Merge, there has been a controversy in the literature over the continuous view (Pinker & Jackendoff 2005, Jackendoff & Pinker 2005) and the discontinuous view (Hauser *et al.* 2002, Fitch *et al.* 2005). To the extent that Merge as a set-formation operation derived from the set-formation component of inter-relational categorization as descent with Darwinian modification, with the property of full recursivity in Merge and that of partial recursivity in interrelational categorization, as argued in this opinion piece, the property of recursivity should not completely be a novelty in Merge.

4. Concluding Remarks

In this opinion piece, I addressed *Darwin's Problem* as it is concerned with the origin of Merge and its related labeling in the evolution of faculty of language (FL) in our species, and proposed a neo-Lennebergian approach to this issue by up-dating Lenneberg's (1967) conjecture on the evolution of the capacity for language. Specifically, I hypothesized a possibility that Merge and its related labeling in the FL in our species derived as Darwinian descent with modification of (interrelational) categorization, which can be observed ubiquitously among vertebrates, including primates (e.g., Lenneberg 1967).

Given that both the ability of interrelational categorization and that of Merge/labeling will develop in a child ontogenetically, the presumed genetic change behind such phylogenetic modification, which was inherited from our pre-FL ancestor as part of our species' genome, must have been responsible for creating the ability of Merge/labeling out of that of interrelational categorization, while preserving the latter in our species. I speculated that some kind of gene duplication in biological evolution must have been at work in the derivation of Merge/labeling.

Finally, I would like to touch upon the relation between language evolution and language disorders. As clearly demonstrated in Benítez-Burraco & Boeckx (2014) and Benítez-Burraco & Murphy (2016), the issues of language evolution and language disorders are intimately related with each other (see also Lenneberg 1967: Chap. 9). While disentangling and solving various issues in language evolution is without doubt an honorable enterprise in and of itself, I strongly believe that the outcome of such investigation should not be confined to the field of language evolution proper, but should be usefully and systematically put to use in the field of medicine as well as that of clinical linguistics (see Benítez-Burraco 2016 for review of the latter) for making effective medical intervention for language disorders.

Although the complicated aspects of language evolution obviously demands interdisciplinary investigation based on various methods and approaches, I speculate that research results in the study of language evolution at the dynome

and genome level, for instance, should offer useful and valuable hints for developing effective protocols of medical intervention for language disorders.

If a language disorder is not clearly associated with any particular gene(s) but is clearly linked with oscillopathy as reflected in electroencephalographic (EEG) abnormalities (e.g., Deonna & Roulet-Perez 2016), then the proper medical intervention for such cases would be based on the combination of medication controlling synaptic transmission with neuromodulation techniques such as transcranial direct current stimulation (tDCS), which ideally should take place during the critical period of language development (see e.g. Hoshi & Miyazato 2016, Hoshi 2017 for a proposal of medical treatment protocol for patients with child aphasia of epileptic origin).

On the other hand, if a language disorder is identified as being linked to (a) particular gene(s) (see e.g. Kambanaros & Grohmann 2017, Benítez-Burraco *et al.* 2018, and references therein), then the ultimate medical intervention for such cases might be administered possibly by regenerative medical techniques using, for instance, induced pluripotent stem (iPS) cells (e.g., Takahashi *et al.* 2007), though this surely should be cautiously examined further.

Consequently, we should recall that, regardless of whether language disorders are of oscillatory origin or of genetic origin, there are always remaining future hopes for discovering methods of recovery from those language disorders, if new findings in the filed of language evolution could be effectively and systematically utilized in the field of medicine. Thus, prompt interdisciplinary endeavor in the light of biolinguistic perspectives on medicine is highly expected for investigating possibilities to "cure" these apparently "incurable disabilities", as Lenneberg (1967) hoped to pursue (see Hoshi 2017).

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