Blending in Language, Conceptual Structure, and the Cerebral Cortex

RICK GRUSH
Philosophy-Neuroscience-Psychology Program
Washington University in St. Louis

NILI MANDELBLIT
Department of Cognitive Science
University of California, San Diego

0. Introduction

The past decade has seen Cognitive Linguistics (CL) emerge as an important, exciting and promising theoretical alternative to Chomskyan approaches to the study of language. Even so, sheer numbers and institutional inertia make it the case that most current neurolinguistic research either assumes that the Chomskyan formalist story is more or less correct (and thus that the task of neurolinguistics is to determine how the brain implements GB, for instance), or that the there are two possibilities, Chomskyanism or associationism/connectionism, and that the task of neurolinguistics is to discover which is really the way the brain does it. In either case, the theoretical apparatus of CL is not being explored by neurolinguistics, and hence the promise CL holds for making genuine fruitful contact with theoretical neurobiology is not materializing as quickly as one might hope. This paper is an attempt to make some initial steps at fulfilling this promise.

1. Blending in Language and Conceptual Structure

We follow a principal assumption of Cognitive Linguistics that mastery of a language consists, inter alia, in mastery of a structured inventory of form-meaning pairs (Fillmore & Kay, ms., Langacker 1987, 1991, Goldberg 1995). This view of language sees not only single words, but also phrasal and clausal constructions as inherently meaningful, even if their associated semantics is abstract or schematic. A given sentence, therefore, has whatever composite semantics it has in virtue of not only the words, but the higher-level constructions in it (and other factors as well).

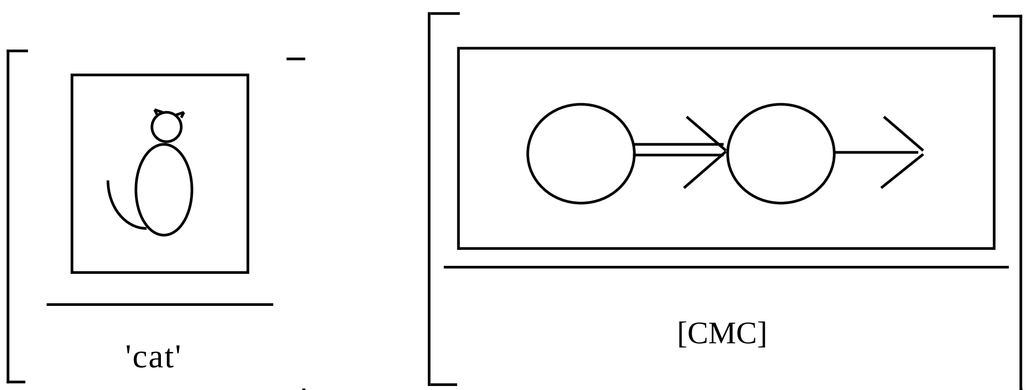

Figure 1: The symbolic units, or constructions, for the word *cat* (left) and for the English caused-motion argument structure construction (right).

Figure 1 shows a way, based on Langacker's Cognitive Grammar diagramming conventions, of representing these form-meaning pairs. The top half of the bracketed material indicates the meaning component of the form-meaning pair (the semantic pole, in Langacker's terminology). In this case the cat stick figure is meant to schematically represent the rich, cognitively represented semantic structures associated with the word 'cat', while the semantic pole of the construction on the right is a schematic caused motion event in which an agentive subject (the leftmost circle) acts on (diagrammed with the double arrow) a patient/theme (the rightmost circle) causing it to move in some direction (the single arrow on the right).[1] These semantic structures will typically be of encyclopedic scope, and can include any aspect of cultural or personal experience related to cats. The bottom half of the bracketed material represents the form aspect of the form-meaning pair (the phonological pole, in Langacker's terminology), in this case the word 'cat' (left), and a schematically specified clausal argument structure (right). These two aspects are combined and bracketed to diagram their status as a construction, a pairing of form and meaning.[2]

On this account, the integration at the phonological pole of words and the phrasal or clausal argument structure symbolizes the integration, at the semantic pole, of the meaning of the words with the meaning of the clausal construction (Langacker, 1987).[3] This semantic integration, however, typically involves mismatches, from slight to glaring, between the semantic specifications of words and the higher-level constructions involved. This process, whereby the semantics of one or more components gets altered or specified in order to integrate with other components is often called *accommodation* or *coercion.* Examples of this will be provided shortly. We will follow Fauconnier and Turner (1994) in

[1] Goldberg (1995) argues that clause-level constructions in English are associated with schematic scenes basic to human experience. The CMC is associated with an agent causing some object to move. Another example is the ditransitive construction, which is associated with an agent causing some entity to be at another agent's disposal (*Mary sent bill the letter. Bill baked Mary a cake. Joe cleared me a spot on the floor (where I could sleep).*), and so forth. Thus clausal argument structure constructions are not simply contentless syntactic forms providing the scaffolding for putting the semantics of the contentful words together in the right way, as traditional theories would have it. Rather, they carry their own meaning independently of the verb and argument fillers.

[2] Henceforth 'form' and 'phonological pole' will be used interchangeably, as will 'meaning' and 'semantic pole'.

[3] Henceforth 'form' and 'phonological pole' will be used interchangeably, as will 'meaning' and 'semantic pole', and 'construction' and 'symbolic unit'.

describing this as a type of *blending*, since thier blending framework emphasizes the possibility of novel emergent structure not predictable from the inputs alone.

Consider as an example the English caused-motion construction (CMC), analyzed by Goldberg (1995), and later also analyzed in the blending framework by Fauconnier and Turner (1995). The CMC is a clause level argument structure construction which consists of the clausal verb and three arguments: an agentive subject (X), a patient or theme (Y) coded as the direct object, and a direction of motion (Z) coded as a prepositional phrase. The prototypical meaning of the construction is 'X cause Y to move Z'. Some instances of this construction are given in examples (1)-(4).

(1) Frank sneezed the napkin off the table.

(2) The audience laughed the actor off stage.

(3) The wind blew the ship off course.

(4) She trotted the horse into the stable.

As Goldberg has argued, the CMC construction must be posited as an independent item of linguistic knowledge because it has properties which are not predictable from the sub-clausal elements in the sentence. For example, the inferred event of motion in examples (1)-(3) cannot be predicted from any of the independent lexical items in these examples. The motion is supplied by the construction's semantics. Fauconnier and Turner (1994) argue not only that the semantics of the described event is not predictable (or composable) from the semantics of the sub-clausal elements (in agreement with Goldberg), but that it is also not predictable from those elements together with the construction's semantics. In discussing an example such as (1), they remark:

> But crucially, there is more structure to the blended space than to the inputs. First, the two processes are incorporated into a coherent process where it is the sneezing that causes the napkin's motion. Second, not just any process will do: a prototype is imposed on this understanding -- it is the air displaced by the sneezing that moves the napkin.

Prototypes thus play a role in imposing additional content to the general caused-motion schema contributed by the generic construction. For example, a specific manner of motion is almost automatically inferred in each example, though nothing in the linguistic expression (neither the lexical items, nor the argument structure) explicitly provides this information. In (4), for instance, the prototypical activity of riding a horse is selected, even though it could be interpreted to mean that the subject carried the horse into the stable with a trotting stride -- that is, nothing obviously present in either the words themselves or the construction fixes either interpretation.

This type of emergent semantics is exemplified quite sharply and clearly when we examine the translation of the English CMC to other languages which do not contain a special clausal argument structure to express caused-motion episodes (Mandelblit, 1995). In such cases the translation will highlight those most salient aspects of the caused-motion event through the available constructions of the target language. Those aspects may or may not be explicitly expressed in the English source sentence. Examples (5)-(8) provide the Hebrew translations for the English Caused-Motion sentences (1)-(4). The English examples (a) are followed by the Hebrew translation (b), and a word-to-word transfer of the Hebrew version into English (c).

(5) a. Frank **sneezed** the napkin off the table.

b. Frank hepil et hamapit min hashulchan behitatsho.

c. Frank **fall-CAUSE$_{past}$**[4] OM[5] the-napkin off the-table **by-sneezing**.

(6) a. The audience **laughed** the actor off stage.

b. Hakahal hivrix et hasaxkan mehabama.

c. The audience **run away-CAUSE$_{past}$** OM the-actor off-the-stage.

(7) a. The wind **blew** the ship off course.

b. Haruax hesita et hasfina mimaslula.

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[4] *CAUSE$_{past}$* marks the causative form of the verb in the past tense.

[5] *OM* stands for ‘Object Marker’.

c. The wind **shift-CAUSE**$_{\textbf{past}}$ OM the-ship off-its-course.

(8) a. She **trotted** the horse into the stable.

b. Hi hidhira et hasus letoch haurva.

c. She **trot-CAUSE**$_{\textbf{past}}$ OM the-horse into the-stable.

The main verb in each Hebrew translation expresses the resulting motion event, as grammatically obligated by the generic causative construction in Hebrew. The manner of motion is sometimes expressed in the source English sentence (as in example 8), but more often it is not (as in examples 5-7).

Compare the main verb in the translation of examples (5-7). As pointed to by Mandelblit (1995), there is nothing strictly coded by any of the linguistic elements in the English source sentences that tells a translator how to properly understand and translate the motion event. It is emergent structure supplied from other sources that completes the generic caused-motion scene. In the case of *sneeze the napkin off the table* (example 5), we (the listeners or translators) picture the napkin **falling down** from the table (and translate it as such); in the case of *laugh the actor off stage* (example 6), we picture the actor **running away** from the stage from embarrassment; and in the case of *blow the ship off course* (example 7), we picture the ship **shifting away** from its original course. It is our encyclopedic knowledge (rather than any narrowly linguistic knowledge) about napkins, ships, and actors on stage, as well as their typical movements, and the typical events involved in their movement, that leads us to interpret each sentence differently -- as clearly expressed in the choice of the main verb in the translation. It is the smooth, efficient, unnoticed operation of this process which keeps us from interpreting the sentences to mean that the napkin left the table, or that the actor fell off the back of the stage (like the napkin may have fallen off the table), or that the ship sank to the ocean floor from its course on the surface.

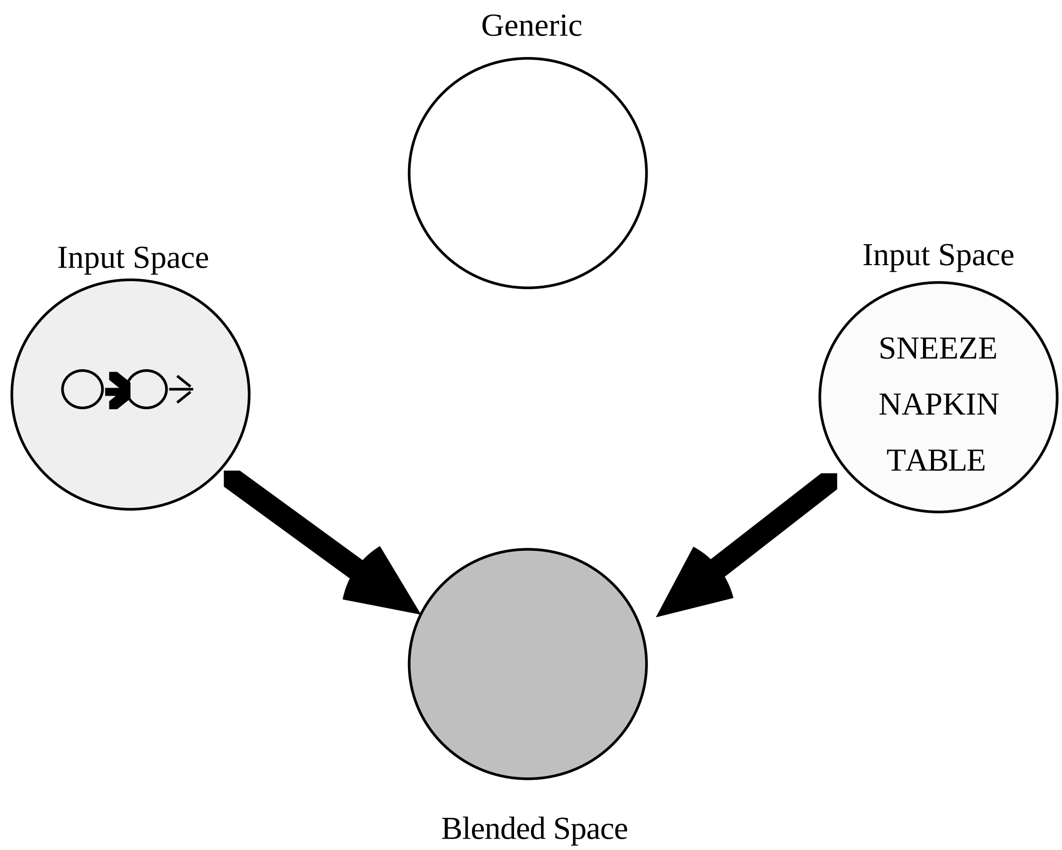

Figure 2: Schematic representation of the blending process involved in a caused-motion clause. The two input spaces, on the left and the right, represent the inputs of the clausal semantics (a caused-motion event) and the semantics of the specific words involved, respectively. The blended space is a conceptual region where the actual semantic import of the clause is constructed. Crucially, this final semantic import is not simply the sum of the semantics of the input spaces, but can involve emergent structure which is completely absent from the

inputs. We will not be concerned with the generic space (see Fauconnier and Turner 1994, 1995).

As a final example, consider the following sentence: [6]

(9) I don't think we'll be able to just badge him out of there.

The context of this sentence is that an undercover federal agent was mistakenly arrested by local police. The agent's superiors are discussing whether or not their authority as federal officers will suffice to get the operative out of the local police jail -- the idea being that showing their (federal) badges should demonstrate enough authority to 'cause' the operative to exit the jail. The emergent semantics here is obvious enough (it is only our encyclopedic knowledge of jurisdictional disputes, symbols of police authority, etc., which allows us to construct the correct interpretation).

2. Blending in the Cerebral Cortex

2.1 Abstract Model

The model we propose here is tentative and makes a number of simplifications. Specifically, we will discuss only one 'level' of blending, that between clause-level construction and argument fillers, and thus we ignore blending which occurs at phrasal,

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[6] This sentence is a minor paraphrase of one from the short-lived television drama 'Wise Guy'.

discourse, and other levels. Also, we will say nothing about the implementation of the generic space (Fauconnier and Turner 1994, 1995). Finally, our exposition will focus on comprehension, though some of the evidence for the model draws on production data as well.[7]

Our implementation model takes the conceptual features of blending seriously, and assumes that each of the constructs appealed to at the conceptual level is a reflection of some aspect of the implementation architecture. This means in general that each of the input spaces as well as the blended space has a separate implementation base. Not only are separate cortical areas by and large responsible for storing the constructions and lexemes, but that there is a separate (at the very least functionally separate) cortical area whose responsibility is implementation of the blended space. Accordingly, our exposition of the model will proceed as follows: first we discuss the implementation of the input spaces, we then turn to the implementation of the blended space, and finally, we discuss the blending process itself.

2.2 Input spaces

2.2.1 Words

Following Langacker (1987, 1991) we assume that language comprehension involves the recognition of phonological units, and that when such units are recognized during comprehension, this invokes the appropriate stored conceptual semantics (of course, this is

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[7] One final proviso is in order. Though we make some appeal to neurolinguistic data, especially aphasia data, in an attempt to make initial stabs at possible sites for these separate processes, this data and our use of it should be taken as a tentative exploration. There are three reasons for this. The first is that we have as yet made no complete or adequate survey of the literature, nor designed any experiments ourselves to test some of these hypotheses. Second, the data are ambiguous, noisy, and save in a few cases, nearly impossible to interpret with any confidence (for example, even a phenomenon such as Broca's aphasia, which is extensively studied, is explained by various researchers as a syntactic, or a lexical, or a morphological, or a phonological deficit!) Finally, there is good reason to doubt that the same linguistic functions are subserved by the same cortical areas in different people (Caplan and Hildebrandt, 1988). Accordingly, even though we make some effort to determine cortical locations for specific functions, it should be kept in mind that even if the theory we are developing is correct, the functions it posits may not be localized in the same areas in all people.)

an interactive process -- the semantic conception built up at a point in discourse aids in the recognition of phonological material). So in the case of an individual word, such as 'napkin', the acoustic signal is processed by neural machinery which constitutes a pattern recognition process. The normal result of this process is the neurocognitive mobilization of the symbolic unit [NAPKIN/napkin]. Though the recognition of the appropriate phonological unit may be largely confined to a small cortical area, the encyclopedic semantic structures associated with it need not be.

Anomia is a deficit in which patients lose the ability to associate words with the concepts they stand for. For example, Damasio and Damasio (1992) describe cases of color anomia, in which patients retain normal color experience (e.g. they can sort colored chips into groups correctly, etc.), and they have no trouble producing color words, but they are unable to *name* colors appropriately: they "use the word 'blue' or 'red' when shown green or yellow." This deficit follows from lesions to the left posterior temporal lobe, around Brodman area 37 (Damasio and Damasio, 1992. See figure 3.). The patients' mastery of the phonological pole seems quite intact, and thus its neural substrates are presumably unharmed. And their mastery of the concepts of, e.g., *blue* and *red*, whose neural substrate seems to largely involve visual areas throughout the occipital lobe, also seems intact. The temporal lobe lesions seem to selectively compromise their pairing.

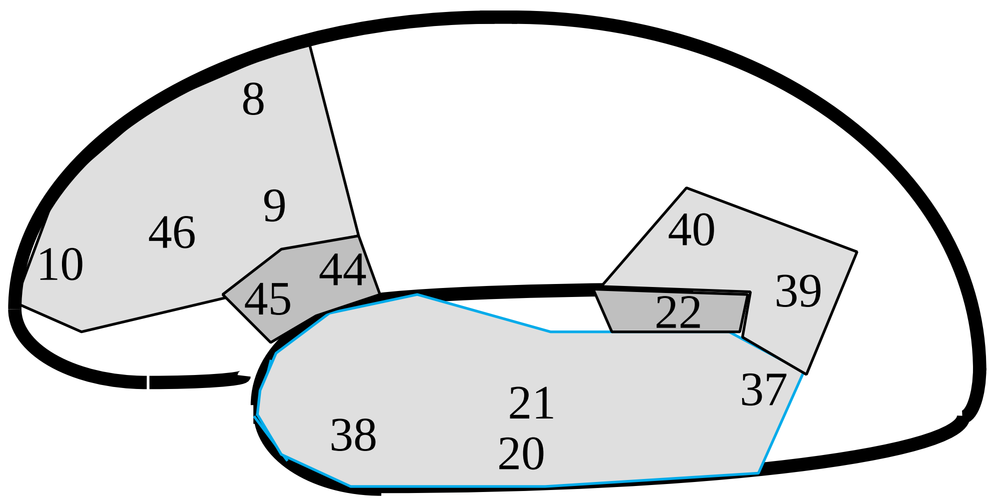

Figure 3: Schematic of left cerebral hemisphere, lateral view. Numbers indicate Brodmann's areas, and are referred to in the text.

Anomia is not restricted to color nouns. Indeed, as one proceeds rostrally along the temporal lobe (to the left in the diagram), areas which mediate form-meaning pairings of other nouns are encountered, and these areas are often geographically organized in surprising ways (Semenza and Zettin, 1989, Ojeman 1983). Damasio and Damasio (1995) call such areas 'convergence zones', emphasizing their role not in representing anything per se, but rather in organizing and *linking*, in a flexible manner, other areas which store information or, e.g., effect pattern recognition. It seems natural to describe color anomia as the ablation of the *symbolic units* (i.e. constructions) of color terms, even though the phonological and semantic poles remain intact. Following Damasio and Damasio[8] (though they do not use this terminology) we suggest that the *association* of the phonological and the semantic poles, which *is* the symbolic unit (or construction), is a reflection of the operation of convergence zones. That is, every construction -- morpheme, word, phrase, clause, whatever -- will involve three functionally distinct mechanisms: one which processes the form or phonological pole, one which stores or processes the relevant semantic matrix, and a third which appropriately links or associates the former with the latter. In the case of many nouns, the left temporal ablations appear to disrupt this third mechanism while leaving the other two intact.

2.2.2 Constructions

Since according to the linguistic theories we are assuming, clausal constructions and individual words are on the same continuum (i.e. they differ not in kind, but in degree of complexity and schematicity) we are led to look for a similar neural mechanism underwriting their recognition and application. That is, we are led to look for specific cortical regions containing convergence zones that implement clause-level symbolic units or constructions.[9] For instance, among the more commonly studied constructions are passives, and in particular reversible passives.[10] These are sentences such as 'The boy was

[8] Damasio and Damasio (1992) suggest something along these lines, though not using this terminology. A major difference between their account and ours is that they do not see competence at the phrasal and clausal level as similar in kind to what is happening at the level of words.

[9] This task is made more difficult by the fact that neurolinguistic experiments are not designed with the theoretical apparatus of construction grammar in mind. Neurolinguistic studies typically assume that clause level syntax is only explicable via one of two traditionally accepted options, either generative formal syntax or associationism (neither of which recognizes the possibility of stored clause level structures). Such researchers design and interpret their experiments accordingly. If one assumes that argument structure is supplied chiefly by the verb, and that syntactic operations act on this deep-established verbal argument structure (as is the most common traditional assumption), then it is no surprise that the appropriate confirming or disconfirming data have not been unearthed.

[10] Schwartz et al., 1980; Caplan and Futter, 1986; Caplan 1995. For an interpretation of the passive as a

kissed by the girl', which are such that the agent and patient can switch roles without semantic anomaly (compare 'The banana was eaten by the girl', which becomes the semantically odd 'The girl was eaten by the banana' when the agent and patient switch roles.). Some forms of aphasia lead to an inability to assign the correct interpretation to such sentences. This is seen by traditional theorists as a *syntactic* deficit, the loss of some passive transformation rule, or the inability to bind the overt subject with the trace theta-governed by the clause's matrix verb, or something of that nature. Indeed, this is often taken as evidence for a dedicated syntax module (e.g. Caplan and Futter 1986).

Alternately, one can see this deficit as the specific ablation of some aspect of the passive construction. Three possibilities present themselves: the ablation could compromise the ability to recognize the passive form; it could compromise the representation of the schematic passive semantics; or it could compromise the association of the former with the latter -- a clausal analogue of anomia.

Given that the central semantic value of the passive construction is to focus attention on the tail of the profiled portion of a coded action chain (Langacker, 1990, Chapter 4), and that patients can in fact do this for non-reversible passives, it seems unlikely that such patients are losing their command of the passive construction's *semantics*. Trying to distinguish the first and third possibilities is a difficult matter, but in either case, the formal aspect of the construction will not reliably invoke its semantics.[11] The sentence, therefore, cannot be interpreted correctly, and a closest argument structure match is found, perhaps with a more common, and intact, transitive construction, which assigns the first encountered argument to the role of agent. A passive sentence will differ from the associated transitive only in that it includes passive verbal morphology ('be' and a participial morpheme '-en' or '-ed') and a 'by'. But the number and serial location of

construction in its own right and not just a syntactic derivation of the associated active, see Langacker (1990).

[11] It might be thought that the ability of patients to correctly interpret non-reversible passives shows that there is no impairment of the ability to recognize and implement the construction's semantics. This is not the case, however. In the case of non-reversible passives, it is the semantic import of the arguments which suggests the correct clausal semantics. That is, the semantic import of the sub-clausal elements 'girl', 'eat', and 'banana' strongly suggests the appropriate interpretation.

potential arguments is the same, and thus could very well be the closest possible formal match in most cases.

Anterior perisylvian regions of the left hemisphere seem to play the same role for constructions that temporal pole regions play for nouns. Most available evidence points to Broca's area[12] (Damasio and Damasio 1992, Mesulam 1990, Caplan 1992, 1995). This area is widely held to process syntactic properties of sentences. For instance, it is damage to this area which compromises the ability to correctly interpret reversible passives. When viewed with the theoretical apparatus of construction grammar, however, this 'syntactic' deficit could simply be an inability to access the appropriate semantics of the phrasal or clausal construction at issue.[13]

An interesting theoretical possibility for how the construction's semantics might be supplied is due to Jean Petitot (1995). Petitot's model is aimed at describing how the semantics of a verb might create schematic semantic event participants, and what these 'events' and 'participants' might amount to neurophysiologically. The basic idea (see Petitot 1995 for details) is that the recognition of the verb causes subtle neurodynamic changes which induce a number neurodynamic attractors (limit cycles in this case) equal to the number of event participants. Though Petitot's model assumes that it is the verb which is responsible for the argument structure, and thus that recognition of the verb is what induces the correct attractor profile on the region where the clausal semantics is coded, the same mechanisms could as easily be engaged not (just) by recognition of the verb, but by recognition of the clausal argument structure itself.

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[12] Broca's area proper is limited to the inferior left frontal gyrus (Brodmann's areas 44 and 45). However, 'true' Broca's aphasia is typically associated with much broader cortical lesions, including areas 8, 9, 10, 46, part of 6, as well as the underlying white matter and basal ganglia (Damasio 1992).

[13] Indeed, it is interesting to note that the received opinion seems to be that this area subserves not only syntactic operations, but the ability to correctly apply so-called grammatical markers and other closed-class grammatical morphemes. This is of interest because of the parallels between constructions as a closed grammatical class, and these other items, which also serve a topological (Talmy, 1978) role in the construction of the clause's semantics.

2.3 Blended Space

It might be assumed that given the recognition of the clausal argument structure construction and the individual words and phrases which are the arguments, all one needs to do is to directly combine the semantic contributions of the latter and the former. This in fact is the assumption of Shastri and Ajjanagadde's model (1993), as well as models by Petitot (1995), and countless others. However, this would seem to be unable to account for the blending processes which we have argued must occur. As has been demonstrated in the above translation examples, the blending processes often involve the novel extension of meanings (Langacker 1987) and the creation of emergent partial structure (e.g. 'falling' vs. 'shifting' in the translation of examples (5/7a)). That is, it is not limited to simply determining which of a number of available senses is appropriate in a given context (e.g. of 'off' in 'off the table' (5i) vs. 'off the stage' (6i) vs. 'off its course' (7i)). Rather, it often involves the addition of temporary emergent structure not available or predictable from the inputs at all (e.g. 'falling' vs. 'shifting' in the translation of examples (5/7i)). In the case of (9) above, a theorist who maintained that a word's argument structure possibilities are simply listed in its lexical entry would be in the difficult position of claiming that native speakers' lexicon includes a three-argument verbal sense of 'badge' which is selected on the basis of the argument structure of the sentence! We thus propose that the blended spaces are allotted their own dedicated hardware which has independent access to encyclopedic world knowledge, as well as *a priori*[14] structure of its own.

Consider the following analogy. When I attempt to diagram a football play for someone on a sheet of paper or a blackboard, I might draw Xs and Os, and lines and even arrows, as part of an explanation of how a play works. But what makes the marks on the paper

[14] In this context, by 'a priori' we mean structure which is represented and manifested independently of the particular bit of discourse at issue, and perhaps even independently of and prior to linguistic competence in general. This structure may be learned from actual embodied, spatial, forceful exploration of the world, and thus may not be a priori in an absolute sense.

stand for receivers and linebackers as opposed to neutrinos and positrons? Nothing in the paper itself, because I might diagram subatomic interactions using largely the same sorts of symbols on the same page. Rather, *within the context of the explanation*, I tell you things like 'this *X* is the middle linebacker', and in so doing I **link** a representation, the X, to a richer knowledge base, your knowledge of football and linebackers, their typical activities and responsibilities. Thus a major source of the semantic import of what is written on the paper is not on the paper itself but is rather in the brains of the people engaged in the diagramming/explaining activity. The page, in this example, is a sort of *semantic convergence zone* (SCZ). It is a place where temporary schematic representational vehicles, which are themselves linked to more extensive knowledge structures, are constructed and manipulated. Furthermore, the content of these representations is not exhausted by marks (Xs, Os, etc.) together with the contributions of the sheet-independent knowledge structures. The sheet itself has a certain amount of *a priori* structure which it supplies regardless of what it represents - in this case a two-dimensional Euclidean surface (this is not trivial -- were I to diagram the play on a cylinder, it would have the apparent consequence that a defensive player might catch an offensive player by running initially *away* from him, for example). So in this case, there are three sources of structure: i) the marks (Xs, Os, arrows, etc.), ii) richer knowledge structures in the heads of the discussion participants, and iii) structure provided by the sheet itself.

In the case of the neural semantic convergence zone (which implements the blended space), the situation is similar. There will be i) schematic representations or event participants which are set up in the semantic convergence zone by the construction's semantics (these are like the Xs and Os and the arrows), ii) these schematic representations will be linked to richer, more specific semantic information (perhaps via synchrony binding to other convergence zones, see below), and iii) a priori structure supplied by the SCZ itself (some candidate types of structure provided by this cortical region are: a spatio-temporal manifold (perhaps structured image-schematically), notions of causality, or force-dynamism generally (Talmy 1988), etc.)) In addition to providing a source of the emergent structure evident in the blended spaces, the hypothesis that the neural machinery of the blended space carries its own *a priori* structure independently of the interpretation of its elements could account for the ubiquity of such structure in language.[15]

The left temporal-parietal-occipital association area seems well suited for this function. In the right hemisphere, this region is known to be crucial for spatial reasoning, representation, and attention (see e.g. Townsend and Courchesne 1994). It is plausible that this area in the left hemisphere also is geared to processing spatiotemporal information, but does so in the service of language and off-line thought rather than actual navigation through space. This area is also argued by Deane (1992) to process spatial information in an off-line manner in the service of language, though on Deane's account the spatial structures thus employed carry syntactic rather than semantic information.

So what happens, on the present account, is the following: The recognition of the appropriate clausal construction (which happens in or around Broca's area) causes a certain schematic event semantics to be imposed on the semantic convergence zone (SCZ). These elements are associated with a richer semantic base elsewhere in the cortex, and this association effects the imposition of additional structure into the SCZ. What this 'association' amounts to is the topic of the next section.

2.4 Binding

We have accommodated the contribution of the blended space by positing a separate cortical area which acts as a semantic convergence zone. The price of this is some way of linking the schematic elements within the SCZ (i.e. the arguments of the construction in this case) with the appropriate semantic matrices whose substrate lies elsewhere. In the analogy above, this was accomplished by, e.g., my *telling* you that 'This X is the middle

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[15] George Lakoff and Mark Johnson (Lakoff and Johnson 1979, Lakoff 1987, Johnson 1987) have argued extensively that image-schematic structure permeates every aspect of language and thought. Again, the hypothesis that the semantic convergence zone, which implements the blending used in language, supplies such structure provides a simple explanation of this fact.

linebacker', and by both of us consciously keeping track of this fact during the course of the explanation.

One solution to this problem from a neural perspective is an attentionally mediated binding mechanism such as synchrony binding (Singer 1995). To illustrate with a toy example, it is well known that the mammalian visual system processes color and shape/motion information in separate pathways (the 'parvo' and 'magno' pathways, respectively). For simplicity, let us assume that each pathway codes the presence of some feature by a high firing rate of some pool of neurons, e.g. the RED or BLUE pool in the parvo pathway, or the SQUARE or CIRCLE pool in the magno pathway. Thus when looking at a blue square, the BLUE pool in the parvo pathway fires rapidly, as does the SQUARE pool in the magno pathway. The problem this raises is: How, then, can the visual system per se distinguish (red square and blue circle) from (blue square and red circle)? In both cases, all four pools will be firing rapidly.

The fact that active neurons have not only a firing rate, but a firing *pattern*, suggests an answer. For instance, suppose that neurons which represent some feature code the presence of that feature by firing at 100Hz. One can then bind specific features by phase-locking those neurons which represent features that are to be bound. In the present example, this could mean that neuron pools coding the features BLUE and SQUARE will fire at t = 0ms, 10ms, 20ms, etc., while those coding for RED and CIRCLE will fire at t = 5ms, 15ms, 25ms, etc.

Of course, we are not here concerned with vision, but with language. Our problem, recall was to explain how the elements of a schematic event type, which are set up by the imposition of the clausal semantics on the SCZ, are linked to the neural resources that encode the fillers' semantic input to the blend. This problem is more complex than the toy vision example, because we are not here dealing with binding just two element types (colors and shapes), but with three: the regions encoding the clausal semantics, the regions encoding the filler semantics, and the temporary representations in the SCZ. We thus need two sorts of links, links between the clausal semantic structure and the SCZ, and links between the fillers' semantics and the SCZ. This first sort of link is that whereby the clausal semantics projects a schematic event structure, including schematic participant representations (e.g. agent, moving patient, etc.), on the SCZ (we suggested in section 2.2.2 that this might be accomplished by a mechanism similar to that explained in Petitot (1995)). The second sort of link is that whereby these schematic participant representations are bound to regions encoding the appropriate semantic structures (e.g. the moving patient representation is bound to the semantic structures representing NAPKIN), and it is this binding which we hypothesize is effected by temporal binding.

This picture, though itself very schematic and incomplete, has three features which merit discussion. First, these links are not limited to a static, unidirectional interaction. The links establish the possibility of *interaction* between the linked elements. The binding process in the case of vision was represented as static, which might suggest that in the case of linguistic blending the semantics of the words are determined independently of the semantics of the event conception, and are then simply bound to participants of this event. But the linking allows for two-way interactions, so that the schematic specifications of the event participants can interact with the lexical end of the process.[16]

Second, because this binding is done via a mechanism which has been argued (Singer 1995) to be attentionally mediated, the binding mechanism discussed here presents the possibility of addressing the influence of attentional factors on grammaticality judgments (Grush 1995, Chapter 6 explores this with respect to wh-extraction, heavy NP-shift, and c-command).

Third, because of this interactive linking to both the clausal and the lexical semantics, the 'final' semantic import of the elements in the SCZ is based on constraints from both those sources, as well as a priori constraints imposed by the SCZ itself. Indeed, it is the

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[16] For instance, the ditransitive construction forces the first argument to be construed as a potential possessor. We can say 'I threw Jim the ball', but not 'I threw the fence the ball'. Thus if one says 'Clinton sent Japan a stern letter', 'Japan' is interpreted as meaning some official governmental body (a potential possessor), as opposed to just some location, which it could be with the dative 'Clinton sent a stern letter to Japan (because that's where his brother was at the time)'.

interactive and flexible character of these links, together with this a priori structure, which account for the emergent structure of the elements in the SCZ. Thus this promises to be the cortical mechanism responsible for the blending apparent in language and conceptual structure.

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References

Caplan, David. 1992. *Language: structure, processing, and disorders*. MIT/Bradford.

Caplan, David. 1995. The Cognitive Neuroscience of Syntactic Processing, in M. Gazzaniga, ed., The *Cognitive Neurosciences.* MIT/Bradford.

Caplan, David, and Nancy Hildebrandt. 1988. *Disorders of syntactic comprehension*. MIT/Bradford.

Caplan, David, and C. Futter. 1986. Assignment of thematic roles to nouns in sentence comprehension by an agrammatic patient. *Brain and Language* 27:117-134.

Damasio, Antonio and Hannah Damasio. 1992. Brain and Language. *Scientific American* 267:3:88-95.

Damasio, Antonio and Hannah Damasio. 1994. Cortical Systems for Retrieval of Concrete Knowledge: The Convergence Zone Framework. In Christoph Koch and Joel Davis, eds., *Large Scale Neuronal Theories of the Brain*. MIT/Bradford.

Deane, Paul. 1992. *Grammar in the Mind and Brain*. Mouton de Gruyter.

Fauconnier, Gilles, and Mark Turner. 1994. Conceptual projection and middle spaces. Tech. Rep. 9401, Department of Cognitive Science, UCSD.

Fauconnier, Gilles, and Mark Turner. 1995. Blending as a central process of grammar, in Adele Goldberg, ed., *Conceptual Structure, Discourse, and Language*. CSLI publication (in preparation).

Fillmore, C. and Paul Kay. ms. *Construction Grammar*. University of California, Berkeley.

Goldberg, Adele. 1995. *Constructions: A construction grammar approach to argument structure*. University of Chicago Press.

Grush, Rick. 1995. *Emulation and Cognition.* Doctoral dissertation, University of California, San Diego. UMI. http://www.artsci.wustl.edu/~rgrush/

Johnson, Mark. 1987. *The Body in the Mind*. University of Chicago Press.

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

Lakoff, George, and Mark Johnson. 1979. *Metaphors we Live By*. University of Chicago Press.

Langacker, R. 1987. *Foundations of Cognitive Grammar: vol I.* Stanford University Press.

Langacker, R. 1990. *Concept, Image, and Symbol*. Mouton de Gruyter.

Langacker, R. 1991. *Foundations of Cognitive Grammar: vol II*. Stanford University Press.

Mandelblit, Nili. 1995. Beyond Lexical Semantics: Mapping and Blending of Conceptual and Linguistic Structures in Translation, in *Proceedings of the 4th Int. Conf. on the Cognitive Science of Natural Language Processing*, Dublin, Ireland, July 1995.

Mesulam, M.M. 1990. Large-scale neurocognitive networks and distributed processing for attention, language, and memory. *Annals of Neurology* 28(5):597-613

Ojeman, G.A. 1983. Brain organization for language from the perspective of electrical stimulation mapping. *Behavioral and Brain Sciences* 6:189-230.

Petitot, Jean. 1995. Morphodynamics and attractor syntax: constituency in visual perception and cognitive grammar. In Robert Port and Timothy van Gelder, eds., *Mind as Motion*. MIT/Bradford.

Schwartz, M., E. Saffran and O. Marin. 1980. The word order problem in agrammatism I: Comprehension. *Lang. Cognitive Proc.* 2:85-113

Semenza, C. and M. Zettin. 1989. Evidence from aphasia for the role of proper names as pure referring expressions. *Nature* 342:678-9

Shastri, L., and V. Ajjanagadde. 1993. From simple associations to systematic reasoning: A connectionist representation of rules, variables and dynamic bindings using temporal synchrony. *Behavioral and Brain Sciences* 16:417-494.

Singer, Wolf. 1995. Time as coding space in neocortical processing: A hypothesis. in M. Gazzaniga, ed., The *Cognitive Neurosciences.* MIT/Bradford.

Talmy, Leonard. 1978. The relation of Grammar to Cognition, in D. Waltz, ed. *Proceedings of TINLAP-2* (Theoretical Issues in Natural Language Processing). Association for Computing Machinery, New York.

Talmy, Leonard. 1988. Force dynamics in language and cognition. *Cognitive Science* 12:49-100.

Townsend, Jeanne, and Eric Courchesne. 1994. Parietal damage and narrow 'spotlight' spatial attention. *Journal of Cognitive Neuroscience* 6(3):220-232.