Compositionality Reconsidered: With Special Reference to Cognition

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Chungmin Lee. 2012. Compositionality Reconsidered: With Special Reference to Cognition. *Language and Information 16.2*, 17–42. The issues of compositionality, materialized ever since Frege (1982), are critically re-examined in language first mainly and then in all other possible representational systems such as thoughts, concept combination, computing, gesture, music, and animal cognition. The notion is regarded as necessary and suggested as neurologically correlated in humans, even if a weakened version is applicable because of *non-articulated* constituents and contextuality. Compositionality is crucially involved in all linguistically or non-linguistically meaningful expressions, dealing with at-issue content, default content, and even not-at-issue meanings such as implicatures and presuppositions in discourse. It is a constantly guiding principle to show the relation between representation and mind, still posing tantalizing research issues. (**Seoul National University**)

Key words: compositionality, representational systems, contextuality, mind, cognition, thoughts, concept combination, computing, gesture, music, animal cognition

1. Issues on Compositionality

This paper purports to be a review but a critical review of issues related to compositionality, putting forward some direction of more flexible thinking in investigations and pointing out subtle cross-linguistic differences in application of compositionality with Korean examples where relevant. The meaning of an expression is determined by "a function of the meanings of its parts and of the way they are syntactically combined." This is the principle of compositionality in semantics, which largely started from Frege (1892). It can be regarded as "a condition on

* We thank Barbara Partee, Wilfrid Hodges and James Pustejovsky for their kind explanation of parts of their papers and comments. We also express our thanks to the three anonymous reviewers and the editor-in-chief of *Language and Information* for constructive comments. This research was supported by Korean government through a National Research Foundation Excellent Scholar Grant (100-20090049).

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semantics" or "a guiding principle in research on the syntax-semantics interface." This is a strong version of compositionality requiring the meanings of the *immediate* parts of the complex expression under question in linguistic syntactic structures assumed. From a broader perspective, however, it can be a fundamental key feature of all structured representational systems, be they linguistic, conceptual or neuronal, ranging from language and thoughts to music.

An expression can be any complex expression in a language or non-linguistic representational system such as the No-Left-Turn sign (with the shape, the color pattern, the arrow, etc.). The semantic values of complex representations are determined by those of their parts in all areas of cognitive science, i.e., the study of language, mind and brain. To support this principle, the meanings of the constituents of an expression or representation must be held constant from context to context and if we understand an expression built up through a certain syntactic operation we necessarily understand another expression built up through the same syntactic operation (systematicity – Fodor and Pylyshyn 1988), e.g., *the cat* and *the rat* mean the same in 'The cat hates the rat' and 'The rat hates the cat' and if the first sentence is understood the second sentence is also understood. In support of the principle, (creative) productivity is also used: a competent speaker understands an infinitely many expressions she never encountered before on the basis of her structural knowledge of other similar expressions and knowledge of the meanings of the constituents. The learnability condition that natural languages can be learned is another supporting argument that is related to productivity and compositionality. Pagin (his web) states, "Compositional semantic theories contribute to explain the success of linguistic communication."[1] Thought may also have meaningful constituents in a 'language of thought' hypothesis (Fodor 1975) or in an extended definition of the principle. However, Pagin (2005) argues against Fodor's claim that natural language or linguistic meanings as opposed to thought can't be composional because it is "elliptical and inexplicit about the thoughts it expresses" (Fodor 2001). He employs quantifying over context elements. But some oppose compositionality in favor of contextuality: the speaker's intentional meanings, linguistic and nonlinguistic contexts. Even among proponents of the principle, many favor a weaker version rather than a stronger version, as far as natural languages, not formal languages, are concerned. The issue of 'decompositionality', from the early generative semantics era, is also raised: whether it really 'enables' compositionality (Pustejovsky 2011).

2. Weak Compositionality and Contextuality

I propose to divide the strength of compositionality into four different degrees for the current discussion: (1) very strong, (2) strong, (3) weak and (4) very weak. If the meaning of complex expression is claimed to be exhaustively determined by the meanings of its components, plus their mode of composition, the claim belongs to

[1] Pagin further goes on, "... precisely this explanatory role is the foundation of semantic concepts like truth and reference." Compositionality is: $\mu(\sigma(e_1 \ldots e_n) = g(\sigma, \mu(\sigma(e_1), \ldots, \mu(\sigma(e_n))$, a homomorphism from a language expressions L to meanings of a domain M *à la* Montague and was simplified by Hodges (Pagin 2005).

(1) and no one would endorse it. The reason is that even part of WHAT IS SAID including deictic, indexical, pronoun reference resolution and ellipsis may not be allowed to pick their referents and content contextually. Their mode of composition may also be needed. It is too strong. How about (4), very weak? That claim may deny anything similar to (syntactic) composition, as in diagrammatic reasoning or nonhuman representational systems. But that is also hard to endorse because it may endanger the notion of composition and compositionality itself. We are left with (2) and (3), strong and weak. But the boundaries are not easy to draw and there will be constant boundary wars, as long as semantic theories dynamically develop.

Frege also discusses the *Context Principle*: never ask for the meaning of a word except in the context of a sentence. But, then, people debate whether it is an expression of semantic holism and whether it is in conflict or compatible with the principle of compositionality. If it is taken to imply semantic holism, it is argued to be not a view Frege held (Pagin and Westerståhl 2001, Pelletier 2001), although it still remains controversial whether Frege's implication that word meaning is not fixed and changes with context is compatible with his overall view of language. In the case of the idiomatic reading of *kick the bucket*, the meaning of 'kick' is different from that of 'kick' in its non-idiomatic reading and 'the bucket' has no meaning of its own; the whole VP must be learned as a word in meaning but still the verb shows inflection and yet a sentence with the VP cannot be passivized. Such expressions with no fixed interpretations present a problem to a Montague grammar.[2] Westerståhl (1999) still applies Hodge's (1998) algebraic treatment to the above kind of idioms as atomic, treating *kick the bucket* as an atom meaning *DIE* as a whole but such idioms as *pull strings* are different in the sense that 'pull^i' and 'string^i' each have a non-standard atomic meaning *EXPOIT* and *CONNECTION*, combined with each other. For this, some extended application of functions is suggested, with the ambiguity between 'pull' and 'pull^i' and the latter's necessary combination with 'string^i' in mind. This is a way not to throw away compositionality.

Hodges (1998, 2005) nicely presents a synonymity condition and a context principle. Re-wording his position, he says (p.c. e-mail 1/6/2008): "Adapting Frege, we can explain meanings of expressions in terms of what the expressions contribute to meanings of sentences containing them. We can make this precise in terms of substitutions: two expressions are synonymous if and only if in any meaningful sentence containing an occurrence of one of them, we can replace this occurrence by an occurrence of the other, and the result is always a sentence with the same meaning as the original sentence. At first sight this notion of meaning looks unnecessarily strict: couldn't two expressions have the same meaning but not be grammatically substitutable for each other? The question leads to some contentious examples, as in (1).

[2] Partee suggests saving compositionality, though weak, by meaning postulates in a translation level specifying the meanings of the relevant larger units such as *keep tabs on* or *kick the bucket* that contain the 'meaningless' NPs (*tabs* or *the bucket*) as 'dummy constants.' But the two idioms are distinct in Hodges.

(1) a. He was fast asleep.
b. *He was fast sleeping.

Syntactic category is sensitive to and involves syntactic contexts, as in the contrast between *loves* and *love* in *He loves her* and *I love her*. Substitution may violate syntactic agreement in person and number (not realized in many languages) but may not change meaning. But I critically claim that (1) is different; *asleep* and *sleeping* are different not just in syntactic categories but in event structures: *asleep* is aspectually stative, showing a result state of *fall in sleep* or *fall asleep*, an achievement event, whereas *sleeping* is aspectually progressive from an activity event *sleep*. The modifier *fast* 'completely and thoroughly' is a degree state modifier, not an action modifier. Because of the aspectual meaning difference, we cannot attempt to 'find a sentence where either word will do but the choice affects the meaning of the whole sentence.' There must be a semantically adequate (hand in hand with syntax) complete description of the meanings of subsentential constituent expressions to test for functionality or partial substitutability, as Hodges himself calls for. His higher level 'target expressions' or 'contexts' seem to remain as yet as sentences (sentential functions for Husserl) simple or complex, rather than discourse.[3]

Sentences with propositional attitude verbs do not maintain the truth-value of their embedded complement sentence. If they take synonymous complement clauses such as *Clara believes that* (a) *eye doctors*/(b) *ophthalmologists are rich* they may or may not violate compositionality, depending on how we view the complement clauses. Although (a) and (b) may be synonymous, the sentence with (a) may be true when (b) may be false if Clara is ignorant of the fact of the complement with (b). Some may deny genuine synonymy in this sense (of *de dicto*) and some may take the compositionality principle in a referential meaning position with 'reference' (roughly Frege's *Bedeutung*, Montague/Lewis's 'extension,' Barwise and Perry's 'reference,' and Kaplan's 'content') as 'meaning' (of an expression) in the definition, then tautology and truth-conditional equivalence may be synonymy (particularly with a *de re* reading of the term at issue). Hodges incorporated both sense and reference. On the other hand, Schiffer (1987) argues against compositionality with examples of *Tanya believes that Gustav is a* (a) *dog*/(b) *shmog*, where *shmog* stands for any creature of the same biological species. Partee counterargues against him, saying that Schiffer does not make a sufficient distinction between semantic facts via entailment and synonymy and psychological facts of processes concerning e.g. how one can sincerely utter such a sentence.

Partee (1984/2004), basically advocating the principle of compositionality and its theory-relativity, introduces and discusses challenges to Montague's (1970/1974) ("UG") strong compositionality and opts for weak compositionality. She argues that the principle depends on the theory of meaning and of syntax; "well-motivated

[3] He added on my comments here in his e-mail to me: "One could equally well define synonymy in terms of the contribution that expressions make to the meanings of **discourses** (not sentences) containing them. Formally my setup allows this. I would very much welcome attempts to make this idea work in practice." Hans Kamp also very much wants to see the idea be pursued. Peter Pagin is also trying to think about it (see his relevant papers in his web). Hodges feels that there are real problems about making sense of the idea of meaning or in deciding what is the ''meaning' of a discourse, and not just artifacts of his setup.

constraints on syntax and/or on the mapping from syntax to meaning" may loosen the principle. For Montague, 'senses' are functions of only one argument, a possible world, as those intensional entities sometimes denoted by expressions, while 'meanings', as an algebra homomorphic to the syntactic algebra, are functions [of two arguments] from possible worlds and *context of use* for indexicality to possible denotations. Although Montague enriched 'meanings' this way for one bit of context-dependence, which Frege avoided, he has no provision for context-dependence effects "between parts of a single sentence," as Partee points out.[4]

In theories of grammar that posit "conceptual or semantic representations" such as Generative Semantics (McCawley 1970; Lakoff 1971), the expressions "built" syntactically are each assigned a meaning.[5] In this respect, Generative Semantics is regarded as a kind of "direct compositionality theory," although it has no model-theoretic interpretation for its initially syntactically computed semantic representations or "Logical Forms." The proponents of direct compositionality, relying heavily on type-shift, etc. set forth the slogan: "The syntax and semantics work together in tandem" (Barker and Jacobson 2007). They are against movement and postponing semantic interpretation until a later LF level, where Quantifier Raising occurs. Chomsky's sequential grammars (Chomsky (1975b), 'Extended Standard Grammar,' Government-Binding Theory, and the Principles and Parameters Theory) and Heim and Kratzer's semantics (1998) take the postponement position.[6]

Partee (1984) introduces Discourse Representation Theory (DRT) (Kamp 1981, Heim 1982) as another challenge to Montague's 'bottom-up' interpretations (as opposed to 'top-down' ones). She views that the 'global' properties of the intermediate level of 'discourse representations' (or 'file cards') are affected by some NPs from the syntactic structure. Indefinite NPs, interpreted as existentially quantified ultimately, show their existentially quantified variable scopes not locally or 'bottom-up' but globally over a whole discourse at times at the 'discourse representations.' At this rather less constrained symbolic representational level of box notation, *every* and *if* are more alike than *every* and *a*, quite unlike Montague's syntactic category-to-semantic type correspondences. The *if* introduces an "unselective" binder, a variably polyadic universal quantifier, giving rise to a new solution to the *donkey* sentence problem and posing a challenge to direct compositional model-theoretic interpretability at the same time.

Such dynamic models as DRT (and dynamic semantics in general to be discussed shortly), with less constrained symbolic manipulation, however, can be reformulated compositionally (as in Zeevat 1989). Kamp (2005) himself, not giving up a strong form of compositionality, treats lexical and structural ambiguities such as in *He ran out of the house/money* or *She caught the worm in the kitchen* as resolved in the context of the sentence, viewing them as conforming to composition-

[4] Cooper's (1975) "storage" mechanism, not adhering to the strong version of compositionality, generates multiple interpretations depending on quantifier scope, corresponding to a single syntactic structure, though still within the Montague framework.

[5] Katz and Fodor (1963), Katz (1972), Jackendoff (1972), etc. are similar but Jackendoff's partial surface structure interpretation is "less locally compositional."

[6] Chomsky (1975a) is somewhat skeptical towards compositionality because of the autonomy of syntax and the organization of grammar with independent subsystems.

ality.[7] In the case of scope ambiguities (particularly between quantifying NPs), as in (2), he feels the necessity of relaxing strict compositionality, allowing for the possibility that one syntactic derivation of expression E and one choice of lexical meanings is compatible with different meanings of E. Consider:

(2) At least two languages are spoken by everyone in this room.

On the basis of a systematic meaning-form connection, Kamp argues that local ambiguities regularly disappear at a more 'global' level incrementally.[8] So, (2) can be followed by either (2′) *So we even have a choice as to which language we pick for our discussion, so that everyone can understand and participate* or (2″) *But that doesn't mean there is even a single language that all of us understand.* But he does not seem to provide strict constraints on a possible range of scope ambiguities and their representations (whether a second position ∃ with wide scope must move out or not, etc.), simply defending strict compositionality with the aid of context filter reducing the set of different meanings of an expression. (2) is different from *run out of* or *in the kitchen*; it does not involve any lexical ambiguity or even any natural syntactic constituent structure ambiguity. Theoretical constructs such as 'storage,' 'quantifying-in,' 'traces,' 'gaps,' 'QR' and 'derivation' with the aid of contexts can resolve ambiguity.

Partee (1984) takes the example of generic vs. non-generic reading of DPs of identical surface form as ambiguity resolution by selection (since Carlson 1980) rather than a matter of sentence level, as traditionally believed. In other words, she is against those who object to compositionality by saying that often you cannot know the meanings of the parts without looking at the meanings of other parts. Partee thinks that genericness does not involve a 'sentence-wide' property but can be locally compositional with a compatible selection of either a generic kind subject or non-generic subject. The DP in (4), co-occurring with a stage-level predicate, denoting a transitory or ephemeral phase of event, is non-generic. Generative grammar posits an aspectual phrase AspP for a stage-level predicate like this to distinguish it from an individual-level predicate, which denotes a permanent property, as in (3). A non-stage- or individual-level predicate is compatible with a generic DP, as in (3). A generic statement is a Topic construction and the DP in this case functions as a Topic with an explicit Topic marker (*-nun*), whereas the DP in (4) simply takes a Nominative marker (*-ka*), with different information structure specifications, in Korean (K) and Japanese (J) (Lee 1996a). The selection restriction is more explicitly and perhaps more compositionally marked in K and J in this respect. The species vs. individual DP subject readings are ambiguously possible in (5) in English but the selection must be done by different marking in K and J and consequently no ambiguity arises in these languages. Selection restriction relation seems to require some semantic (and information structural) coherence.

[7] The PP *in the kitchen* is not even ambiguous in Korean and Japanese, where its association with the DP must be a relative clause. Analogously, *the worm in the kitchen* can be seen as a result of *WHIZ*-deletion. Otherwise, *in the kitchen* gets associated with the verb as an adverbial phrase.

[8] This reminds us of Cooper's storage, by which the interpretations of quantifying DPs are put in a storage (exempted from composition temporarily) until retrieved in a suitable wider context.

Thus said, not only *immediate* constituent parts but also sisterhood relation and further c-commanding relation as in Topichood may contribute to the meanings unlike in strict local compositionality. The same *the horse* in English is interpreted (and presumably structured) differently in the following and is ambiguous in (5):

(3) The horse is widespread. [generic]

(4) The horse is running. [non-generic] (modified from Partee's *is in the barn*)

(5) The horse is growing stronger. [ambiguous]

Partee also gives the examples of *any* sentences, paying attention to the ambiguous status of (7) between the 'weak' polarity-sensitive reading (Lee 1996b) and the free choice reading as witnessed in (6), although admitting Ladusaw's (1979) model-theoretic solution in terms of downward-entailingness as elegant. Constraints on free choice *any* are less clearly understood, though modality is clearly involved, and so far the inherent 'concessively scalar' mechanism (Lee 1996b) behind (giving rise to domain widening effect and strengthening (Kadmon and Landman 1993)) in strong and weak polarity and free choice has not been compositionally incorporated in English. But 'even' is posited for *any* in English in Y. Lee and Horn (1995) and similarly for *ever* in Heim (1984). Under a conditional, as in (7), *anyone*, as Indefinite – Nonspecific, predominantly receives an existential reading, whereas *anyone* in (7), because of the modal *can* gets universal force. Consider:

(6) Anyone can solve that problem.

(7) If anyone can solve that problem, I suppose Mary can.

The Korean counterparts of *anyone* in the above two sentences have the same weak polarity form, although the free choice one has a strong stress on the first syllable of *amwu-ra-to* 'anyone.' Thus, polarity-sensitive items have the same Indefinite plus *-to* 'even', with the distinction between strong and weak in form; the weak has an additional marker denoting a 'hypothetical' sense. The weak form with stress is employed for universal force of free choice. The three distinguishable subcategories belong to one 'nonveridcal' (to be discussed shortly) category. The three have distinct etic formal features in Korean in distinct contexts and have covert parts in English and are realized in one Indefinite form *any*, representing one emic category. Korean is more microscopally compositional. By incorporating 'even' in *any*, scalrity can be explained even in English. With the three (weak, strong, free choice) or two (polarity-sensitive vs free choice) distinct interpretations in distinct contexts, *any* can be compositional, contra Hintikka (1983).

Partee cites Keenan's (1974) claim that the interpretation of a function word may depend on that of its argument but not vice versa, as in *flat tire*, *flat beer*, *flat note*, etc., an extreme case being a minimum-content-verb like *do*. Although it appears so, she argues that the function word in a function $f(x)$, often defined disjunctively with {— if $P_1(x)$ or — if $P_2(x)$ or —otherwise, is not shown to have different meanings with different arguments. She indicates that the value or interpretation of the function symbol f is given by the whole and is compatible with

the 'independent interpretability of function-expressions and argument-expressions required by compositionality.' Partee is right in this respect and her argument reminds us of the qualia structure of Generative Lexicon (GL) Theory (Pustejovsky 1995) (to be discussed further). The qualia structure of lexical specification for, say, *build* consists of (a) the AGENTIVE act of build_act or process involving its first argument, which acts on its default argument **material**, which is linked to the CONSTITUTIVE role of the second argument of the verb (say, *a house*) in the first subevent, and of (b) the FORMAL role or quale, which shows the resulting substantive existence of the second argument **artifact**, as a result of **creating** process at its telic point in the second subevent of the complex event of *build*. All artifacts are created for some purpose and the third role or quale is a PURPOSE/TELIC role and that of *house* may be **live in**. All the artifact nominals have this quale. The qualia structure is then to find felicitous associations between such predicates (often covert) and their arguments. This applies to the logical polysemy with a core meaning of *fast* in *fast boat*, *fast typist*, *fast garage*, *fast game*, *fast book*, *fast driver*, *fast road*, etc. The purpose quale of each head noun is some predicate (verb) and fast applies to the verb that is the purpose role of the qualia structure of the artifact nominal in question. If the noun is not an artifact but a natural or functional kind, as in *red* (outside) *apple*, *pink* (inside) *grapefruit*, its CONSTITUTIVE role (part-whole relation) applies. The agent head noun *typist* also has the predicate *type* in it and selective modification by *fast* is quite possible now for the above *fast typist*. It is decompositionally compositional, in other words, which will be discussed shortly. A frequency adverbial *occasional* in the DP in the sentence *An occasional sailor walked by* can get an analogous solution.

Partee also points out Frege's non-restrictive relative clause example of non-literal 'added meaning' or conversational implicature such as 'because,' 'in spite of' in *Napoleon, who recognized the danger —, himself led his guards —*, which is not strictly compositional. The same thing happens in free/invisible variables, implicit arguments. Treating infinitives as VPs syntactically and providing a subject argument semantically, as done in most current syntactic theories such as LFG and HPSG, except the Minimalist Program, may become somehow compositional but would create a mismatch between syntax and semantics. Such mismatches abound in natural language. For weak compositionality, intermediate levels of representation and determinacy via linguistic **context** are proposed.

Partee's problem of absence of overt antecedent for cross-sentential anaphora is also intricate. An anaphoric relation between (b) and *It* is clearly odd in (8). Consider:

(8) I dropped ten marbles and found (a) all but one of them/(b) ?nine of them. It is probably under the sofa.

In (8), the first sentence with (a) and that with (b) must be truth-conditionally equivalent and if we insist they are synonymous, then it may appear to be a counterexample to compositionality. From the inferred meaning of 10–**1** = 9, 'one' is not the number of marbles the speaker found but it is exceptionally marked and becomes salient in the context in (a) but it has not shown up in (b) and 'nine of them,' the number of marbles found, is not salient enough to be connected to

the following expression and cannot bind the definite pronoun *It* yet. However, in 'They got married. *She* is beautiful' (Heim), *she* refers to the *implicit* bride; 'married' requires 'a man and a woman' as subject selectionally and 'they' includes 'he and **she**' in it, and this inferred antecedent seems to be more salient than the hidden 'one' in (8b). Topicality and contrast facilitate the link, as supported by psycholinguistic experiments.[9] We need a sequential cognitively justified dynamic, compositional conception of inferred implicit meaning for proper anaphor resolution. Partee's lifelong works, particularly since her type-shifting, all relevant to compositionality, have been collected under the title of *Compositionality in Formal Semantics* (Partee 2003).

Another challenge is about the following pair, where (9) is well translated into a first-order language of universal quantification and conditional but an analogous translation of (10), which I believe underlyingly involves negative polarity, into $[\sim \exists x(x \text{ goofs off} \rightarrow x \text{ will succeed})]$ is inadequate and a conversion to $\forall \sim$, as in $[\forall x(x \text{ goofs off} \rightarrow\sim (x \text{ will succeed}))]$, forces the negation into the consequent of the embedded conditional, 'shaking' compositionality (Szabó 2007).

(9) Everyone will succeed if he works hard.

(10) No one will succeed if he goofs off.

Depriving 'if' of its conditional meaning (Higginbotham 2004 argues 'if' in (10) is not conditional, with (10) meaning that there is no one whose goofing is compatible with his success, unlike (9)), we can make it mark a restriction on the domain of the quantifier, as follows:

(9′) Everyone who works hard will succeed.

(10′) No one who goofs off will succeed.

This lack of conditional, I assume, implies that the negative polarity-involved *no one* (*not anyone*) cannot be a case of universal quantification. It should start out as an existential minimizing numeral *one* with Indefinite *any* and Concessive *even*, to reinforce negation. But if the subject quantified DP involves 'most students,' as follows, the relativization of the conditional denotes a different set:

(11) Most students will succeed if they work hard.

(11′) Most students who work hard will succeed.

Sentence (11) states that those students who succeed if they work hard are most of the students in the contextually relevant domain. (11′) is different and a generalized

[9] Postal (1969) discusses a phenomenon called anaphoric islands with *Max is an *orphan* and he deeply misses *them*. (orphan = 'a child whose *parents* have died.') Ward *et al.* (1991) argue that pragmatic factors such as topicality and contrast facilitate comprehension of word-internal anaphors via psycholinguistic experiments. In a suitable context, an anaphor can refer to *parents* in *orphan*: 'I haven't got a mother,' said Johnny pathetically, staring at his ham sandwich. 'I'm an orphan.' 'Why, that's terrible, Johnny, when did it happen? You never told me you were an *orphan*.' Fitz was deeply concerned. 'I'm getting sort of used to it. *They* died when I was there. (*Ever after*; noted by Beth Levin)

quantifier theory for natural language is needed and 'if'-clauses under monotone-increasing/-decreasing quantifiers may pose a problem for compositionality in English, but only apparently, as discussed or hinted at above (see Higginbotham 2004).

Thus viewed, most examples that appear to pose a problem can be dealt with in a compositional way. Particularly, the contextualist line in philosophy of language advocated by Recanati (2011) calls for semantic flexibility that uses contextual 'modulation' for variant meanings of 'cut', 'drop', etc. in different linguistic and extra-linguistic contexts. It is not a 'threat' to compositionality, he argues, because the context is always finite and meaning stabilizes despite potentially unending meaning variation. However, more cross-linguistically semantic and information structural analyses are often needed for fairly well accepted semantic principles as stepping stones, avoiding 'modulation', which may be too powerful at times. .

3. Atomism vs. (Molecular) Decomposition

Fodor (1970, 1998), Fodor and Lepore (1992), Kintsch (1974) and other meaning theorists believe that simple expressions like words are non-decomposable and have no internal structure. The meaning (or concept) of *kill* is **kill** and that of *house* is **house**. For instance, Fodor (1970) objected to and criticized generative semanticists' (such as Lakoff, McCawley, Ross, Postal, Gruber, Dowty) lexical decomposition of *kill* to something like *cause to die*. But he took decomposition as syntactic paraphrasing with resulting predicates each modifieable unlike the original word. However, modifiability may depend on which constituent predicate/event has more weight or is headed; in (12) the process *act-cause* predicate/event is headed in the sense of Pustejovsky (1995) in his complex event analysis, whereas in (12) the result state event in some form must be headed.

(12) Last week, Brutus killed Caesar ($^{?}$*this week – *died this week*).

(13) a. Kennedy flew to New York for three days. (Lee 1973a)
b. Mary ran home for an hour. (Pustejovesky 1995)
c. My terminal died for two days. (Pustejovesky 1995)
d. nay terminal-un acikto cwuk-e iss-ta/*cwuk-ess-ta
my terminal-TOP still dead-E exist-DEC/*die-PAST-DEC
(Korean)

'My terminal is still dead/*still died.'

In (12), the entire complex transitional event of process and result state, though with the process event headed, as opposed to Davidson's single event argument thesis, can be modified by a time adverbial. Here, the object Theme's existence and being alive is presupposed, change of state arises by the causation process (Lee 1973b) and there is no need for duration in the headless result state event. But in (13a, b), the result state event is headed and because of the Goal argument with to (overt or covert), *be_at* is underlyingly involved. The Korean translation of (13a) is something decomposed like 'Kennedy WENT BY PLANE TO New York

and WAS (or EXISTED) there for three days' (in Korean, humans cannot FLY in selection). I claim that the motion predicate with the Goal preposition *fly to* has an inertia result state predicate *be*, *stay*, or *exist* at the specified Location underlyingly. The Goal preposition *to* or Location preposition *at* is not sufficient for allowing duration adverbials, as done in all the literature. Furthermore, we can posit an internal causation predicate for agentive intransitive verbs such as *run* for cases like *Mary ran herself ragged* as opposed to **Mary arrived herself ragged/exhausted*, which has an unaccusative verb. In (13b), without decomposition the duration adverbial must modify the process of running (and so many non-native speakers who lack semantic competence falsely understand that way). The event consists of e_1[*run*(*m*)] and e_{2*}[*be_at_home*(*m*)] (unlike Pustejovsky's simple [*at_home*(*m*)] without a predicate). Therefore, in (13c), again the duration adverbial *for two days* modifies not the process of inchoation BECOME but the state of (BEING) DEAD. This distinction is justified by (13d), where *still* (and *for two days* in Korean) applies to the state *dead* but not the inchoative process verb *die*, as in the translation and in Korean. Therefore, in generative semantics, the underlying structure of (12) was suggested as:

(14) [Brutus DO SOMETHINGx (X CAUSE (BECOME (NOT (Caesar ALIVE))))]

It was meant to be a composition of abstract 'semantic units' (ideally meant to be primitives as theoretical constructs) corresponding roughly to the words in question. Lexicalization was performed systematically by 'predicate raising' (McCawley 1968, 1994) such as NOT-ALIVE (=dead), BECOME (NOT–ALIVE/dead) (=die, $\lambda y \lambda e$ BECOME-DEAD(y) (e)), or CAUSE (BECOME (NOT-ALIVE))/die) (=kill). Crosslinguitically a variety of possible combinations are realized out of these concepts and this fact can better be explained by decomposition. In Korean and a vast number of languages, there is no single morpheme transitive verb 'kill' but a combination of an intransitive verb 'die' and a causative morpheme 'cause' for the same transitive meaning of 'kill,' as in *cuk* 'die'+ *i* 'CAUSE' = 'kill' in Korean. Facing these linguistic facts, decomposition is advantageous. Across languages, the same states of affairs are expressed by different vocabulary items in decompositional relations, e.g., *Mary galloped the horse* ≒ *Maria liess das Pferd gallopieren* (German). The realization of argument types is predicted. Basque lacks the intransitive verb 'to die' and a sentence with the transitive verb *hil* 'kill' such as *Itziar hil da* can have a middle, passive and reflexive (suicide) meaning (Wunderlich 2004). The transitive verb *bring* was also decomposed into CAUSE to come to explain the parallelism between even idiomatic combinations with *come* (*come about*, *around*, *to*, —) and their counterparts with *bring* (Binnick 1971). Dowty's (1979) Montague lexical semantics, Jackendoff's (lexical) conceptual structure theory, Wierzbicka's universal semantic primitives theory, Hale and Keyser's (1986) theory, minimalist program (with *v*P for light verbs), and Pustejovsky's generative lexicon theory all adopt some form of lexical decomposition approach.

On the other hand, atomists argue that the simple and its 'corresponding' 'underlyingly' complex but element-by-element derived surface forms do not have the same meanings. If we stick to the functionalists' claim that if forms are different their meanings are different (Bolinger 1977), whatever meanings they may be,

it is true. But decompositionalists' initial response was that the captitalized constituent elements in (14) brought about by decomposition were abstract conceptual theoretical constructs (and must be lexicalized into corresponding simpler forms step by step). Later it was argued that even such non-truth-conditional meaning discrepancies on the surface can be well explained by a version of Grice's maxim of manner by which a simple surface form is preferred to a complex alternative unless the latter reveals a peripheral instance of the cagtegory, e.g., using **indirect** means for causing Caesar to die (McCawley 1994). This kind of explanation by means of implicatures is widely exploited even independently of decomposition.

For atomists, words are not definable and (15a) may not entail (15b) in a meaning relation, just as (16a) entails (16b) without a lexical entailment relation because necessity does not entail analyticity (Kripke 1980, Fodor 1998) (see Davis and Gillon 2004).

(15) a. Sam is a bachelor.
b. Sam is an unmarried human adult male.

(16) a. Two is an even number.
b. The even prime number is an even number.

In ordinary language, a lexical item with complex concepts is decomposable into simpler and easier terms and surely (15a) entails (15b). Apparent circularity is practically avoided. The relation between *two* and *even prime number* is different and of mathematical structure. Quine and Fodor's worries about such "unclear" and "circular" notions as analyticity and synonymy, and their holistic idea of comparing against the world as the wholes, leave them atomistic. But human beings are instinctively curious about its ultimate constituent concepts if a lexical item is a composite of complex concepts. Lexical items and their decomposed constituents are typically structurally related, e.g., in *bachelor* vs. *spinster*, *widow* vs. *widower*.[10] However, we must be careful about an unconstrained meaning postulate of *bachelor* (even when decomposed) as a conjunctive meaning of $\lambda x[unmarried(x) \wedge human(x) \wedge adult(x) \wedge male(x)]$. For the meaning of *bachelor*, ordinarily, *unmarried* is assertive, essential, focal or foregrounded, whereas *human*, *adult* (or*be in marriageable age*), and *male* are prerequisite or presuppositional. Something like *headedness* (weight) assigned to constituent subevents of verbal predicates may have to be also applied to such constituent common noun predicates. Therefore, (17a) alone makes sense and if *Sam* happens to be known as *human*, *adult*, and *male*, as in (17b), it is equivalent to (15a).

(17) a. Sam is unmarried.
b. Sam is human, adult and male.

[10] They also constitute semi-join lattices in ontology and show entailment relations and at times cross-classificatory features in the hierarchies. Therefore, some analog of compositionality must be involved even here. A partially ordered set $< A, \leq >$ is a join semilattice if $a \vee b$ the join of a and b exists for any elements a and b, as *a bachelor* or *spinster* is *an unmarried human* at their immediate top node.

Other constituent elements come forward only in contrastive situations, e.g., a group of *bachelors* and a group of *spinsters* (*unmarried human adult female*) played a game and the final verdict is *The winner is bachelors* or *The bachelors won*, then the *male* feature becomes salient (e.g., *The winner is unmarried* is true but not informative at all and even odd). In this sense, information structure (given-new, foregrounded-backgrounded) must be taken into account.

One interesting lexical semantics model, GL Theory, is heavily and widely 'decompositional' but is not necessarily based on the assumption of a fixed set of semantic *primitives*; rather it is based on that of a fixed number of *generative devices* such as coercion, selection and co-composition. The GL decomposition ranges from parametric decomposition adding additional arguments, simple predicative decomposition of *die* and *bachelor* into a complex expression of subpredicates over the parameter, and full predicative decomposition of *kill*, event decomposition involving event headedness, argument covering and qualia saturation even to "supralexical" decomposition, which is important in enriching parameter structure through additional operations. Pustejovsky (2005) argues that **decompositionality** 'enables' **compositionality** contra Fodor and Lepore's (FL) (1998) attack on his theory from an atomistic view. FL argues that if the lexicon is constrained to show "interlexical relations," as in decomposition, then, it is neither atomistic nor purely denotational. GL treats the polysemy of *bake* and other words importantly in terms of predicate argument relations. If the object argument happens to be a natural kind individual like *a potato*, its meaning becomes its basic meaning of change of state of 'warm up' or 'heat,' whereas if the object happens to be an artifact like *a cake*, it comes to have the concept of creation (18).

(18) a. Mary baked a potato. [change of state]
b. Mary baked a cake. [creation]

FL denies this, saying that the verbs have separate meanings, not the object nouns. However, GL represents the **bake_act** Agentive qualia role in the (18a) *bake* and the common noun predicate *cake* as an artifact also has the same **bake_act** AGENTIVE qualia role. By function application with qualia unification of qualia structures of expressions α and β, $QS_\alpha \Pi QS_\beta$ comes out as the unique greatest lower bound. Likewise, co-composition results in a VP level semantic representation of *bake a cake* with the creation concept of the FORMAL qualia role of *cake existing* in the result subevent. Simply speaking, the basic change of state meaning of 'warm up' may be metonymically extended to the creation (resulting from 'warm up') meaning. This line of approach is also supported by Wilks (1998), who attacks FL, giving the examples 'a *baked potato*' vs. ungrammatical 'a *baked cake*.' The latter, however, can be all right only if the process of *baked* is modified like 'a well baked cake' and 'a well built house,' but not 'a built house.' For FL, there are two different processes of *bake*: warming up and creative. For Wilks and other 'Inferential Semantics Role'[11] researchers, (19) is received for *want* with an artifact

[11] Inferential role semantics, somewhat opposed to truth-conditional semantics, was attacked by Fodor as holistic and relates meaning with use, influenced by Ludwig Wittgenstein's later philosophy. Some focus on the representation's role in the mind of the agent rather than external factors.

object. Observe:

(19) X wants Y ⇒ X wants to do with Y whatever is normally done with Y.

If *I want a rest* is *I want to have a rest*, *have* here is not possession contra FL, according to Wilks. Of course, there is a big controversy between the claim that this kind of 'normal or default use' should be stored in the lexicon and the claim that it is non-lexicon pragmatic knowledge. However, for aspectual verbs like *begin* and others, having the TELIC (purpose) qualia role for filling predication in the lexical specification is more reasonable. Some non-normal contextually idiosyncratic use should be pragmatic, as I claim. If we adopt the action philosophy process of desire, belief and action, *want* is an expression of desire and a malignant speaker of *I want a beer* may believe that throwing the bottle of beer will hurt that guy. Then, the *beer* in that situation has no TELIC (purpose) quale of *drink* and must be interpreted pragmatically.

FL is against semantic well-formedness constrained on lexical entries and repeats GL examples like (20a), saying that if a contextual clue is given and she began to paint its perplexity vanishes. Perplexity arises exactly because a *rock* is a natural kind, associated with no TELIC (purpose) or AGENTIVE qualia role for predication. A very non-normal context can save it pragmatically. In (20b), the subject *God* is a creator. Then, *oceans* and *rocks* must be creatures having the AGENTIVE quale predication. Hence (20b) is semantically well-formed.

(20) a. ?Mary began the rock.
b. Having finishesd the oceans on Monday afternoon, God began the rocks on Tuesday morning.

In GL, words encode local context as typing information. Because the aspectual verb *begin* requires not an individual type but an event type, the surface NP object must be coerced in typing.[12] If someone says, 'Goats eat anything. That goat began the book,' coercion must apply but the lexically specified TELIC (purpose) qualia predication *read* of *book* does not help and an idiosyncratic context must give a clue for the right predicate, *eat* here. The noun *book* may have *paper* as its CONSTITUTIVE quale in the lexical specification and a goat is likely to eat the paper (physical object) of the book rather than its information in a dot object operation. A lexicon with meaning explanations and causal and inferential relations (often metonymy/metaphor-motivated) must be more helpful (in AI applications) and interesting (in theoretical Linguistics) than a lexicon full of "dog" -DOG, etc. with denotational intents, or 'empty,' as advocated by atomists.

Decomposed complex concept items can be compositional in the reversed direction of decomposition.

[12] Putejovsky (e-mail p.c.) comments: "... FP's arguments about other interpretations for how something is begun or enjoyed is exactly what GL allows. In no way is this a counterexample but in fact strengthens the GL position that there is coercion in the first place. This is a separable issue from whatever default interpretation one wants to supply to the complement reading. This has always been the position from 1991 within GL actually."

4. Compositionality of Thought (?)

Fodor (2001) tries to establish the thesis that thought rather than language has content via the argument that language is not compositional. But his (1975) Language of Thought Hypothesis postulates that thought takes place in a mental language (mentalese) in a symbolic system of representations that is physically realized in the brain of the organism and has a combinatorial syntax. Thinking thus consists in syntactic operations defined over such representations. Therefore, scholars such as Jensen (2002), just like Pagin above, takes issue with his contradictory rejection of the compositionality of natural language. Fodor even goes so far as to suggest the semantics of English is a study of nothing and that it is the semantics of thought. Jensen naturally asks: 'how do we know that thought is compositional? Rather, the compositionality of language is being used as evidence for the compositionality of thoughts. Some identify thinking with cognition, with a Turing-Machine model of thinking or with no space for rational deliberative thinking working with low-level cognitive processes such as perception and categorization within the micro-cognition perspective. Another position is viewing thinking as a special kind of cognition in cognitive science or specifically as an inferential process sensitive to the constituent structure of representations, still compositional but not necessarily language-like, not necessarily digital but analogical, though mereologically and combinatorily structured (at least for animals and babies) (Poirier and Hardy-Vallée 2005). Analogical representations are photographic or pictorial; a representation that s is F is analogical if it carries other information besides s's being F; modal, continuous, particular, iconic and holistic while digital ones are amodal, discrete, general, symbolic and structured. Dretske (1981) says: "a representation that s is F is digital insofar as it carries nothing else than s's being F." Devlin (1991) adopts this distinction.

The Language of Thought hypothesis on sentential or propositional thought content does not have much to say about the nature of some image-like mental phenomena such as **subjective feelings**, sensory processes, mental images, visual and auditory imagination, perceptual pattern-recognition capacities, dreaming, hallucinating, etc. Connectionists have more to say about them and connectionists in general including Smolensky (1989, 1995) and Chalmers (1993) think their representations are structured without classical computation. Their proposal for non-concatenative constituent structure exploits so called **distributed representations**, using vector (and tensor) algebra in **composing** and **decomposing** connectionist representations which consist in coding patterns of activity across neuron-like units which can be modeled as vectors.[13] Their constituent structure is largely implicit (see Avdede (2004). Fodor's argument against connectionism has been based on compositionality.

Fodor also argues against the prototype theory of concepts by means of com-

[13] De Hoop *et al.* (2007) argue that compositionality is bi-directional optimization. Although they allude to Smolensky's (1991) 'weak compositionality' based on vectors and van Gelder's (1990) functional or non-concatenative compositionality, their example *Most people drink/sleep at night* seems to call for an informational structural analysis via presuppositional/given/topical vs focal/new/informational above all.

positionality. A complex concept often has emergent properties that don't derive from the prototypes of its constituents, e.g., PET FISH encodes properties such as brightly colored, which have no basis in the prototype structure for either PET or FISH. STRIPED APPLE is another instance. A suggested solution is to hold that a prototype constitutes just part of the structure of a concept. Kamp and Partee (KP) (1995) criticize Osherson and Smith's (OS) (1981, 1984) attack on prototype theory of conceptual gradation allegedly to be severed from compositionality, attributing most problems raised there to difficulties intrinsic to fuzzy set theory, in terms of which OS analyzed concept combination. KP suggests some union of prototypicality of concept combination and compositionality via a supervaluation approach to vague concepts. KP gives different types of adjective-noun combinations, as in (20).

(21) a. intersective: $\|\text{carnivorous}\| \cap \|\text{mammal}\|$, good for extension
b. subsective: $\|\text{skillful}\| \subseteq \|\text{surgeon}\|$, 'Mia is a skillful surgeon' and 'Mia is a violinist' $\nrightarrow$ 'Mia is a skilllful violinist'
c. privative and other nonsubsective: $\forall x[\textit{fake-gun}'(x) \rightarrow\sim \textit{gun}'(x)]$; an *alleged murderer* may or not be a *murderer*.

(22) Is that gun real or fake?

From (20c), if the sentence happens to be (21), it is well-formed and interpretable. Partee (2005?), therefore, hypothesizes that we expand the denotation of 'gun' here to include both fake and real by coercion. Then, *fake* in the predicate would be privative and *real* would be redundant, as also noticed by Lakoff (1987). In my view, the Topic definite description *that gun* has a referential use as opposed to a descriptive use (Donnellan 1971) and is successfully referential, no matter whether it is descriptively adequate or not (it can be potentially fake; the man in *the man who is drinking a martini* can actually be drinking water but *the man* has been successfully referred to). A vague gradient adjective such as *tall* is intersective but context-dependent. KP proposed a number of principles for the 'recalibration' of adjective interpretations in context such as (22).

(23) **Non-vacuity** principle
a. Bob is a man and not a man.
b. This apple is either red or not red.

In classical logic, (22a) is a contradiction and (22b) is a tautology. But when we first hear these sentences we tend to interpret them logically, only to realize they are non-informative. Then, we backtrack and look for informative messages, employing Gricean inferences and get an interpretation for (22a) such as 'Bob is a man (with respect to age and gender) and not a man (in some other respects, such as in 'manliness,' etc.) in context. A context-dependent weakened compositionality is necessary. A reduplication of identical words such as *salad-salad*, a Contrastive Focus Dynamic Prototype (Song and Lee 2011), is not a vacuous meaningless repetition and seems to be another case of non-vacuity.

An initially serious semantic anomaly arises from a copula construction such as (K) below. The predicative copula initially requires some identification or set inclusion relation between the predicate nominal and the subject, which is grossly violated on the initial reading. Backtracking, we can find an informative interpretation from the context and the topic marker *–nun* such as '[What I ordered (Top)] (is a pizza).' (K) is also possible in Japanese, French and many other languages.[14]

(K) nan–nun pizza–i-a
I–TOP pizza-COP-DEC
'I am a pizza.'

(24) **Head primacy** principle
a. giant midget (a midget, but an exceptionally large one)
b. midget giant (a giant, but an exceptionally small one)

In combinations in (23) or *red brick* vs. *brick red*, one first interprets the head noun and then 'recalibrates' the modifier adjective as necessary in the context. The head principle is non-absolute and the head noun can be coerced by a privative adjective like *fake* or be shifted to a 'representation' meaning from its literal one by 'constitutive material' modifiers, as in *stone lion*. Here, Partee suggests some constraint hierarchy in Optimality Theory between head primacy and non-vacuity: For privative modifers and 'representation' cases, non-vacuity wins, overriding head primacy. KP hopes for a compositional theory of concept combination with prototype theory as a component compatible with the logic of vague concepts.

Gärdenfors (2000) proposes an interesting geometrical structure model of concept combination, using domains of quality dimensions and their relevant regions for certain concepts. Representing the 'apple' regions verbally, he gives (24).

(25)

Domain	*Region*
Color	Red-yellow-green
Shape	Roundish (cycloid)
Texture	Smooth
Taste	The sweet and sour dimensions
Fruit	Specification of seed structure, flesh and peel type, etc.
Nutrition	Values of sugar content, vitamins, fibres, etc.

The relative weight of the different domains is dependent on the context and the concept representation contains information about the prominence of the domains, which determine associations and inferences in the use. If you are eating an apple, its taste will be more prominent (the purpose quale of an apple in GL is eat but this predication information is not in this model) than its shape if you are using an apple as a ball idiosyncratically when playing with an infant. A *pink elephant* in combination, *pink* "revises" *elephant* (*elephant* normally takes the grey region of the color domain and such revisions will result in non-monotonic effects of the contents of the concepts). Gärdenfors uses the effect of **contrast classes**.

[14] I thank a reviewer's pointing to this issue.

When combinations are not intersectively extensional, *red* would denote *tawny* when predicated of skin, as in *red skin*, then, a contrast class of skin colors takes a subspace embedded in the full color spindle. In the smaller spindle, the color words used in the same way as in the full space don't match the hues of the complete space, 'white' being used about the lightest forms of skin, even though it is pinkish, 'black' being used to denote the darkest, brown. Change in prominence in folk taxonomy results in a recategorization of bats and whales as mammals. This model may be compatible with compositionality but does not discuss the matter.

Computer scientists, attracted by comositionality since the inception of a formal semantics in programming, favor denotational semantics, which follows logic. I touch upon computer programming here because it is a naïve, practical and systematic implementation of logic. Here compositional meaning assignment is done via compositional translation into a logic (Janssen 1997). Logic is compositional. The complexity of a network of cooperating systems is possible via compositionality. Natural language translation is done by isomorphic algebras, e.g., in an algebra E for English an operator $R_{E,2}$ takes as input a positive sentence and yields its negation (25a) and the simpler Dutch operator $R_{D,2}$ yields a Dutch negative sentence (25b).

(26) a. $R_{E,2}$ ($R_{E,1}$ (Peter, to sing)) = Peter does not sing.
b. $R_{D,2}$ ($R_{D,1}$ (Peter, zingen)) = Peter zingt niet.

The term of the algebra, the left hand side of (25a) and (25b), represents a derivation of an expression. $R_{E,1}$ first applies to the generators, *Peter* and *to sing*, and next $R_{E,2}$ applies to its result, *Peter sings*, which is just like *Peter zingt*. The term algebras (derivations) of (25a) and (25b) are isomorphic. Janssen states that such algebras are designed but not discovered as properties of the mind. But he admits that the design of the algebras is guided by semantic insights, which must be the function of the mind. He adopts Montague's idea that natural languages and the artificial languages of logicians and computer scientists are theoretically alike and can be comprehended within mathematical theory. But some other computer scientists think it is not efficient to adhere to compositionality, opting, for instance, for a noncompositional, ontologically poorer arrays-subscripts system with no meaningful parts in programming languages.

5. Compositionality of Non-linguistic Areas

How about a nonlinguistic area of gestures? Corina et al (1992) presented an interesting comparison between disorders of sign language and those of gestures. They observed that the left-hemisphere lesion of a deaf signer produced a marked sign language aphasia in both production and comprehension. But the ability to communicate in nonlinguistic gesture was remarkably spared. The latter was in sharp contrast to the breakdown of a sign language and they argue that the differences in the fractionation of linguistic versus nonlinguistic gesture 'reflect differing degrees of compositionality of systems underlying language and gesture.' The compositionality thesis refers a hierarchically organizational principle in which basic meaningful units such as phonemes and morphemes are constructed from a set of recurring

lower elements to form syntax and discourse. Phonemic paraphasias in sign language production illustrate structural dissolution which is absent in pantomimic gesture and are supportive of compositionality. Such investigations seem to be a first step to understanding the neural encoding of compositional motoric systems, leading to an anatomical account of the neural separability of language and gesture for significantly differing degrees of compositionality. Pantomimic gesture is also intentional for communication but is not systematically structured.

In a rather novel area of music, it has long been agreed that there is a grammar of music and generative or formal grammars of music have been proposed (Lerdahl and Jackendoff 1983, etc.) although such grammars have lagged behind the linguistic ones in various aspects including harmonic analysis (Steedman 1996). However, tonal music is compositional in Horton's (2001) theory with respect to tonal harmonic functions of pitch events. The structural units of tonal music are taken to be functionally-determined parts (S 'Subdominant' + D 'Dominant' = DP 'Dominant Phrase'; DP + T 'Tonic' = TA 'Tonic Articulation'; T + TA = TP 'Tonic Phrase,' forming a tree of binary branching hierarchy) and thereby tonal structures exhibit compositionality. Horton thinks meaningful properties of tonal music emerge from its functional-harmonic content entailing a model-theoretic approach to semantics for tonal music, alluding to Raffman's (1993) 'feelings and sensations (such as tension and relaxation)' or more radically functional-harmonic content itself, as in Steedman (1996), as the semantic component. Horton claims that the model-theoretic interpretation of tonal structures is non-conceptual, unlike that of linguistic structures. Huntley (1984) also argues that music has non-conceptual content. Then, we can wonder if *Baby Elephant Walk* composed by Henry Mancini is conceptual. The composer may have intended so and we can have that kind of association but theorists seem to argue that it is impossible to get that kind of specific conceptual content without the title information. Associations seem to be more abstract, vague, and varied. How about animals? Hurford (2007a, b), based on the relevant literature on animal experiments, suspects some early emerging proto form of compositionality in aninmal calls of chaffinches and coqui frogs. Chaffinches' territorial calls deter males and their mating calls attract females, with the two different kinds of calls combined. In the case of coqui frogs, 'co' deters males and 'qui' attracts females. Their combined calls, however, are "not interpreted as a function of the meanings of their parts by any single hearer." Thus, Hurford admits that human language is unique among animal communication systems in having expremely complex semantically composional signals, although he buys into the jargon of animal 'cognition,' 'mental representations,' 'proto-concepts,' 'proto-propositions, etc., projecting an evolutionary path from holistic to compositional from his pro-Darwinian, anti-Cartesian or "adaptationist" (in the contrast by Chomsky (2006)) perspective. By this hypothesis, the language faculty is a complex biological adaptation that evolved by natural selection for communication (Pinker 2003). Penn, Holyoak and Povinelli (2008) show an opposite view on the cognitive capacities of apes, finding a massive discontinuity between ape and human forms of cognition, reanalyzing findings similar to those cited by Hurford; apes and other hon-human species cannot perceive higher-order relationships such as transitive inferences and hierachical structuring (Bick-

erton 2007). Animals lack representational drawing and tap-dancing, which do not require language. The authors underline a profound discontinuity between human and non-human minds. This line of thinking may only be compatible with the 'saltationist' hypothesis, often referenced to Chomsky (2006), according to whom the language faculty more probably arose "through some slight genetic event that brought a crucial innovation" by which "the brain was rewired, perhaps by some slight mutation, to provide the operation Merge" (Chomsky (2006: 184); hence, recursion).

6. Concluding Remarks

So far, we have discussed language, thoughts, concept combination, computing, gesture, music, and animal cognition in connection with compositionality. Most experts in these fields other than language try to defend compositionality but they admit that their claims are rather tentative and that further research is needed.

In natural language and other representational areas, compositionality is regarded as necessary, even if a weakened version is applicable because of contextuality. Janssen (1997) cites Hintikka's game interpretation of logic as an exception, saying that it does not work compositionally bottom up, but proceeds top down. When a subformula is interpreted, context information comes to be available that way. Hintikka gives the example of *any*, which varies in force in different contexts. But Partee suggests a compositional solution, arguing that *any* is ambiguous in sentences like (5) above, as we examined. Janssen considers Situation Semantics as compositional, establishing a relation between an utterance and a situation described and a relation between the subject NP for an individual and the VP for a property. He also considers texts as a special area, taking the hermeneutic method as an approach in which both going from the part to the whole as well as going from the whole to the part play a role. DRT is a theory of semantic representations of texts, a system for compositionally constructing (psychologically relevant) representations, but not for compositional semantics (Janssen). Even for game theory and discourse (texts) theory, we can think of Pustejovsky's supra-lexical decomposition (for some top down way), opening up the possibility of ultimate compositionality (cf. Jacobson 2002).

Compositionality, whether flexibly conceived or not, is crucially involved in linguistic semantics dealing with not only the at-issue content in sentences but also the not-at-issue meanings such as implicatures and presuppositions in discourse and pragmatics, for which multi-propositional theory (by Kaplan, Neal and Bach) and multi-dimensional theory (Potts 2005) have been proposed. By a recently conducted 'Literary Lucy' experiment, generalized conversational implicatures were found to be significantly distinct ($p < 0.001$) from WHAT IS SAID such as entailments, contradictions and necessary contextual elements (indexicals, ellipsis and anaphor resolution) (Larson *et al.* 2007). A weaker version of compositionality should treat not only *immediate* parts but also neighboring constituents and *non-articulated* parts such as implicatures and presuppositions. Such compositionality may be also involved (to a certain degree) in all other (even non-human) representational systems, revealing the relation between representation and mind as a

constantly guiding principle, still posing tantalizing research issues.

References

Barker, Chris and Pauline Jacobson. 2007. *Direct Compositionality.* New York, NY: Oxford University Press.

Barsalou, Lawrence. W. 1999. Perceptual symbol systems. *Behavioral & Brain Sciences* 22, 577–660.

Bermudez, Jose Luis. 2003. *Thinking Without Words.* Oxford: Oxford University Press.

Bickerton, Derek. 2007. Did syntax trigger the human revolution? In Paul Mellars *et al.* (eds.), *Rethinking the Human Revolution: New Behavioural and Biological Perspectives on the Origin and Dispersal of Modern Humans.* Cambridge, UK: McDonald Institute for Archaeological Research.

Binnick, Robert. 1971. Will and be going to. In *Papers from the Seventh Regional Meeting, Chicago Linguistic Society.* Chicago, IL: Chicago Linguistic Society.

Bolinger, Dwight. 1977. *Meaning and Form.* London: Longman.

Carlson, Gregory 1980. *Reference to Kinds in English.* New York: Garland.

Casati, Roberto and Achille Varzi. 1999. *Parts and Places.* Cambridge, MA: The MIT Press.

Chalmers, David. 1993. Connectionism and compositionality: Why Fodor and Pylyshyn were wrong. *Philosophical Psychology* 6 (3), 305-319.

Chomsky, Noam. 1975a. *The Logical Structure of Linguistic Theory.* Chicago, IL: University of Chicago Press.

Chomsky, Noam. 1975b. *Reflections on Language.* New York, NY: Pantheon.

Chomsky, Noam. 2006. *Language and Mind.* Cambridge, UK: Cambridge University Press.

Cooper, Robin H. 1975. *Montague's semantic theory and transformational syntax.* Unpublished U. Mass. dissertation (Amherst).

Corina, David, Howard Poizner, Ursula Bellugi, Ursula Bellugi, Todd Feinberg, Dorothy Dowd, and Lucinda O'Grady-Batch. 1992. Dissociation between linguistic and nonlinguistic gestural systems. *Brain and Language* 43, 414-447.

Davis Steven and Gillon Brendan. 2004. *Semantics: A Reader.* Oxford: Oxford University Press.

Devlin, Keith. 1991. *Logic and Information.* Cambridge, UK: Cambridge University Press.

Donnellan, Keith. 1971. Reference and definite descriptions. In Danny D. Steinberb and Leon A. Jakobovits (eds.), *Semantics: An Interdisciplinary Reader*

in Philosophy, Linguistics and Psychology. Cambridge, UK: Cambridge University Press.

Dowty, David. 1979. *Word Meaning and Montague Grammar.* Dordrecht: Reidel.

Dretske, Fred. 1981. *Knowledge and the Flow of Information.* Cambridge, MA: The MIT Press.

Fodor, Jerry Alan. 1975. *The Language of Thought.* Cambridge, MA: Harvard University Press.

Fodor, Jerry Alan. 1998. *Concepts.* Oxford: Oxford University Press.

Fodor, Jerry Alan. 2001. *The Mind Doesn't Work That Way: The Scope and Limits of Computational Psychology.* Cambridge, MA: MIT Press.

Fodor, Jerry Alan and Ernie Lepore. 1998. The emptiness of the lexicon: Reflections on James Pustejovsky's *The Generative Lexicon. Linguistic Inquiry* 29, 269-88.

Fodor, Jerry Alan and Zenon Pylyshyn. 1988. Connectionism and cognitive architecture: A critical analysis. *Cognition* 28, 3-71.

Fodor, Janet Dean, Jerry Alan Fodor, and Merrill Garrett. 1975. The psychological unreality of semantic representations. *Linguistic Inquiry* 6, 515-32.

Frege, Gottlob. 1892. 'Über Begriff und Gegenstand', Vierteljahrschrift für Wissenschaflliche Philosophie, XVI. Translated as "On Concept and Object" In Peter T. Greach and Max Black (eds.), *Translation from the Philosophical Writings of G. Frege.* Oxford: Oxford University Press.

Gärdenfors, Peter. 2000. *Conceptual Spaces - The Geometry of Thought.* Cambridge, MA: Bradford Books, MIT Press.

van Gelder, Tim. 1990. Compositionality: A connectionist variation on a classical theme. *Cognitive Science* 14, 355-364.

Hale, Kenneth and Samuel Keyser. 1986. Some transitivity alternations in English. *Lexicon Project Working Papers* 7. Cambridge, MA: MIT Center for Cognitive Science.

Heim, Irene. 1982. *The semantics of definite and indefinite noun phrases.* Ph.D. thesis, University of Massachusetts-Amherst.

Heim, Irene and Angelika Kratzer. 1998. *Semantics in Generative Grammar.* Oxford: Blackwell.

Hintikka, Jaakko. 1983. Semantical games, the alleged ambiguity of 'is' and Aristotelian categories. *Synthese* 54, 443-467.

Hodges, Wilfrid. 1998. Compositionality is not the problem. *Logic and Logical Philosophy* 6, 7-33.

Hodges, Wilfrid. 2005. From sentence meanings to full semantics. Ms. Queen Mary, University of London.

De Hoop *et al.* 2007. Semantic aspects of differential object marking. In: Estela Puig-Waldmüller (ed.), *Proceedings of Sinn und Bedeutung* 11, 568–81. Universitat Pompeu Fabra, Barcelona.

Huntley, Martin. 1984. The semantics of English imperatives. *Linguistics and Philosophy* 7, 103-134.

Hurford, James. 2007a. *The Origins of Meaning: Language in the Light of Evolution.* New York, NY: Oxford University Press.

Hurford, James. 2007b. Syntax, semantics, and cognition: invited talks at the Institute for Linguistic Research, at Seoul National University, Seoul, Korea.

Jackendoff, Ray. 1972. *Semantic Interpretation in Generative Grammar.* Cambridge, MA: The MIT Press.

Jacobson Pauline. 2002. The (dis)organization of grammar: 25 years. *Linguistics and Philosophy* 25, 601-626.

Janssen, Theo. 1997. Compositionality. In Johan van Benthem and Alice ter Meulen (eds.), *Handbook of Logic and Linguistics.* Amsterdam: Elsevier.

Kadmon, Nirit and Fred Landman. 1993. Any. *Linguistics and Philosophy* 16, 353-422.

Kamp, Hans. 1981. A theory of truth and semantic representation. In J. A. G. Groenendijk, T. M. V. Janssen and M. V. J. Stokhof (eds.), *Formal Methods in Study of Languages.* Mathematical Centre Tracts, Amsterdam.

Kamp, Hans. 2005. Dynamic Semantics: Principles for the incremental Interpretation of discourse and text. Paper presented at the International Conference on Lexical Semantics and Prgamatics, Shanhai.

Kamp, Hans and Barbara Partee. 1995. Prototype theory and compositionality. *Cognition* 57, 129-191.

Katz, Jerrold. 1972. *Semantic Theory.* New York, NY: Harper & Row.

Katz, Jerrold and Jerry Fodor. 1963. The structure of a semantic theory. *Language* 39, 170-210.

Keenan, Edward L. 1974. Logic and language. In Morton Bloomfield and Mortonand Einar Haugen (eds.), *Language as a Human Problem*, 187-196. New York, W.W: Norton and Company

Kintsch, Walter. 1974. *The Representation of Meaning in Memory.* Oxford, England: Lawrence Erlbaum

Kripke, Saul. 1980. *Naming and Necessity.* Cambridge, MA: Harvard University Press.

Ladusaw, William A. 1979. *Polarity sensitivity as inherent scope relations.* PhD thesis, University of Texas, Austin

Lakoff, George. 1971. On Generative Semantics. In Danny David Steinberg and Leon A. Jakobovits (eds.), *Semantics: An Interdisciplinary Reader*, 232-296. Cambridge: University Press

Lakoff, George. 1987. *Women, Fire, and Dangerous Things.* Chicago, IL: University of Chicago Press.

Larson, Meredith, Ryan Doran, Yaron McNabb, Rachel Baker, Matthew Berendes, Alex Djalali and Gregory Ward. 2007. Distinguishing the SAID from the IMPLICATED using a novel experimental paradigm. Paper presented at the LSA Annual Meeting.

Lee, Chungmin. 1973a. *Abstract Syntax and Korean with Reference to English.* Seoul: Thaehaksa.

Lee, Chungmin. 1973b. The Performative Analysis of 'Why not B?'. *Language Science* 25, 39-41.

Lee, Chungmin. 1996a. Generic Sentences Are Topic Constructions. In Thorstein Fretheim and Jeanette K. Gundel (eds.), *Reference and Referent Accessibility.* Amsterdam: John Benjamins.

Lee, Chungmin. 1996b. Negative Polarity Items in English & Korean. *Language Sciences* 18, No. 1-2, 505-523. Also in K. Jaszczolt and K. Turner, 1996 (eds.), *Contrastive Semantics and Pragmatics*, Elsevier Science.

Lee, Young-Suk, and Laurence Horn. 1995. Any as indefinite plus even. Ms., Yale University.

Lerdahl, Fred and Ray Jackendoff. 1983. *A Generative Theory of Tonal Music.* Cambridge, MA: The MIT Press.

McCawley, James. 1968. Concerning the Base Component of a Transformational Grammar. *Foundations of Language* 4, 243-269.

McCawley, James. 1970. English as a VSO Language. *Language* 46 (2), 286-299.

McCawley, James. 1994. Remarks on the Syntax of Mandarin Yes-No Questions, *Journal of East Asian Linguistics* 3, 179–94.

Montague, Richard. 1970. English as a formal language. In B. Visentini *et al.* (eds.) *Linguaggi nella Società e nella Tecnica*, 189-224. Milan: Edizioni di Comunità (Reprinted in Montgaue (1974)).

Montague, Richard. 1974. *Formal Philosophy: Selected Papers of Richard Montague.* New Haven: Yale University Press.

Osherson, Daniel and Edward Smith. 1981. On the adequacy of prototype theory as a theory of concepts. *Cognition* 9, 35-58.

Pagin, Peter. 2005. 'Compositionality and context', in George Preyer (ed.), *Contextualism in Philosophy*, 303-48. Oxford: Oxford University Press.

Pagin, Peter and Dag Westerståhl. 2001. Editorial: Compositionality: current issues, *Journal of Logic, Language and Information* 10 (1), 1-5.

Partee, Barbara Hall. 1984. Compositionality. In Fred Landman and Frank Veltman (eds.), *Varieties of Formal Semantics* 281-312. Dordrecht: Foris. (Reprinted in Barbara Hall Partee. 2004. *Compositionality in Formal Semantics: Selected Papers by Barbara H. Partee.* 153-181. Oxford: Blackwell Publishing.

Partee, Barbara Hall. 2003. Privative adjectives: subsectives plus coercion. Ms., University of Massachusetts at Amherst.

Partee, Barbara Hall. 2004. *Compositionality in Formal Semantics: Selected Papers by Barbara H. Partee*. Oxford: Blackwell Publishing.

Partee, Barbara Hall. 2005. Reflections of a formal semanticist as of Feb 2005, URL `BHP_Essay_Feb05`, ms. (longer version of introductory essay in 2004 book).

Pelletier, Francis. 2001. Did Frege believe in Frege's Principle? *Journal of Logic, Language, and Information* 10, 87–114.

Penn, Dereck, Keith Holyoak, and Daniel Povinelli. 2008. Darwin's mistake: Explaining the discontinuity between human and nonhuman minds. *Brain and Behavioral Sciences* 31, 109-178.

Poirier, Pierre and Benoit Hardy-Vallée. 2005. Structured thoughts: The spatial-motor view. In Markus Werning, Edouard Machery, and Gerhard Schurz (eds.), *The Compositionality of Concepts and Meanings: Foundational Issues*. Frankfurt: Ontos Verlag.

Postal, Paul. 1969. Anaphoric Islands. In *Papers from the Fifth Regional Meeting of the Chicago Linguistic Society*, April, 18-19.

Pustejovsky, James. 1995. *The Generative Lexicon*. Cambridge, MA: The MIT Press.

Pustejovsky, James. 2005. *Meaning in Context: Mechanisms of Selection in Language*. Cambridge, MA: The MIT Press.

Pustejovsky, James. 2011. Co-compositionality. In Markus Werning, Wolfram Hinzen, and Edouard Machery (eds.), *The Oxford Handbook of Compositionality*. Oxford: Oxford University Press.

Raffman, Diana. 1993. *Language, Music, and Mind*. Cambridge, MA: The MIT Press.

Recanati, François. 2011. *Truth-Conditional Pragmatics*. Oxford: Oxford University Press.

Schiffer, Michael B. 1987. *Formation processes of the archaeological record*. University of New Mexico Press.

Smith, Edward and Daniel Osherson. 1984. Conceptual combination with prototype concepts. *Cognitive Science* 8, 337-361.

Smolensky, Paul. 1989. Connectionism and constituent structure. In Rolf Pfeifer, Zoltan Sschreter, Françoise Fogelman, and Luc Steels (eds.), *Connectionism in Perspective*. Amsterdam: Elsevier.

Smolensky, Paul. 1989. Connectionist modeling: Neural computation/mental connections. In Lynn Nadel, Lynn A. Cooper, Peter Culicover and R. Michael Harnish, (eds.), *Neural Connections, Mental Computation*. Cambridge, MA: The MIT Press/Bradford.

Smolensky, Paul. 1991. Connectionism. In William Bright (ed.), *The International Encyclopedia of Linguistics*. New York, NY: Oxford University Press.

Smolensky, Paul. 1995. On the structure of Con, the constraint component of UG. Handout of talk at UCLA, April 7.

Song, Myounghyoun and Chungmin Lee. 2011. CF-reduplication in English: Dynamic prototypes and contrastive focus effects. *Proceedings of SALT* 21, 444–462.

Steedman, Mark. 1996. *Surface Structure and Interpretation.* Cambridge, MA: The MIT Press.

Szabó, Zoltán Gendler. 2007. Believing in Things. *Philosophy and Phemomenological Research* 66 (3), 594-611.

Ward, Gregory, Richard Sproat, and Gail McKoon. 1991. A Pragmatic Analysis of So-Called Anaphoric Islands. *Language* 67, 439-474.

Westerståhl, Dag. 1999. On predicate logic as modal logic. In Andrea Cantini, Ettore Casari, and Pierluigi Minari (eds.), *Logic and Foundations of Mathematics.* Dordrecht: Kluwer.

Wilks, Yorick. 1998a. Language processing and the thesaurus. In *Proceedings National Language Research Institute.* Tokyo, Japan.

Wilks, Yorick. 1998b. Is Word-sense disambiguation just one more NLP task? In *Proceedings SENSEVAL Conference.* Herstmonceaux, Sussex.

Wilks, Yorick. 1998c. *The "Fodor" - Fodor fallacy bites back.* University of Sheffield Computer Science Dept. Memoranda in Computer and Cognitive Science.

Wunderlich, Dieter. 2004. Is there any need for the concept of directional syncretism. In Gereon Müller, Lutz Gunkel, and Gisela Zifonun (eds.), *Explorations in Nominal Inflection*, 373-395. Berlin, New York: Mouton de Gruyter.

Zeevat, Henk. 1989. A compositional approach to discourse representation theory. *Linguistics and Philosophy* 12, 95-131.

Submitted on: June 18, 2012
Accepted on: November 26, 2012