Theoretical Perspectives in the Neurological Investigation of Combination:

There is little controversy that interdisciplinary work along the border between cognitive-neuroscience and theoretical linguistics has the potential to be extraordinarily profitable for both sides. In an ideal scenario, linguistic theories would provide specific targets for cognitive neuroscience research, such that those findings would bear on qualifying extant theories and help to gauge the validity of possible alternatives. However, this is not so easily achieved in practice. The level of theoretical information which linguists are familiar with is often not readily translatable to the equally abstract results of neurological inquiry, and between the two fields there is a constant opportunity for miscommunication in what Poeppel and Embick call a “granularity mismatch” (Poeppel & Embick 2005). The constant evolution of theoretical perspectives that more adequately describe our working neurological understanding of the brain is thus a necessity for productive cooperation between linguistics and neuroscience.

In consideration of a recent set of MEG studies which investigated the neural mechanisms supporting basic combinatorial operations (Pylkkänen, Brennan, Bemis 2011, Pylkkänen & McElree 2007, Westerlund & Pylkkänen 2012), we see evidence consistent with the idea that there are distinguishable neural reflexes for two different types of composition. This finding begs an explanation from current theories of combination and, as we will see, there is a range of approaches which may describe the apparent division. On one view, which we will call Functionist (after Hornstein & Pietroski 2009), combinations involving adjuncts/modifiers like [BLACK SWEATER] are semantically assembled in different way than head/complement combinations like [EATS MEAT]. An alternative, which we will refer to as the Conjunctivist view (again following Hornstein & Pietroski 2009), suggests that semantic composition in these two cases works in an essentially uniform way. We will see that the Functionist view offers a ready interpretation of the relevant
MEG findings, while the *Conjunctivist* view does not. We will consider both here because we believe that theoretical perspectives are the most advantageous to research programs when they are applied pragmatically, i.e. in ways that make the best use of them. In the case of neurolinguistic research, being aware of multiple theoretical explanations for one set of data provide different ways to think about the same facts. Developing those theoretical perspectives in parallel further allows researchers to take a multifaceted approach to finding the truth since, compared to the Functionist explanation, we expect the Conjunctivist perspective to rationalize the data in different, perhaps explanatorily useful, terms.

This paper considers some recent MEG against the background of a Functionist account of semantic combination, discussing the benefits and difficulties of holding such a perspective. We then move to explicate an alternative Conjunctivist account of semantic combination drawing on Pietroski & Hornstein’s discussion of “Basic Operations” (Hornstein & Pietroski 2009), and examine what assumptions could be altered to render a Conjunctivist view consistent with the MEG evidence.

2. **A Functionist Approach:**

A Functionist semantics can be characterized by thinking of lexical items as either argument seeking or argument composing. Verbs, for example, are thought of as functions which have open slots that they are looking to fill, an idea that historically derives from Frege's claim that “the meanings of most words are in some sense incomplete, or unsaturated, unless they are combined with other words with suitable meanings” (Pylkkänen, Brennan, Bemis 2012 – pg.1320). Other lexical classes such as adjectives and adverbs are thought of as argument modifying in that they apply to already existing arguments and make them in some way more complex Pylkkänen, Brennan, Bemis 2012 – pg.1320). Based on this distinction function-like words and argument modifying words are thought to undergo different operations during semantic combination:

**Predicate Modification (PM)** which operates between arguments and argument modifiers to construct more complex arguments, and **Argument Saturation (AS)** which fills function slots
with the type of argument they are selecting for (Pylkkänen, Brennan, Bemis 2011 – pg. 1320-1322).

**ARGUMENT SATURATION** applies between verbs, determiners, prepositions, and the arguments they select for. A simple transitive verb like hit, for example, requires two arguments, a subject and an object, to form a complete sentence, and so it can be characterized by lexical identity like hit:λx.λy or hit(y, x) where λx and λy denote predicates (Pylkkänen, McElree 2007 – pg. 1320). The lexical categories that can be considered functions all share in common that they create complement relations with the arguments they select, and so it reasonably follows that **ARGUMENT SATURATION** is the operation which interprets syntactic complements and substitutes the lambda symbols of an unsaturated function with lexical arguments (Pylkkänen, Brennan, Bemis 2012 – 1321).

**PREDICATE MODIFICATION** is defined as the operation responsible for building complexes such as ‘big red ball’ or ‘softly ran’. Instances of **PREDICATE MODIFICATION** do not involve argument selection relations or thematic information, but are still compositional in that they “build complex properties from simpler ones” (Pylkkänen, Brennan, Bemis 2012 – 1322). Adverb-verb, adverb-adjective, and adjective-noun combinations, for example, are thought to undergo **PREDICATE MODIFICATION**.

Verifying the existence of differences between how **PREDICATE MODIFICATION** vs. **ARGUMENT SATURATION** combinations are handled in the brain is a particularly useful project. If differences do exist, then we have reason to follow and develop the Functionist view, but if they do not than an alternative perspective should be considered. The appeal of testing for such a distinction is the possibility to resolve broad theoretical claims through a relatively small empirical scope (Pylkkänen, Brennan, Bemis 2012 – pg.1320).

2.1 Targeting Only Semantics:

One of the most daunting obstacles to any study of combinatory operations lies in discerning which aspects are syntactic in nature and which are semantic. Most studies in
neurological physiology proceed by identifying informative stimulus contrasts meant to highlight correlations between a hypothetical mental properties and physical events in the brain. However, syntactic and semantic composition have remained practically inscrutable in such paradigms because of how difficult it is to isolate one from the other (Pylkkänen, Brennan, Bemis 2012 – pg.1325).

Linguists have traditionally understood compositions as including distinctly syntactic and distinctly semantic components. The theoretical division between the two has typically been based on the idea that syntactic structures are to some degree constructed first and provide some form of instruction which the semantics later interprets. Serial models of parsing argue that syntactic structures are completely derived prior to semantic interpretation while parallel theories argue that syntactic and semantic steps occur in alternation or directly alongside one another (Friederici 2011). Thus, although we can be fairly certain that even simple combinations like [BLACK SWEATER] and [EATS MEAT] undergo both syntactic and semantic combination, it should be understood that any temporal mapping of the relationship between the syntax and semantics therein is still up for debate.

What this amounts to is an issue with defining stimuli that could be useful in identifying specifically semantic neurological activity. If even simple combinations, such as [BLACK SWEATER], will elicit both a syntactic and semantic effect then it becomes a challenge to decode which aspects of neurological activity might correlate to either one. One might think that MEG would be a strong candidate to help in this dilemma since it can record neurological activity with a good temporal measure, but even provided accurate results there is still no good method for differentiating syntactic and semantic MEG signals. For this reason it is exceedingly difficult test either aspect of combination individually¹.

Currently, researchers have limited options. One is to probe semantic combination using

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¹ The MEG studies which we’ll be focusing on do not explicitly state any model of syntactic combination so we will assume that they adopt a traditional view of the MERGE operation which uniformly handles all syntactic combination (e.g., yielding labeled sets as in the Bare Phrase Structure view of Chomsky 1995 and subsequent).
minimal stimuli like [BLACK SWEATER] and remain wary that the neurological signals elicited during combination could be ambiguously syntactic or semantic. Another is to look for a particular kind of stimuli that activates either syntax or semantics exclusively.

Pylkkänen & McElree suggested that there may be MEG reflexes of syntax-independent semantic processing involved in so-called complement coercion sentences where “the complement of the verb is 'coerced' from an entity to an event.” (e.g., Pustejovsky, 1995, Pylkkänen & McElree 2007 – pg. 1906). Some examples of complement coercion are presented below. The first example in each pair shows the original sentence, while the 2nd includes the coerced information in brackets.

1a. “The author began the article.”
1b. “The author began [writing] the article.”
2a. “The baker finished the cake just before the wedding.”
2b. “The baker finished [icing] the cake just before the wedding.”

**Pylkkänen & McElree 2007 – pg. 1906**

In each sentence the coerced information won’t necessarily be the same for every reader, but what is necessary is that some semantic meaning be created to fill the event-ish gap created by words like *began* and *finished* which imply the beginning or end of SOME event. This coercion process seems unrelated to syntax since a syntactically identical sentence such as “The author wrote the article” clearly does not involve coercion; we therefore assume that the inferred meaning arises from purely semantic activity (Pylkkänen & McElree 2007 – pg. 1906). Although coercion cases might not be directly related to combination, they are significant to the current discussion since it may be possible to use them as stimuli to identify semantically inclined regions of the brain.

### 2.2 Reviewing MEG Data

Plykkanen & McElree attempted to investigate the neurological basis of this difference by testing coercion sentences against their non-coercive pairs as well as against anomalous sentences such as “The author astonished the article” (Pylkkänen & McElree 2007 – pg. 1906). Their exact
testing paradigm is shown below.

3a. The author began the article **Coercion**
3b. The author wrote the article **Control**
3c. The author astonished the article **Animacy Clash**

*(Pylkkänen & McElree 2007 – pg. 1907)*

The results of this MEG study indicated significant activity in several brain regions, the Ventromedial Prefrontal Cortex (vmPFC), and the Left & Right Anterior Temporal Lobes (RATL & LATL). The approximate locations of the Left Anterior Lobe and Ventromedial Prefrontal cortex can be seen highlighted in the figure below.

![Figure 1: vmPFC (green) & LATL (red)](image)

In the anomalous animacy clash cases, activity was found in both the Right and Left Temporal Lobes at approximately 350ms after encountering the target word, ‘article’ (Pylkkänen & McElree 2007 – pg. CHECK). This activity has been thought of as the MEG equivalent to the ERP literature’s N400 effect and is therefore not of major interest to us here (Pylkkänen & McElree 2007 – pg. 1913).

For all the sentence cases subjects also showed activity along the so called Anterior Midline Field (AMF), a magnetic field located above anterior inferior areas of the cortex (Pylkkänen & McElree 2007 – pg. 1911). However, coercion cases elicited significantly higher levels of activation in the area (Pylkkänen & McElree 2007 – pg. 1911). The source of this increase was traced to the Ventromedial Prefrontal Cortex (vmPFC), which had not previously been implicated to have any connection with language (Pylkkänen & McElree 2007 – pg. 1911).
As it turns out, this increase of activity in the vmPFC was replicable using other stimuli such as aspectual coercion, inchoative coercion, able-adjective coercion, particular semantic violations, and most importantly simple compositions, all of which are shown below. Each a-case yielded greater AMF amplitudes compared to each corresponding b-case when the underlined word was read.

**Complement Coercion:**

4a. Coercion The journalist began the article after his coffee break.
4b. Control The journalist wrote the article after his coffee break.

**Coercion with able-adjectives:**

5a. Coercion The nimble climber imagined the ice *survivable* even though others did not.
5b. Control The nimble climber imagined the fall *survivable* even though others did not.

**Aspectual Coercion:**

6a. Coercion Throughout the day the student *sneezed* in the back of the classroom.
6b. Control After twenty minutes the student *sneezed* in the back of the classroom.

**Inchoative Coercion:**

7a. Coercion Within a few minutes, the child *cherished* the precious kitten.
7b. Control Without a doubt, the child *cherished* the precious kitten.

**Semantic Violation:**

8a. Ill-formed … the wine was being *unchilled*…
8b. Well-formed … the wine was being *uncorked*…

**Simple Composition: (Predicate Modification)**

9a. Modification red boat
9b. No Modification boat

*Figure 4: Coercion Examples (Pylkkänen, Brennan, Bemis 2011 – pg. 1328)*

These surprisingly diverse pairs each displayed a systematic difference in vmPFC activity so
there is some question about whether any common generalizations can be made across the cases. Cases 1 – 4 all feature a variation of what appears to be a general coercion phenomenon where something about the relation between semantic items in the sentence (cited under each pair) necessitates the generation of an event interpretation. Because the difference in activity in the vmPFC between the a-cases and b-cases in 1 – 4 seems to be driven by the particular semantic relations between words in each sentence, it follows that activity in the vmPFC may be related to some aspect of semantics, perhaps specifically to interpreting event information. However, case 5 (Semantic Violation) and case 6 (Modification vs. No Modification) do not fit a generalization related specifically to event information since the examples elicit an increase in vmPFC activation without manipulating anything related to events. The increased vmPFC activity in case 5 seems to be related to a mismatch between world knowledge, while increased activity in case 6 seems to be related to the presence/absence of combinatory activity. Another factor that seems to disqualify a specific description of activity in the vmPFC is that the b-cases in each pair did also elicit activity in the vmPFC although that activity was significantly weaker compared to the a-cases. These observations leads us to interpret the above cases as evidence that activity in the vmPFC is more likely correlated to a more general range of semantic processes including at least coercion phenomena, anomalous cases related to world knowledge, and perhaps a semantic aspect of combination, and this last assumption is what holds the most interest for us here.

If the vmPFC is indeed related generally semantic processes then the increased activation seen between examples 9a ‘red boat’ and 9b ‘boat’ could be related to semantic combination. A way to probe this hypothesis involves considering how a model of semantic combination would expect that vmPFC activity to vary across different combinatory contexts. Remember that a Functionist model of semantics predicts two modes of semantic composition for argument modifying and argument composing combinations. Based on that distinction, perhaps they would expect to find a difference in neurological activity for **Predicate Modification vs. Argument Saturation** cases.
A follow up study was conducted by Westerlund and Pylkkänen in 2012 which was specifically designed to test if the Ventromedial Prefrontal Cortex exhibited distinctions between cases involving Argument Saturation or Predicate Modification. Basic examples from that testing paradigm can be found below.

**Table 1: AS vs. PM Paradigm** (Westerlund & Pylkkänen 2012 – pg. 15)

<table>
<thead>
<tr>
<th>Predicate Modification</th>
<th>Combinatory (two-word)</th>
<th>Non-Combinatory (one-word)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjective-Noun</td>
<td>black sweater</td>
<td>rkgjg sweater</td>
</tr>
<tr>
<td>Adverb-Verb</td>
<td>never jogged</td>
<td>nhcny jogged</td>
</tr>
<tr>
<td>Adverb-Adjective</td>
<td>very soft</td>
<td>rmwz soft</td>
</tr>
<tr>
<td>Argument Saturation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verb-Noun</td>
<td>eats meat</td>
<td>trwq meat</td>
</tr>
<tr>
<td>Preposition-Noun</td>
<td>in Italy</td>
<td>xq Italy</td>
</tr>
<tr>
<td>Determiner-Noun</td>
<td>Tarzan’s vine</td>
<td>fkbczswh vine</td>
</tr>
</tbody>
</table>

The stimuli were designed in combinatory (two-word) and non-combinatory (one-word) pairs to contrast minimal examples of combination like ‘black sweater’ against non-combinatory cases like ‘rkgjg sweater’ that are meant to provide a profile for neurological activity without combination while controlling for possible confounding factors like frequency, word length, semantic variability, etc… (Westerlund & Pylkkänen 2012 – pg. 12). By subtracting the MEG profile for the non-combinatory half of the pair, from the MEG profile of the combinatory half the hope is that only the combinatory activity will be left as a difference. The stimuli pairs were also classified based on whether they were expected to elicit Predicate Modification (Adjective-Noun, Adverb-Verb, and Adverb-Adjective pairs) or Argument Saturation (Verb-Noun, Preposition-Noun, and Determiner-Noun pairs) (Westerlund & Pylkkänen 2012 – pg. 15). Three subtypes of each mode of combination were tested to insure that no single combination of lexical categories would drive the results (Westerlund & Pylkkänen 2012 – pg. 12). If neurological
activity in a region was higher for the combinatory half of a pair compared to the non-combinatory half this was considered as a main effect possibly indicative of combinatory activity. The main intent of the study, however, was to gauge if any regions exhibited different activation for the PM cases vs. the AS cases.

MEG readings of the vmPFC showed a significant main effect for combinatory vs. non-combinatory stimuli for both the PM and AS cases at 334-509 ms in the vmPFC, maintaining that the vmPFC is active during minimal combinations (Westerlund & Pylkkänen 2012 – pg. 23). However, there was not a significant difference in activity between Modification and Saturation cases, indicating that there was no difference in vmPFC activity for AS vs. PM cases. The Left Anterior Temporal Lobe (LATL) also showed significant levels of activity at 276 ms (Westerlund & Pylkkänen 2012 – pg. 23)..Predicate Modification combinatory cases showed significantly more activity than their one word non-combinatory counterparts, but Argument Saturation cases showed no relative increase (Westerlund & Pylkkänen 2012 – pg. 25). In fact, the AS combinatory cases at times showed less activity than their non-combinatory pairs (Westerlund & Pylkkänen 2012 – pg. 25). This indicates that activity in the LATL is in some way specialized for PM cases. For ease of reference, graphical summary of this information is presented on the following page.

Figure 2: A Summarization of Activity in the vmPFC and LATL
2.3 The Functionist Story:

These results are exciting for a Functionist perspective since they can be easily interpreted as support for their position. Increased activity in the LATL for PREDICATE MODIFICATION vs. ARGUMENT SATURATION indicates that there is a difference in how the brain handles particular types of combination, and that difference patterns along the lines that PM & AS predict. Because the Functionist perspective advocates two modes of semantic composition, it’s simple to explain this difference as resulting from the application of one operation over the other. Whatever the brain does when it performs modification, the LATL is specifically involved in some way and shows an increase in activity as a result. Thus without saying that activity in the LATL literally IS PREDICATE MODIFICATION, a Functionist perspective able is to describe the activity as specialized for PREDICATE MODIFICATION and take it as evidence that are two modes of semantic composition at work in the brain.

The activity seen in the Ventromedial Prefrontal Cortex; however, requires more descriptive leg work. Of the two areas that showed a significant increase in activation for combinatory vs. non-combinatory contexts, if one area showed a preference for PREDICATE MODIFICATION than perhaps it would be reasonable to expect the other to show some preference for ARGUMENT SATURATION. Recall, however, that this was not the case. The vmPFC showed equal activation for the ARGUMENT SATURATION and PREDICATE MODIFICATION subtypes, suggesting that if that activity is related to combination, it is related to PREDICATE MODIFICATION and ARGUMENT SATURATION cases in a uniform way. Furthermore, while activity in the LATL peaked relatively quickly (between 276-307ms) activity in the vmPFC was sustained from 307-509ms (Westerlund & Pylkkänen 2012 – pg. 27).

One way that a Functionist model can think about the lack of a distinction between ARGUMENT SATURATION & PREDICATE MODIFICATION cases in the vmPFC relates to our previous discussion of activity in that region, namely that it is related to more generally semantic processes rather than any specifics of combinatory operations. Such a position tentatively accepts that
activity in the vmPFC is not specialized for AS vs. PM, and suggests that whatever its role, activity in the vmPFC relates equally to all combinatory subtypes. Separate studies have found that activity in vmPFC can be manipulated by higher level language stimuli such contextual and discourse level comprehension that share a similar character with the coercion and anomaly examples discussed previously in figure 4 (Westerlund & Pylkkänen 2012 – pg. 38). This solution is thus well supported, although somewhat nondescript.

A second approach available to the Functionist perspective involves accepting the previous hypothesis, and also adopting a view of combination where ARGUMENT SATURATION is uniform across all combinatory subtypes and PREDICATE MODIFICATION applies in addition for modification cases. This is to say that all cases of combination undergo ARGUMENT SATURATION, but only some undergo PREDICATE MODIFICATION. Separate evidence for this position derives from coercion cases, which always elicited activity in the vmPFC, but only elicited activity in the LATL when Modification constructions were involved, ex. “For ten minutes the clown jumped” (coerced to an iterative meaning), activated the LATL (Westerlund & Pylkkänen 2012 – pg. 38). This position would more strongly maintain that activity in the vmPFC is at least partially combinatory and also accounts for the lack of a brain region specialized for ARGUMENT SATURATION.

Considering the wide scope of the problem space, the Functionist perspective seems to have a number of intelligent ways to talk about the MEG data. Future research could be directed at testing the co-occurrence of PREDICATE MODIFICATION and ARGUMENT SATURATION in traditional Modification contexts, as well at further explicating activity in the LATL and vmPFC. If activity in the LATL and vmPFC is in fact related to semantic combination, it would be strong evidence for adopt the two operation view of combination that Functionists project. Despite the apparent strength of this position, we next move to consider how a Conjunctivist theory of combination might make sense of the same set of data.

3. A Conjunctivist Perspective:

The core belief of Conjunctivist perspectives is that all semantic combination is completed
by a single combinatory operation, (ie. that all semantic combinations are essentially instances of the same process). Considering what we’ve just discussed, it should be obvious that applying that perspective to the MEG results poses a significant challenge. The activity elicited in the Left Anterior Temporal Lobe during PREDICATE MODIFICATION and not during ARGUMENT SATURATION states that there is some distinction between the two sets of cases, and a Conjunctivist perspective is incapable of characterizing that difference as two separate semantic operations. The appeal of a Functionist model of semantics is in fact so great that the reader may wonder why we should bother to investigate an alternative perspective at all. With that sentiment in mind, the next section will first present our understanding of a Conjunctivist take on combination, which has been largely borrowed from Pietroski and Hornstein’s Basic Operations account, and directly follow it with several independent reasons we have for wanting to consider such a perspective. As mentioned before, our logic in seeking out alternative views to describe the MEG data is not necessarily to pit one theory against another, but rather to expand our theoretical range of motion around the subject.

3.1 Conjunctivist Combination:

Unlike the Functionist perspective, a Conjunctivist theory proposes only one mode of semantic composition called SEM which predicts that meaning semantic combination should be uniform across all cases (Pietroski & Hornstein, 2009 pg.5). The particulars of how SEM translates information into interpretable meaning is married to a Neo-Davidsonian understanding of semantics. While Functionist theories traditionally think of meaning as focused around a verbal predicate, a Neo-Davidsonian view proposes that the meaning of an utterance is centered around the event it describes (Pietroski & Hornstein, 2009 pg.5). So instead of thinking of John and Bill in “John hit Bill” as filling the slots connected with the verb (e.g., hit(x, y) \(\rightarrow\) hit(John, Bill)), we can think them as being thematically related to events as different kinds of participants in those events(e.g., …hitting(e) & Agent (e, John) & Patient (e, Bill)). In essence, the Neo-Davidsonian account allows us to think of thematic information as separate (“severed”) from the sentence’s main
An additional difference between the Functionist perspective and the Conjunctivist position that we are developing here is that the Conjunctivist perspective abandons the idea of a uniform syntactic MERGE in favor of a functionally identical, but theoretically expanded, operation called COMBINE. The Conjunctivist COMBINE operation handles all syntactic combinations, and divisible into two smaller sub operations, CONCATENATE and LABEL. CONCATENATE can be thought of as the most basic form of linking two atomic elements. How we define atomic element therefore bears a great deal on CONCATENATE’s result. If we CONCATENATE the & cat while considering words atomic elements the output could be either the^cat or cat^the (Pietroski & Hornstein, 2009 pg.5). If we instead consider letters as atomic elements than the possible results of CONCATENATE become far more numerous: t^h^e^c^a^t, h^e^t^a^t^c, c^a^t^h^e^h, etc… In either case, a defining aspect of CONCATENATE is that the representation which is being built is flat “like beads on a string”, ie. lacking headedness, and completely void of complex semantic meaning (Pietroski & Hornstein, 2009 pg.5). LABEL can apply to the results of CONCATENATE and works to develop headedness for the construction. For example, a simple concatenate like [Adj-BLACK^N-SWEATER] can be LABELed with the result being [N BLACK^SWEATER]. LABEL takes the flat combinations that result from CONCATENATE and yield more complex headed relations such as those seen in branching syntax trees. The whole COMBINE process for [BLACK SWEATER] can be seen bellow.

Start: atomic lexical item Adj-“BLACK” & atomic lexical item N-“SWEATER”

CONCATENATE: [Adj-BLACK^N-SWEATER]

LABEL: [N BLACK^SWEATER]

**Figure 3: COMBINE [BLACK SWEATER]**

This characterization of a Conjunctivist semantics is somewhat simplified from Pietroski and Hornstein’s presentation which is directed as a programmatic perspective with multiple interpretations available within (Hornstein & Pietroski 2009, Pietroski 2005).
3.2 Independent Reasons for Valuing a Conjunctivist Analysis

After having seen the basics of a Conjunctivist account of combination it may not seem like it includes any theoretical advantages compared to the Functionist perspective. It is for that reason that we’d like to take the time to explicate several independent reasons we have more motivating a Conjunctivist account of the MEG data. Many of these arguments derive from the Conjunctivist theory’s association with Neo-Davidsonian event semantics, but the first we’ll cover is an argument made independently by Pietroski and Hornstein about the evolutionary derivability of human language.

This argument is a founding idea behind Pietroski and Hornstein’s Basic Operations program and is reliant on the simple claim that a probable theory of syntactic-semantic composition should be feasibly implementable by human biology (Pietroski & Hornstein, 2009 pg.1). The goal of thinking in manner is to develop a theory of combination that could be derived in small evolutionary increments and would account for an explosive increase of generative power over a small series of changes. That there may still be living records of our previous linguistic competence, is an especially interesting aspect of this idea. During our evolution as primates there must have been some gradual change in our neurological makeup that enabled us to form a complex conception of language, and that biological difference theoretically still exists today as what separates our understanding of language from that of a chimp’s (Pietroski & Hornstein, 2009 pg.1). Thus, an approach to identifying that difference is formulating a linguistic theory based not on what is elementary to us, but what is elementary to the higher animals. For Pietroski and Hornstein, this concept is embodied in CONCATENATE, the simplest possible conjunction of individual items (Pietroski & Hornstein, 2009 pg.1). They likewise hypothesize that the jump to human levels of linguistic complexity derives from the incorporation of headedness, namely the LABEL operation (Pietroski & Hornstein, 2009 pg.1). We take this argument to be good motivation for considering a Conjunctivist account simply because a Functionist semantics, as far as I can tell, has no similar way of talking about the evolutionary derivability of language.
A second independent motivation derives from a growing literature from Borkessel-Schlesewsky & Schlesewsky which has developed a program which thinks of arguments as carrying generalized or prototypical thematic roles prior to the parser encountering any relevant associated verb (Borkessel-Schlesewsky & Schlesewsky 2006, 2009). These prototypicality-roles, (which follow the conception of ‘generalized thematic roles’ put forth in van Valin 2005), are general classifications of familiar thematic roles, such as agent, patient, instrument, etc..., that seek to characterize how the parser incorporates thematic information during early online parsing (Borkessel-Schlesewsky & Schlesewsky 2006, 2009). Their program claims that generalized-roles like Actor and Undergoer describe that most basic requirements of all transitive events, and thus could be used as heuristic aids during syntactic and semantic processing (Van Valin 2005). One kind of motivation for this way of thinking can be found in an example from Ferreira and Clifton (1986), concerning the role that animacy information may play in guiding syntactic parsing.

A. The witness examined by the lawyer turned out to be unreliable.

B. The evidence examined by the lawyer turned out to be unreliable.

**Figure 8** Ferreira and Clifton (1986)

In these cases parsing was significantly faster for sentence B, than for sentence A, despite similarities in their length, syntactic structure and content. Both of these cases are ambiguous at the verb “examined” – from this point the sentence could continue with “examined” as the past-tense marked main verb or as the participle in a reduced relative clause (e.g., The witness/evidence that was examined…). The difference between the two sentences can be explained by a relation between role prototypically and the animacy/inanimacy of the initial subject NP. If the parser has access to animacy information immediately, and if this information can be integrated with likely (generalized) thematic roles prior to encountering the main verb of the sentence than the parsing time for sentence B, could be faster because the inanimate subject makes the reduced relative clause
reading more accessible (avoiding a garden path effect that arises for the A-case when the by-phrase is encountered).

This kind of thinking connects to a Conjunctivist/Neo-Davidsonian account of semantics since they are able provide an explanation as to how basic thematic information could be available to the parser through arguments independently of an associated verb. The example from Ferreira and Clifton can only be explained if the animacy of the subject NP was in some way interpretable to the parser and the Conjunctivist approach facilitates such an understanding. A Functionist, on the other hand, perspective would need to develop extra machinery to accommodate a similar conclusion.

Adopting a Neo-Davidsonian view of verb-argument separation also permits certain sentence readings with regards to scope and plurality that would otherwise be impossible. As discussed in our summary of the Functionist position, verbs have generally been thought of as the center of sentential meaning, and when Davidson initially proposed an event based semantics the verb was still responsible for holding the event variable (Lohndal 2011 – pg. 3). Schein 1993, however, discusses examples like “Three video games taught every quarterback two new plays” which has an intended reading of ‘Between the three of them, the video games are responsible for the fact that each quarterback learned two new plays’ which is logically unattainable using only one event variable (Lohndal 2011 – pg. 4). Translating that sentence into logical form using a semantics with only a verbal event variable the yields $\exists e [\text{teaching}(e, \text{three video games}, \text{every quarterback}, \text{two new plays})]$, which reads back “Three video games (together) taught every quarterback (i.e. the group consisting of all quarterbacks) two new plays. The intended reading can only be attained using a semantics that claims separate event variables for verbs and arguments. This is sketched in Figure 3a/b, but I will not further elaborate on this here (see Schein 1993; Lohndal 2011 for discussion).
3.3 Reevaluating MEG data

Now with a few reasons for wanting to consider the Conjunctivist perspective in mind, we return to the topic of adapting it to the MEG data that were reviewed earlier. As previously
mentioned, we expect the Conjunctivist perspective to be particularly concerned with what the
Functionist account characterizes as PREDICATE MODIFICATION specific activity in the Left Anterior
Temporal Lobe since a Conjunctivist model of semantics cannot replicate that distinction whilst
maintaining that there is only one mode of semantic composition.

Perhaps one way to address this issue is to move the locus of the distinction. While the
vmPFC’s involvement in purely semantic operations is evidenced by several types of coercion
cases, there is no such evidence which implicates that the LATL is similarly related to semantics.
The LATL showed an increase in activity during a subset of minimal combinations, and as
mentioned previously, the theoretical nature of the activity in that space is largely ambiguous.
Since instances of semantic combination can be thought as being accompanied by corresponding
syntactic combinations, it may be possible that LATL activity is correlated to the syntactic, rather
than semantic, aspect of combination. PREDICATE MODIFICATION cases typically involve adjunct
syntactic relations and ARGUMENT SATURATION cases typically involve complement syntactic
relations so thinking of the AS vs. PM distinction that was developed from the MEG data in
syntactic terms preserves the same division between cases. And if the distinction found between
PREDICATE MODIFICATION vs. ARGUMENT SATURATION cases in the LATL reflects a difference
between syntactic operations and not semantic operations, than a Conjunctivist’s single mode of
semantic composition can be adapted to characterize the MEG results. Instead of discussing
differences in how the brain handles PM & AS cases, Conjunctivists can discuss differences in how
the brain constructs adjuncts vs. complements.

We see two possible ways to discuss this difference which happen to be non-exclusive.
While COMBINE = LABEL(CONCATENATE) is essentially a more detailed definition of
MERGE perhaps the application COMBINE is not uniform for complements vs. adjuncts. It may
pay to think of Adjuncts as being combined and Complements as being instantiated, where the key
difference is a matter of complexity. In both adjunct and complement cases a syntactic structure
would be derived, but in a Conjunctivist theory of combination complement relationships may be
significantly simpler than adjunct relationships. Remember that a Conjunctivist semantics is able to think of arguments and thematic information as separate from their predicates because they are united by a common event variable. Since arguments and predicates will eventually be connected through the semantic structure, perhaps strong relations between complements may not be necessary. We thereby refer to the syntactic combination of complements as instantiation since complement relations may be as simple as pairings prior to an eventual semantic interpretation. We think of Adjuncts as being syntactically combined since elements in adjunct relations are likely to require a more complex internal structure to be interpretable without the aid of event related information. The terminology of instantiate vs. combine also connotes a difference in the amount of work required by each operation, where combining is harder than instantiating, and that level of distinction may be another way of pulling apart the AS vs. PM (or adjunct vs. complement) MEG distinction.

A working hypothesis about what levels of work each operation might require can be basically formulated as: syntactic relations are easier to build than adjunct relations. Evidence for this claim derives mainly from within psycholinguistic parsing literatures that have tested how the availability of certain information effects sentence processing times. Our hypothesis matches a generalization that complement relations typically make better use of information such as category selection relationships which are more predictable for complement relations since the heads of complement relations (Verbs, Prepositions, and Determiners) always select for the same lexical category, nouns. The instantiate operation formalizes the process of selection for particular property, feature, or category information. Interestingly, this also means that we expect that all cases of instantiation should be linearly complex regardless of the probability of certain lexical/semantic relations (how likely it is for two words to occur with one another), measured as Cloze probability. Thus readings for segments such as “hit John” should elicit equal parsing times compared to highly particularized examples like “de vein shrimp” (think about how many things you can “de vein” vs. how many things you can “hit”). We also expect the opposite effect for
adjunctive *combine* cases because these combinations are not driven solely by information selection, and are more likely to involve semantic information. Thus the work required to combine “red boat” should be greater than the work required to combine “red apple” because the Cloze probability of “red apple” is higher than that of “red boat” and “red apple” should therefore be more predictable. If this hypothesis holds water, than we may also expect that cases of *combine* should elicit different amplitudes of LATL activity based on how probable/predicable a particular combination is. Using the prior case, we would expect “red apple” to elicit a lower amplitude effect in the LATL compared to “red boat”.

The explanatory gain of adopting either or both of these explanations is that they provide a way for the Conjunctivist perspective to account for differences in activity in the Left Anterior Temporal Lobe while maintaining only one operation of semantic combination. We mentioned earlier that defining which signals are syntactic vs. semantic by looking at MEG measures is a matter of theoretical guess work that is always open to ambiguity. While the Functionist perspective is content with citing the LATL as an area specialized for semantic activity there is no evidence to say that it may not be specialized for syntactic activity. Holding that to be the case, the apparent specialization we saw for AS vs. PM cases could instead be a factor of complement vs. adjunct syntactic structures.

A final factor to consider in this discussion is a possible Conjunctivist story regarding activity in the Ventromedial Prefrontal Cortex which we consider to be preferable to the current Functionist understanding. The uniquely semantic nature of coercion cases and their correlative relationship to activity in the vmPFC is relatively strong evidence that activity elicited in the vmPFC is at least partially related to semantics. The vmPFC’s activation during every subtype of minimal combination further cements this idea, and while this uniform activation is puzzling for a Functionist perspective that expects distinct differences in how the brain handles those subtypes, uniform activation during semantic combination is exactly what the Conjunctivist perspective expects. If SEM is responsible for the uniform semantic combination of elements in complement
and adjunct syntactic relations, then any correlated neurological activity should not show distinction between those subtypes. It’s therefore appealing to think of SEM as a possible correlate of semantically related activity in the vmPFC.

4. Comparisons, Conclusions, and Future Directions:

At the end of an analysis that has presented several alternative ways to think about what is already abstract neurolinguistic data, the significance of differences between the two accounts may require some overt explication. Our ultimate conclusion is that both Functionist and Conjunctivist perspectives are capable of telling interesting explanatory stories about the MEG data focused on two regions of interest, the Ventromedial Prefrontal Cortex and the Left Anterior Temporal Lobe. What was unique about the activity recorded in these areas was an apparent distinction in the Left Anterior Temporal Lobe for ARGUMENT SATURATION vs. PREDICATE MODIFICATION cases, and a lack thereof in the Ventromedial Prefrontal Cortex. Our discussion revolved around how each theory of combination could account for this distinction while maintaining that either one or two modes of semantic combination are manifest in the brain. This argument essentially boiled down to a swapping game across the syntax-semantics interface. The Functionist story characterized the distinction in the LATL as a difference between two combinatory operations, while the Conjunctivist perspective characterized it as a difference between constructing adjunct and complement syntactic relations. Both considered activity in the Ventromedial Prefrontal Cortex to be related to semantic combination with the Conjunctivist perspective hypothesizing a correlation to their SEM operation and the Functionist perspective debating between ARGUMENT SATURATION and some more general semantic process. It is our belief that holding onto both these stories is valuable in a pragmatic sense, but we would also like to consider what each account handles well, and what potential questions each poses to the opposing perspective.

The Functionist perspective at this stage of the game appears somewhat more elegant than the Conjunctivist perspective since the distinction it draws between ARGUMENT SATURATION and PREDICATE MODIFICATION cases is theoretically neater than the adjunct vs. complement distinction
that a Conjunctivist theory must rely on. That being said, positing that the LATL is related to syntax rather than semantics is a direct challenge to the Functionist conception of dual semantic combinatory operations. We have discussed at length the ambiguity between syntactic and semantic operations as well as their possible correlates in the brain, and this debate further highlights the importance of this issue. For these reasons, attempting to identify activity in the LATL as syntactic or semantic, perhaps in a way similar to how activity in the vmPFC has been identified as potentially semantic, could be an interesting direction for future research. Likewise, looking for a neurological basis for the distinctions that the Conjunctivist perspective hypothesizes between the syntactic combination of adjuncts and complements could have a similar effect. Particularly, if our ease of parsing explanation for the differences between adjunct and complement combinatorial activity in the LATL is true we would expect that especially easy combinations like “devein shrimp” should elicit less activity in the LATL than less related cases like “eat shrimp”.

The independent reasons we expressed for considering a Conjunctivist perspective also characterize an area where discussion between the two perspectives could be beneficial. As we see it, there are considerable benefits to adopting a Neo-Davidsonian account of semantics, and there seems to be little preventing a Functionist perspective from adopting such an account even without abandoning their dual operation view of semantics. We offer no explanation for how PREDICATE MODIFICATION and ARGUMENT SATURATION could be adapted to an event based semantics, but with a certain degree of work, the potential certainly exists. Another nice aspect of the Conjunctivist story that the Functionist story has very little to say about is the evolutionary derivability of language. This hypothesis appeals to some strong intuitions we have about how language must have come about, and if a Functionist perspective could tell some story about the development of their account it would be better off for it.

Overall, we stress the idea that Functionist and Conjunctivist perspectives of combination should continue to be developed by theorists in parallel so discussions such as these may continue. While choosing plan future programs of research based on one or the other perspective is in the
individual hands of the researcher, at this point in time results are likely to provide usable contributions for refining either conception of combination and in that way we may see the possible range of our theoretical understanding grow twice as quickly.
Works Cited


