Cognitive State Semantics and the Interface Theory of Meaning

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Abstract

Start with the question of conditions of possibility for language to exist: how spoken, written, or inscribed signs differ from other kinds of things, enough to establish language as something that exists in the world. Language is a regime of multiple conversation partners, an ambient surrounding where they share actions, perceptions, and foci of attention, and a common posit of structured rules. If communication is successful, each sign's referent is isolated, collectively/phenomenologically, from a (canonically spatiotemporal) reality that extends beyond it. My goal here is to sketch this process with the help of formal and Computational linguistic theories, but keeping in sight a cognitive nuance and intersubjectivity that is (thankfully) an essential, unavoidable part of human language. I will incorporate technical models mostly from Link Grammar and Type-Theoretic Semantics, understanding the latter as possibly layering on the former to complete a syntax/semantic pairing. I propose both cases for and limits on formal theories' applicability for Cognitive Linguistics/Humanities/Phenomenology, through the lens of the Philosophy of Science — arguing how Phenomenology and Cognitive Linguistics, while distinct traditions, can work powerfully in consort.

> On connaît la célèbre affirmation de Claude Lévi-Strauss: "les sciences humaines seront structurales ou ne seront pas". Nous aimerions lui en adjoindre une autre: "les sciences humaines seront des sciences naturelles ou ne seront pas". Evidemment, sauf à en revenir à un réductionnisme dogmatique, une telle affirmation n'est soutenable que si l'on peut suffisamment généraliser le concept classique de "naturalité", le généraliser jusqu'à pouvoir y faire droit, comme à des phénomènes naturels, aux phénomènes d'organisation structurale.
> — Jean Petitot, [67, p. 1]

> The nature of any entity, I propose, divides into three aspects or facets, which we may call its form, appearance, and substrate. In an act of consciousness, accordingly, we must distinguish three fundamentally different aspects: its form or intentional structure, its appearance or subjective "feel", and its substrate or origin. In terms of this three-facet distinction, we can define the place of consciousness in the world.
> — David Woodruff Smith, [84, p. 11]

A sign demands an individuation — a criteriology, for anyone addressed and solicited by each sign, to recognize and isolate it as such. Signs, and their referents, need an isolating, from the world around (and one another), or they are not signs. In extreme cases a sign may stand alone, like the smoke fire telling a hiker's location; but by norm, embedded in discourse and performance, signs require (and carry with them, internally) understood inter-boundaries. Both the recognition and the interpretation of signs therefore implicates cognition-logics of part/whole (mereology), and (dis/)continuity, each sign/referent disconnected in some ways, and continuous in others, with larger wholes inside which they are semi-autonomous parts.

Ad-hoc signs can blur the boundaries between conventionalized languages (verbal or not) and more impromptu social interactions — the smoke fire is in part a conventional distress signal and in part a tool, an engineered natural phenomenon designed with intended effect, like causing rescuers to see it. The distress fire is also in a sense its own referent: its function as a sign is to call attention to itself, and so its location. Or, choosing to write on one's own body — like Hamas commander Mahmoud Ishtiwi, betrayed and killed by his own movement, carving into his leg the word "zulum" ("wronged") — is expression spreading beyond the conventions of words; the signs are made to signify the conditions of their execution. These rather dramatic examples are more the provenance of semiotics than linguistics. But people in ordinary verbal communication equally rely on a mixture of linguistic and other signs — we point, make gestures, use "body language" and tone of voice. When conversation turns to some topic, like "that building over there", such cues help speakers synchronize their attentions. Tone and gestures clarify sentiment (honest, joking, sarcastic, anger) that may be ambiguous in spoken words alone, taken "out of context". The weight of linguistic meaning is borne by semantics and pragmatics in fusion. Semantics has both formal and informal dimensions — linking first to cognitive schema, or (as I will argue) prototypes of how schema are triggered; and second to pragmatics and contexts. Conventionalized in semantic norms, schema, part abstract and part cognitive, help prime language users to manipulate formal structures in language, relative to the situational aether. (Dis/)continuity in the plane of reference brings consciousness to a mereo-logic [30], [82] that language-cognition can then reshape into syntax and semantics [13]. Semantic layers are abstract tools, but they offer a tableau of forms and combinations which users adapt, concretely, to each context. The deep potential of language, I believe, comes from the perpetual combination of the formal/abstract and the concrete/phenomenological.

For signs, the largest whole is a "plane" of articulation; for referents, it is an overall phenomenological surround; or, for more abstract signifieds, a space of concepts. Like a footprint, whose very existence depends on both material continuity and visual break, for each sign there must be a blend of continuity and discontinuity, both around the sign and its referent. Attending to a mereologically ordered world, we need innate theories warranting criteria for seeing things as both individuals and as causally/behaviorally constrained by and from a whole. These criteria include structural consideration of the whole, and it is often in structural terms that the blend of autonomy and linkage for each part is realized. Attunement to structured organization therefore warrants the perceptual and mental isolation of particular foci of attention [102], [103].

As this plays out on planes of articulation alongside general situational awareness, the structures of discourse — its division into distinct signs and their structural interrelationships — and that of patterns we identify in our surroundings, that provide a context of discourse, play off one another. Grammar does not iconify interrelationships among referents — unlike diagrams, maps, scientific simulations, or scale models — but it ensures communicators may create structures among words that suggest, in each others' minds, concordant patterns in the environing world/situation. Even where there is direct sensory and perceptual evidence for objects' individuation and intercontinuity, visually and experientially present (which of course is only one kind of talk and reference), our preparedness to focus attention here or there depends on mental models of situations which are more abstract and schematic, and receptive to functional and interpersonal details. The objects around us are not just blobs of matter, but usually have a constructed purpose, socially sanctioned meaning, nostalgic weight, and other significance that cannot be grasped by perception alone.

A central theme in Cognitive Linguistics is that language meaning depends on situational understanding, and by extension on mental schema of spatial, temporal, and functional organization — not only how environments are arranged, but how they are causally and physically determined [69], [91]. The difference between *pour water* and *spill water*, for example, is the person's deliberate intentions in relation to natural forces and tendencies (such as that of water to fall downward). To "apply paint" to something, compared with to "cover" with paint, suggests different spatial configurations; to *fill a glass with water*, versus *pour water into* the glass, suggests both different spatial details and maybe rationale as well. These are differences in emphasis, not necessarily in actuality: those pairs of alternatives could describe identical state of affairs. But they direct conversants' attention in different ways, they choose one or another part of a scene as a reference frame, and suggest different "takes". These are driven by *semantic* variations — the choice of verbs like *pour* versus *fill*, *pour* versus *spill*, or *apply* versus *cover*. But semantic and syntactic rules work in federation, relative to context: for example, different verbs take different prepositions in different situations. Pour *into* vs. fill *with*. To join "pour" with *with* places emphasis elsewhere — onto the device which enables the pourer to do the pouring. So the grammatic and semantic norms of a language jointly offer a terrain of options from which speakers assemble combinations invoking those aspects of situations that they wish to emphasize.

In short, grammar is language's substitute for *visual* or *physical* resemblance-to-structure. Take Ronald Langacker's "landmark"/"trajector" model as an example: one (very general) manner of spatial gestalt, subject to either intuitive, reflective analysis or to formalization ([11], [99]). "That boat crossing the lake": *boat* (trajector) perceived against *lake* (landmark), which provides context; together they produce a mental model; a figured spatial relationship. This is communicated, not by visual or kinaesthetic effect,[1] but by the more abstract effects of intentions signaled, via both exact words ("crossing" paints a different picture than would *across*, *on*, *by*; still more so, *at the bottom of*), and morphosyntactic tropes (like the form x `r` y; where "`r`" here means one from many spatial relations, taking *trajector* to the left and *landmark* to the right). *Landmark* and *trajector* are anchors around which both syntactic and semantic selections are organized.

Language needs both abstract laws and cognitively-mediated construals of ambient situations. The abstract laws are shaped by the situations, not directly — it is that extra indirection which cleaves language from other sign systems — but derivatively: language rules are optimized for conversants to mold linguistic possibilities into selection-spaces, which then become raw materials for representations of situational context. Each choice of word and form adds a piece to a representational complex, and the sum of those pieces — be this a sentence, a conversation turn, or an entire discourse — is a language act that hews to the structure of a situation, as the speaker wants to emphasize it. Here I take this perspective as pregiven: not as a perfected or homogenous theory, but as a working hypothesis on the origins of linguistic structuration as such. The scope of this paper is then to analyze its ramifications for our understanding of grammar and formal semantics.

This essay adresses topics in linguistics and the philosophy of language, though (by conventional measures of expertise) I am more of a Phenomenologist and a Computer Programmer than a linguist. I confess this not as biography, but to introduce my metatheoretical anchor points, from which derive intuitions that others might find unconventional. I am, in particular, sensitive to the experiential nuances of human cognition and skeptical that mechanical systems can emulate human minds except for narrowly defined tasks. At the same time, I think computational systems have interesting aspects that can enrich our understanding of cognition, even if we do not philosophically buy a "cognition is computation" metaphor.

To be precise, I am skeptical about "AI"; and I am also skeptical about a kind of logical reductionism that I believe exerts a definitive influence on several interrelated filds, including philosophy, linguistics, and computer science. As the paradigm seemingly goes, if we accept some form of "mind as computer" analogy, then we intrinsically accept *first* the idea that "mind" encompasses as some important part a logically articulated subsystem, which can be scientifically studied via formal logic; and *second* that as a consequence of this scientifically tractable logicality, AI is a good model or proxy for the study of mind. The unconscious deduction here seems to be that *mind as computer* has as a consequence that mind is (to some salient degree) a logical system, following a premise that computers are logical systms. But this premise is more false than it is true; so for me the whole paradigm is on shaky grounds. I will explain later why computers are not as logical as non-programmers seemingly believe. For now I'll just say this: there are rigorous accounts of computation that, I contend, are not grounded on formal logic in any techical or reductive sense. As a result, someone's non-logical-reductive views on language and consciousness do not *a priori* preclude computational models having some intuitive, explanatory, or structural-analogy place in their analyses of cognition.

Meanwhile, on the Phenomenological menu I am a committed "realist". What I mean is that, in a nutshell, we should renew our commitment not to read Husserl too psychologically; for instance, not to read *intentionality* as a psychological phenomenon. If I see a red sofa, we should go ahead and accept that what I see is a red sofa — that very object. I do not see a mental image of a red sofa or a phenomenal appearance of a red sofa or a token of red-sofa-appearance-ness. We should not be led

[1] At least in prose — poetry, which can bring back a semiotics of raw visual layout and auditory effect, is an exception that proves the rule.

astray by the sofa being a few feet away from me, so it is not "in my brain". Yes, my brain is over here, not over there — If I am suddenly distracted by something, look away, and forget about the sofa, my sofa-impression (but not the sofa) goes away, which seems to suggest that there my sofa-impression is not the same kind of thing as a sofa — which in turn invites us to qustion whther what I am really seeing is that sofa-impression, not that sofa.

But, without disputing that in *some* sense the impression is not ontologically identical to the thing itself, I still maintain that the best gloss on the situation still starts from the givenness that I do see the sofa (and not the sofa-impression or any other psychologistic posit). I will have more about to say about this realism, also. For now I'll say this: the case for "impressions" over "things themselves" seems stronger when talking about vision (which works at a distance) rather than touch — if I actually sit down on the sofa and physically contact it, we may feel more comfortable saying that my experience is directly encountering that physical object (though someone could still say that tactile sense-impressions are still not identical to objects; for one thing, the contact point between my hands/torso and the sofa — the locus of those haptic nerve cells — is not in my brain either, ergo a spatial gap still exists between brain and the sensed object). If we accept that our nervous system is in some sense a functionally organized complex, then an encounter between some external body and *part* of that system, with suitably holistic functional response, can plausibly be treated as "my brain" (or nervous system or mind) contacting the sofa — we don't need to rule out this gloss because my *central* nervous system remains physically isolated, any more than we would dispute that a knife has punctured a sealed carton when in fact only the knife-tip did so. In short, sense-causing physical contact as part of my embodied propensity to register tactile contact experientially, through the medium of functionally-organized processing that eventually includes the brain, is — I would say — a sensate manifestation of my contact with the sofa (not with a tactile-sense-impression or haptic-phenomenon of the sofa).

And if we accept this line of reasoning for touch, we should do so for vision also — partly because an intrinsic feature of *seing* something is that we *could* with proper movement touch it, and apprehension of visual form includes anticipation of how surfaces will respond when we kinaesthetically interact with them (we might presume, for instance, that we can run our hand over the wall to the right but not to the left, if there's another wall there: this visual disclosure is also in a sense proto-kinetic).

So, before making claims about language, I have hereby asserted two main intuitive feints guiding my subsequent discussion: computer programs as useful but not logically reductive analogs for cognitive processes; and the virtues of a "realist" Phenomenology which accepts arguments to the effect that we experience "things themselves": that touching and seeing (etc.) are experiential encounters with real, external, non-psychological entities. This does not have to be a blunt realism — I don't dispute that we experience appearances in some sense — but we need to articulate the thing/apearance distinction in a way that does not disallow common-sense intuitions like "seeing the sofa" meaning that I do see some real, external sofa-thing. That would make for an analysis in pure Phenomenology if I just framed my arguments with reference to, say, Husserl's own treatment of the noemata/phenomena distinction. Here, howevere, I am going in a different direction and package a loose theory of "realism" about intended "external" objects within a treatment of "externalism" (and *internalism*) in the philosophy of language.

I am not ignoring that "external" in the sense of "wide scope" mind-world relations as a Semantics hypothesis is only tangentially related to "external" in a phenomenological sense of experienced external objects (as opposed to experienced internal, e.g. somatic, states). But I *will* present a theory that connects these two senses of "external" (and likewise two senses of "internal").

All told, my goal here is to sketch a theory of cognitive linguistics which can resonate soundly with Phenomenology (while not being especially phenomenological on its own). This theory will be incomplete — deliberately, strategically incomplete. Indeed, every theory should be incomplete: an essential quality of modern science is our recognition that scientific explanation covers a vast breadth of scales and kinds of phenomena, and "science" as a singular human institution only exists insofar as there are many sciences, each with some measure of theoretical autonomy but also areas of overlap, so scientific explanations can bridge across scales. Biologists take it for granted that the basic intellectual structures of their disciplines can be justified by appeal to chemistry (as a causative or emergent base of bioloigical phenomena); and the presence of *parts* of biology where this connection is explicit (like organic chemistry) is important for our overall sense of biology as something grounded in a general scientific method. But these "reductive" links are not typically operationalized in biology as a whole — a biologist is not "doing" chemistry, biological properties are not necessarily chemical properties, biological laws are not necessarily chemical laws, and biological terms are not semantically (or even arguably referentially) reducible to chemical terms.

We can consider whether biological concepts are "in some sense" reducible to (or extensionally equivalent to or "the same stuff as") chemical concepts, but framing this discussion as a nuanced debate implies that biology is not *trivially* reducible to chemistry, and we may accept such a reduction as a plausible option only insofar as some of us may hold philosophical commitments, which "we" collectively do not want to dismiss out of hand, that higher-scale sciences are necssarily reducible to lower-scale ones that are their causal or physical-constitutive base. But even if there is a sense of "reduction" and of "biology" and "chemistry" that makes biology reducible to chemistry, this dos not make biological *science* reducible to chemical *science* — that is, a well-constructed and discursively evaluable biological theory should not be expected to consider in any detail its own reductive interprtations, or express its concepts in chemical (rather than biological) terms, or attempt to *explain* rather than just *presuppose* chemical laws (preservation of quantities in chemical reactions, acid/base qualities, solvents and solubility, molecular interactions, etc.). Ditto for chemistry in relation to molecular physics, molecular physics in relation to quantum physics, neurology in relation to biology, and so forth. In short, whatever our philosophical intuitions about emergent phenomena and the ontological duality (or monism) between emergent and base scales, these philosophical points are only tangentially related to the equally important philosophical question about what makes a good theory in a science.

This bears reiterating: when considering a science (I'll include social sciences and humanities here) philosophically, there are two different sorts of questions that can arise. On the one hand, what is the ontological status of the entities, laws, and quantitative models postulated by the science and its currently influential theories? Should we understand terms to be proposed natural kinds (like "protons"), structural features that don't necessarily align with straightforward patterns of reference (like "dark matter"), referring expressions into complex systems whose parts have somehow fuzzy or underdetermined boundaries or criteria of individuation (like "storms" in the context of climate science), or quasi-references which have the form of concrete designations but are really just shorthand for elaborate paradigms (like "natural selection")? These are various options in the semantics of scientific jargon, which are clues to the proper ontological status of sciences' theoretical posits (this much applies to linguistics also, with its theoretical vocabulary of concepts, lexemes, syntax rules, generative semantic rules, and so forth — are these mental subsystms? Innate cognitive faculties? Clusters of nerve cells? Neural pathways reinforced during language acquisition?). But, on the other hand, there is a different order of question philosophers can ask with regard to a particular science: what qualifies as a well-constructed theory for that science? What sorts of formal models hold explanatory merit as, seemingly, capturing the casuative factors determining the behavior of the systems that science investigates: continuum-based numerical models? Models in discrete mathematics? Systems of logic? State machines? And interconnected with that question is the proper scope of the science: a well-constructed theory needs to honor bounaries between and autonomy of different sciences. Having a clear picture of what beliefs in *other* sciences to take as explanatory primitives in *this* science is an essential criteria of theoretical soundness — no less than the urge to pursue explanatory closure within the proper bounds of each science.

One of my objections to "logical reductive" paradigms in linguistics (and computer science) is their failure to distinguish these two aspects of a philosophy of science, by my lights. When discussing chemistry or biology, we can make a clear distinction between metaphysical commitments according to which higher-scale systems reduce (via physical composition and the propagation of causality across levels of organization) to lower ones — biology to chemistry to physics — as a genre of reduction obviously diffrent from reducing sciences as collective intellectual exercises. We do not reduce the community of biologists to the community of chemists, or the kinds of expertise and fluency in certain mental gymanastics, or the criteria of what makes good biological theories, to the concordant community, conceptualizations, gymnastics, and theory-criteria of chemists. This is for me part of what makes biology a successful science — *it is incomplete in an ontologically necessary, intellectual fertile way.* But if this is a reasonable criterion, what can we say about linguistics as a science? Is it incomplete in an ontologically necessary and intellectually fertile way? In fact, I intend to argue here that some popular linguistic theories are *not incomplete enough.* They are (or would be, if successful) too complete — while also, I will claim, incomplete in the wrong ways, leaving too many *relevant* phenomena, issues that *are* in its scientific wheelhouse, incompletely explained.

I will make these arguments as a prelude to describing the (incomplete) linguistic theory I *am* prepared to defend. Specifically, the first two sections here will weigh in on Conceptual Role Semantics and Truth-Theoretic Semantics and explain why I believe some popular paradigms in the philosophy of language are problemmatic. While the details will vary, the main thurst of my points will be that philosophers of language fail to appreciate the importance of sciences' internalizing a map of the division of labor between sciences — a science is constituted in part by how it touches but remains autonomouus from other (both higher- and lower-scale) sciences. So biology is constituted in part by its status as a potential reductive base for (e.g.) neuroscience, medicine, genetics, and paleontology, while having its own reductive base in chemistry and physics. Part of what it means to be biology is to be the explanatory bridge between, say, medicine and physics.

Analogously, I believe, part of what it means to be linguistics is to be the explanatory bridge between, say, sociology, anthropology, and ethnolinguistics, with cognitive science (or Cognitive Phenomenology). Language can be intrinsically characterized as the cognitive bridge between our everyday world — of social situations and kinaesthetic/pragmatic enaction and anticipation, planning and memory — with the neurophysical substratum (whatver it is) of our mental faculties. Language, that is, is an important tool for our negotiating the duality of our higher-scale social/situational world with our lower-scale neurophysical existence. Analogously, a phenomenon in language — say, a sentence — should be analyzed as a kind of transition-system between a social/situational layer of reality and a cognitive/neurological layer. Linguistics is accordingly suspended between these layers — or, better, I claim that linguistics should be the *theory of being suspended* between social/situational and cognitive/neurological strata. A linguistic analysis starts with entities shooting in from the first stratum (sentences we hear uttered, canonicaly), and it ends with some restructured representation or consummation of that sentence (parsed, lexified, etc.) understood as inputs to some neurophysical process belonging (ontologically, and as a matter of scientific jurisdiction) to the second stratum. Such an analysis is *correctly* incomplete because it recognizes that a basic criterion of well-formdness for linguistic theories is that they *refrain from* direct analysis of either societal/interpersonal or cognitive/neurophysical processes. Linguistic analysis is incomplete because a theortical machinery fine-tuned for analyzing processes of linguistic understanding at the intermediate level between social/situational and neurological strata cannot be the same as a theoretical machinery for analyzing either (in one explanatory direction) sociological or (in the other) neurophysical laws in turn — by analogy, the experimental (and theoretical) machinery for detecting Earthlike exoplanets cannot be the machinery for detecting Higgs bosons (and vice-versa).

Here I find an analogy to computer software useful: programs don't run themselves, so application developers realize that they do not control, or have access to much information about, when applications are launched (or when users will perform actions that require response from the software, like clicking a mouse button or pressing a key). Nor do programmers control input/output commands like emitting colors to the screen: they only influence electronic devices (like displays and networking capabilities) indirectly, via preimplemented system calls. In other words, the essential structure of a computer application is to be poised to react to various events (a mouse click, a key click, plus of course program startup initially) by eventually requesting certain operations (like changing the state of the screen) whose exact functioning remains outside the programmer's theoretical arsenal. Application developers have only a vague idea of how values and types in code are marshalled to an from electrical signals physically affecting (or reporting state from) devices like monitors, mouses, and keyboards. This is by design: if you are too closely attuned to low-level cyberphysical details, like how source code function calls map to digital signals, you're no longer doing computer programming (maybe you're doing chip design). To the degree that programming has a theory, it's a theory of how to *bridge* users' desired interactions with the software you are building *to* the digital structures encoded at the level of microprocessors and machine language. It is not a theory of microprocessors themselves. Theory well-formedness in the realm of programming — the field sonetimes called Software Language Enginering — reflects the transforms bridging "Human Computer Interaction" with machine language; it is not a theory of HCI or of machine languages themselves. Indeed, HCI methodology is subjective and statistical; and the methods of physically realizing machine language in microprocessors depend on physical and nanochemical properties. Well-formed Software Language Enginering theories *have* to leave both HCI and microprocessors out of the frame, since software programming languages are not statistical or subjective, nor physical or nanochemical.

The hierarchical nature of computer architecture complicates any "mind as computer" metaphor: computers have many subsystems, with significantly different structures and properties. Using computers as case-studies of artifacts that are in some sense "intelligent" can take us in different directions for different answers as to what scale of computers' organization we propose to inform, say, cognitive-linguistic research: microprocessors? Machine Language? Programming languages? Software systems? The internet? Many instances of "mind as computer" analogic reasoning are not explicit research paradigms being proposed forth but are more like reports of intuitions: a community of linguists feeling that there's something going on in how computers work that usefully models or resembles how human rasoning or language-processing works. But cashing these intuitions into systematic models can prove challenging: even insofar as a computer may exhibit intelligent behavior, it does so only in an emergent manner, the whole "intelligence" being possible only through specific kinds of interaction between subsystems, in particular a tightly determined transition between high-level systems (like applocation source code) and low-level systems (like machine code).

Of course, many researchers probably believe that this emergent dimension is precisely why computers are a plausible cognitive analogy: they suggest that intelligence can be realized in structural systems whose lowest-level operations are not particularly complex. No-one would argue that in and of itslf a simple Van Neumann machine is particularly "intelligent"; but software evincing intlligent bhavior can be implemented as emergent phenomena for which Van Neumann machines are their reductive base. This may seem like a useful analogy to consciousness, realized in neurons and synapses even though neurons and synapses are not themselves conscious. That's an acceptable intuition, but it also leads to a kind of philosophical bait-and-switch: what starts as a "mind as computer" intuition ends up as a different kind of analogy, something more like comparing minds to functional systems *implemented* on a computer. There is a difference between being a system realized on a computer and actually being a computer.

In the case of language comprehension, someone may find a useful analogy in database-like constraint-solving applications, like Prolog: language users maintain an internal store of beliefs — about both language and the world — and a record of prior steps in the current conversation. This "database" gets updated as we hear new sentences, and we are equipped to make or reject inferences based on inference rules and constraints, respectively: from "John is my younger step-brother" we can conclude both that the speaker's parents are divorced and that John is not female. Of course, real-world complications sometimes intrude on the kinds of tidy frames linguists build around words: a brother can actually be a transgender woman, and divorcés can remarry each other. We can debate whether these are semantic or pragmatic issues (I think they're the former, but let's say they are the latter for sake of argument). So let's say language has enough logical order that conversations can be modeled rather like Prolog programs. This leads to a maybe-interesting mind-as-Prolog analogy, but — here's the crux — mind-as-Prolog analogies are *not* mind-as-computer analogies. Computers *run* Prolog programs; it's not that they *are* Prolog sessions.

Indeed, I think many "mind-as-computer" analogies are actually more like "mind-as-Prolog" analogies, or substitute some other technology for Prolog. For instance, mind-as-artifical-neural-network analogies are not mind-as-computer analogies, because computers are not ANNs (though they may implement them). Indeed, ANNs are designed to make computers more humanlike: to transcend the mechanistic limitations of Van Neumann architecture by realizing, at some virtual level, a more connectionist manifestation of computation. A mind-as-ANN analogy is therefore really mind figured as a computer programmed to operate like a mind (so, the analogy is basically circular). Mind-as-symbol-processing analogies have similar issues: computers are not symbol-processors, though they can implement symbol processing systems. As I'll defend below, I think computers are basically stack machines, and stack machines do not "process" symbols — what they do is process stacks, and jump around to different subroutines. When people think about "computers" in mind-as-computer analogies — or write in ways suggestive of such an analogy — I often get the impression that what people are really thinking about is not "computers" but some sort of mathematically formalizable, functionally specified system that can be *realized* on a computer.

These other analogies are not *a priori* bad — it's reassuring if we have accounts of intelligence that traffic through functional organizations that can be realistically embodied in mundane physical artifacts, rather than needing some magical mind-gunk. But if our "mind-as-computer" analogies are nothing more than a desire to find logico-functional systems that can credibly undergird cognitive behavior, computers are basically irrelevant: the computational realizability of such logico-functional systems is a nice reminder that we're not asking non-philosophers to believe in magic, but the structure of these systems are sufficiently remote from how computers internally operate that computer realizability should have no *theoretical* role. In other words, mind-as-computer analogies are usually basically mind-as-logico-functional-system analogies.

We're entitled to find these latter analogies intuitive. My problem is only with mind-as-logico-functional-system analogies that get defended *by appeal to* mind-as-computer analogies. There seems to be a kind of metatheoretical pattern that goes something like this: mind is metaphorically a logico-functional system *because* mind is metaphorically a computer, and logico-functional systems (when not just abstract mathematical territories) are realized via implementation in computer architecture. But mind-as-computer is not logically related to mind-as-logico-functional-system — any apparent link between these analogies is a biproduct of intellectually backgrounding the distinction between *being* and *implementing*. We may or may not like a mind-as-computer analogy, but even if we *do* accept such a perspective, even if provisionally, this does not then legitimize or entail that we are accepting a mind-as-logico-functional-system analogy. Of course, we can judge the latter analogy on its own merits, but the former analogy in no way retroactively justifies the latter.

So, my strategy for the remaining sections of this paper is as follows: I will review some language-philosophy controveries and argue that disentangling mind-as-logico-functional-system from mind-as-computer analogies should change our estimation of theoretical claims apparently motivated by mind-as-logico-functional-system paradigms. I will then present a different basic account of language processing which, I believe, does not work in any logico-functional-system orientation, though I will recognize some fashion of functional orientation. I will in places appeal to computer architecture, though the framework I propose will only absorb "mind as computer" analogies to a limited, targeted extent. A central theme will be that *logic* is not terribly relevant for either language or computers: functionally-organized systems do not have to be *logico-functional* systems. The ambient philosophy guiding these arguments is that "logic" in any formal, symbolic sense is not the proper vehicle for understanding the structured transitions and causative propagation endemic to multiscale, emergent systems.

Biology, for example, is not a *logical* intermediary between medicine and physics. We can consider how best to describe its "intermediariness": as a theory-construction maxim (in the sense that intermediariness is expressed in which laws/obervables are thematized and which are deferred to other sciences), as a causal network grounded in cross-scale physical constitutions and mereologies (e.g., tissues are both physically composed of cells and are wholes where cells are parts), as an emeregnt system which both *is* (vis-à-vis other sciences) and *has* a reductive base. Sciences are like computer programs in that they have *inputs* (observables from other sciences) and "outputs" (laws from other sciences). I use thse terms because they track analytic trajectories: medical *observables* (e.g. that many people who are exposed to a toxin develop neurological damage) are linked *via biological analysis* to causal/material explanations (how the toxin chemically damages nerve cells). Biology neither statistically models the medical observations nor physically explains the causative mechanism, but it provides a theoretical machinery for rigorously modeling and analyzing the transition between them. It writes the second act of the explanatory play, so to speak. Pictured computationally, the analysis is like a computer program whose inputs are higher-scale observables (say, medical data) and whose "outputs" are numerical models whose formulae or justifications are solved by other sciences — by analogy to programmers calling system-kernel functions. In this analogy, medicine is like the end-user, biology is the application developer, and physics is the system kernel.

These are analogies informed by computers, of course, but I am trying to focus in on the "intermediariness" they evoke. How computer software bridges users and bare-metal is a useful metaphor for how scientific theories bridge observations and causal/mathematical microphysical models. And, correlatively, how sciences bridge between other sciences — higher sciences yielding observations that are "inputs" to intermediary explanations, lower sciences defining formats for "outputs". Biology, for example, can defer to chemical or physical explanation if it can provide data in structures adequate to chemical or physical formulae: the reference frames, quantitative measures, dimensional systems. Biology does not need to solve such equations, just marshal data into their form. So a good biological analysis will take observation data (e.g. from medicine) and transform it to equational data in some sense, wherein chemistry and physics take over. By analogy, correct computer software takes observations (data in computer files and user actions) and translates these observations to the proper system-kernal calls, whrein the Operating System takes over.

Sometimes logical constraints come to bear on these transitions, but the importance of logic per se is overshadowed by the overarching phenomenon of "intermediariness": how the technical and ontological status of computer applications is defined by their intermediary position between input data/user actions and low-level system calls. Analogously, sciences are characterized by their posits' ontological status as — and their theories' structural criteria regulated by — intermediariness between observational data from one peer science and causal/mathematical formula from another. As a philosophical gestalt, such "intermediariness", I believe, should take the place of "logic" in our intuitions.

In the specific contexts of Conceptual-Role and Truth-Thoretic Semantics, I will now show what for me this means in practice.

Part I

In this first half of the paper, I will consider several semantic paradigms: Conceptual Role Semantics, Conceptual Space Theory, Truth-Theoretic Semantics, and ultimately Interface Theory of Maning (a term due to Orlin Vakarelov). I approach this material as, hopefully, a mediator: I'd like to negotiate the differences and aggregate the best parts of these analyses, while avoiding reductionism and remaining true to phenomenology. I will eventually tie the peices together into a "Cognitive State" Semantics — but in this case semantic analysis overlaps with theories of syntax, so I will develop this aggregative perspective more in Part II, that addresses syntax more head-on.

1 Conceptual Role Semantics and Externalism

Conceptual Role Semantics is often discussed together with a particular internalism/externalism debate which it tends to engender. Here I want to defend a kind of Conceptual Role Semantics (hereafter CRS) but I will first outline an account of compromise between externalism and internalism. I will suggest a compromise different, I believe, than Ned Block's "two factor" model that seems considered the leading example of an externalist/internalist hybrid.

The basic CRS picture is that linguistic meanings should be associatd with conceptual roles in our understanding situations more than in terms of their reference to external objects. Given sentences like

- (1) He opened the wine bottle with an ornate corkscrew.
- (2) He opened the beer bottle with a butterfly corkscrew.
- (3) He collects antique corkscrews and just bid on one online.
- (4) I thought this was a screw-top but it turns out I need a corkscrew.
- (5) This X3D file shows a very realistic corkscrew created with NURBS surfaces.
- (6) Could you send me the corkscrew (the X3D file you just mentioned)?

we should interpret "corkscrew", first, as a concept in a kind of functional organization. In some of these sentences there is also a specific corkscrew (qua phsyical object) on hand as a referent, but its actual physical properties — or even identity — is not decisive for the meaning of the sentence. After all, in (4) the speaker is not thinking of any corkscrew in particular (probably — more on that later) and in (5) and (6) the corkscrew is not real (at least not real qua corkscrew). But the conceptualization associated with "corkscrew" does not seem markedly different in (1) or (2) versus (4), at least (more on the other three later).

Not only physical details but even lexical identity seems tangential to the important conceptual meanings. Suppose I am hosting two guests, one has a magnum of ale and one a bottle of Malbec. They ask, respectively:

- (7) Do you have a bottle opener?
- (8) Could you get me a corkscrew?

and I give the first guest a butterfly corkscrew and the second a folding multi-knife. What I gave them is different from their request, but they should think nothing of it insofar as the winged corkscrew has a gap on its handle suitable for beer bottles and the multi-knife has a fold-out corkscrew helix. I have not violated any conversational maxims, because I reasonably assume that the instruments I gave them are suitable for the desired goals, of opening their bottles. Semantically "corkscrew" really means "something that can be used to open a wine bottle", and in that sense the lexeme gets it principle content from this operational role, not some list of attributes (like spirally and graspable) or prototypes.

Granted, a suitably designed winged corscrew can be construed as a kind of bottle opener, and a multi-knife a kind of corkscrew respectively. We are prepared to accept these tools as examples of the respctive concepts if they are functionally designed to support those tasks, even if they are not the primary function. But our inclination allowing concepts to dilate modulo functional criteria suggest that our grasp of concepts is first and foremost functional-pragmatic: we tend to internalize concepts in reference to (extralinguistic) functional roles and expand concepts to accommodate variegated implementers of those roles.

We can indeed accept sentences like:

- (9) He opened the bottle of beer with a hammer.
- (10) He pounded the nail with a lever corkscrew.

Of course here we are inserting objects into a conceptual nexus where they are not usually found. Winged corkscrews are often *designed* to double as bottle-openers, but lever corkscrews are not designed to double as hammers. Nevertheless we have no trouble imagining the scenarios being described, where someone uses the thick part of a corkscrew to pound a nail, or a hammer's handle/claw gap to pry off a bottle cap. We have schemata for "a tool to open a capped bottle" and "a tool to pound a nail", and the concepts of bottle-opener and hammer occupy that conceptual niche insofar as they are artifacts designed for those purposes. But the conceptual "slot" for, say, "a tool to open a capped bottle" is more general than the specific tools designed for those purposes.

We nonetheless *would* be presumably violating conversational maxims if we handed our friend who wanted to open a beer bottle a hammer. Even if there's a way to make the hammer work for that purpose, it's further outside the norm than, referring back to (2), proposing to use a winged corkscrew. So the implicature in (2) is satisfied, let's say, by bringing my guest a winged corkscrew, but not a hammer. But we can entertain the *thought* of using a hammer as a bottle-opener, and even this possibility presents problems for simplistic thories of language acquistion as essentially learning a static set of word correspondances, like "a hammer is used to pound nails" or "a corkscrew is used to open wine" — after all, you cannot conclude from

- A hammer is somthing used to pound nails, *and*
- A lever corkscrew is something used to open wine, *and*
- A lever corkscrew can be used to pound nails

that a hammer is a kind of lever corkscrew and can therefore open wine. What we *do* have are conceptual slots available encapsulating ideas like "that which can open bottles" or "that which can pound nails", and we "fill" these conceptual slots with different lexical content in different situations. The "that which can open capped bottles" slot can be filled descriptively — i.e., in declarative speech, like in (9) — by a hammer, but not in other kinds of speech acts (we cannot read the concept "bottle opener" as satisfied by "hammer" in the context of a request for a bottle opner). Note that the scope of conceptual roles can change merely by switching between locutionary modalities.

The takeaway from this discussion in the internalism/externalism setting is that conceptual roles have a linguistic priority over and against both lexical and physical realizers, and the scope for things inside and outside of language to play (or not play) such roles varies with context. I have introduced these issues via tool artifacts (like corkscrews) but would be closer to the spirit of the CRS internalism/externalism debate by discussing natural-kind concepts. Suppose I am building a sand castle on a beach and ask someone one of:

(11) Can you bring me a bucket of water?

(12) Can you bring me a glass of water?

For (11), a reasonable reaction would be a bucket filled with ocean water; but for (12) my addressee would probably infer that I was thirsty, and — since salt water is non-potable — was requesting water I could drink. But "*glass of* water" probably figures here just to establish my intention to drink it: you are entitled to bring me bottle of water instead. In other words, my request has implied content which in some aspects loosens and in some aspects restricts the conceptual scope of semantic entries in my utterance. Thus oceans are composed of water, and near a beach I can say:

(13) The ocean is over there.

(14) The water is over there.

(15) You can see the ocean from here.

(16) You can see the water from here.

Each pair is almost identical. But ocean-water ceases to fall under the conceptual role of "water" when we are in the context of drinking things instead of the context of geography. This suggests that water does not "mean" H_2O or other saline or non-saline water: the meaning is not fixed to any particular chemical composition but adapts to the situational context, including what the water is used for — e.g. as a drink or as a binder for a sand castle.

The most-discussed "water" analysis in the literature is less earthly than this: Putnam's "twin earth" argument about a planet whose substance (with chemical makeup) XYZ functionally indisinguishable from our (H_2O) water. Externalists and internalists use this thought-experiment to express their differences as disagreements over whether twin-earthers' XYZ concept is the same as our H_2O concept. For the latter, as the basic account goes, XYZ plays the same conceptual role in their lifeworld as H_2O plays in ours, so it is the same concept; for the former, the concepts designate different material substances (even if twin-earthers don't know this) so they can't mean the same thing, even if there is some sort of analogy or resemblance between them (concepts can be analogous or similar while still being different concepts).

Before making a case for one alternative here over the other, let me note the following: it is unfortunate that the case-study is formulated in terms of XYZ vs. H_2O, because at the level of molecular composition it is hard for us to conceive that XYZ is *really* indistinguishable from water. After all, our conceptual understanding of water includes things like electrolysis — if XYZ does not emit hydrogn and oxygen when electricallly charged under certain controlled conditions, it is not behaving like water and can not be (even internalistically) construed as conforming to our concept of water. Of course, we are free to expand our water-concept, just as we contract it when switching from geology/geography to drinking. But here we expand it with full recognition that finer-grained conceptual distinctions are possible, just that there are many contexts where they are unnecessary.

We do not need to contemplate far-fetched twin-earth scenarios to see this in practice: here on earth we have deuterium water which is chemically different from normal water (but both have the H_2O signature, although heavy water is also described as D_2O). We are free to let "X" mean normal hydrogen, "Y" mean deuterium ions, and "Z" mean oxygn, so XYZ becomes what chemists call HDO — semi-heavy water. Most people would probably say that HDO is just a kind of water, and so can be subsumed under the concept "water", but this is not conclusive. In reality, I don't think the English community has needed to establish whether "water" should mean ordinary H_2O or should include variations containing different hydrogen isotopes — whether heavy and semi-heavy and other variants of water should be considered "water" or some other concepts.

In practice, a fraction of ocean water has deuterium, which might argue for "water" subsuming heavy water — we don't point to the ocean and say

(17) The water and the Deuterium Dioxide is over there.

But this can alternatively be explained by the principle that referring to an impure sample of a substance is still a valid use of the concept:

- (18) Here's a glass of water (even though tap water is mixed with flouride).
- (19) Bing cherries are dark red (even though the stem is brown).

In the second case, we can validly call something red even if something less than its whole surface shows a red color. Applying a similar rule, we can call a solution "water" if there are only "sufficiently small" amounts of solutes. Clearly we use "water" to designate many substances other than pure H_2O. I can think of two options for explaining that semantically: (1) Salt water, tap water, distilled water, (semi) heavy water, etc., are all different kinds of water, but our coarser "water" concept subsumes them all (in most contexts). (2) There is only one water concept, pure H_2O, but impure samples of liquid that are mostly water can be called "water" by the same principle that a mostly red-colored object can be called just "red".

The second option has a common-sensical appeal because it fits a succinct "concepts as natural kinds" paradigm but does not venture too far from normal language use — that "red" actually means "mostly red" is a pattern common with many nouns and adjectives (someone can be *bald* with a bit of hair; I can point to a turkey burger made with bread crumbs and spices and say "that's turkey"; I can tell someone listening to Keny Arkana's song "Indignados" "that's French", although some of the lyrics are Spanish). However, the "mostly water" reading has a couple of problems: first, what about cases like a "glass of water" where "mostly water" is not "mostly" enough to drink? And, second, why can't we refer to plasma, say — which is 92% water — as water? This is not just a matter of numbers: the dead sea water is much less pure than plasma in the hospital (in terms of percentage H_2O in solution) yet we are authorized to call the former "water" but not the latter. This certainly seems to be a matter of conceptual roles — plasma occupies a certain place in our conceptual systems about blood and medicine (largely because it plays a specific role in biology and medicine) which does not fit the profike of "water", while the stuff in lakes *does* fit that profile, even if the lakes are hypersaline. Blood fits a conceptual ecosystem where we are not tempted to subsume it under the concept *water*, whereas our conceptualization of lakes pulls in the opposite direction — even though by purity the water in Gaet'ale Pond in Ethiopia is apparently not much more watery than blood. Our disposition to either contract or dilate the sense "water" seems to be determined by context — by the conceptual role water plays in different context — rather than by actual hydrological properties.

What about the hypothetical twin-earth XYZ that Putnam imagines is indistinguishable from our H_2O? Well, for this hypoyhsis to even make sense we have to assume that XYZ is scientifically indistinguishable from water, which is a matter not just of pure H_2O but of all solutions and deuterium- or triterium-related variants of water, and so forth. As a thought experiment, where we are free to conceive almost anything, this is not impossible. Let's imagine that there is an undiscovered subatomic particle that on some planets clings to atomic nuclei without affecting them in almost any way. We can call nuclei harboring these particles "twin nuclei", so hydrogen becomes "twin hydrogen", oxygen becomes "twin oxygn", and presumably water becomes "twin water". This twin water would essentilly retrace the the compositional structure of water — since it would have to form (and unform, under electrolysis) just like "our" water. If we plug this "twin water" into Putnam's scnario, I can't see why we don't just call this a variant kind of water, water with some extra (but observationally negligible) particles, just like heavy water is water with extra neutrons.

This does not do perfect justice to "twin earth" discussions, because I am describing "twin" water as something whose composition is almost identical to "our" water. In the original story, "twater" is XYZ, which as written suggests something whose physical constituents are much different than water, even if all propensities that influence our "water" conceptualizations are exactly the same as our water. But something compositionally different than water *can't* be functionally identical to water, at least if any of the actions we can take that reveal water's composition come out different. In short, whatever XYZ are, they must have a capability to *become* hydrogen and oxygen, because XYZ's emulating water means it emits hydrogen and oxygen under electrolysis. Meanwhile there is no action that could "release" the "X" (or whatever) because that would also behaviorally differ from water. So XYZ would differ from water only insofar as in its "unobserved" states it can float around as something without hydrogen or oxygen but, whenever subject to actions that cause water proper to emit these gasses, it would somehow conjure them up in exactly the same patterns as water (which actually *is* composed of hydrogen and oxygen) does.

By dictum, then, XYZ is not actually composed of hydrogen and oxygen, but whatever it *is* composed of can act as *as if* it *does* contain these gasses so as to emit them. In that case I'd question the argumentative force of claiming that XYZ does not contain hydrogen and oxygen to begin with. We are asked to believe that XYZ is made up of some ethereal non-hydrogen and non-oxygen that can nevertheless become hydrogen and oxygen whenever it is in the physical states wherein water that *is* made of hydrogen and oxygen will release them. I am inclined to say that this is just another way of being made of hydrogen and oxygen. After all, atoms are not little ping-pong balls: what we picture as a water molecule is actually apparently much more ethereal, suspended in quantum indeterminacy. I take it there is some Shrödinger equation for a water molecule, and only when the "wave function" collapses — say, by our observing the water subject to electrolysis — do we actually get hydrogen or oxygen atoms. So "our" water isn't really "composed" of hydrogen or oxygen in its pure quantum state. Maybe XYZ "collapses" to hydrogen or oxygen in different ways than earthly water (but with no way to measure the difference), but this is still not divergent enough that for me to feel compelled to call XYZ anything other than some variant form of water.

Of course, I am assuming that twin earthers have *the same* water-concept that we do, *in all respects*. Maybe a more faithful review would consider that twin earthers might have a related but more primitive water-concept than ours — maybe some subset of our concept in terms of the scientific knowledge embedded in our concept. Before we earthers knew about hydrogen, oxygen, or electrolysis, the behavior of water under electrolysis was not a factor in our concept of water. So imagine if twin earthers' level of scientific knowledge was akin to that on earth centuries ago — their XYZ is measurably different from our water, but they have no experimental or scientific apparatus to notice the difference. But this is *contingent*: the twin earthers *could* some day discover hydrogen and oxygen. Then, if XYZ really is not composed of hydrogen and oxygen (or acts as if composed of them when not in a nonobservable ethereal state) their scientific theory of water, and accordingly their conceptualization, would diverge from ours.

We can imagine a non-water XYZ that is water-like enough to play an identical rooe to (our) water, but this story can go in two directions: either XYZ is *absolutely* identical to water, its differences from water so obscure as to be observationally and causally maningless; or it has legitimate differences from water that *could* be conceptually significant but in some context are not (at least not yet). These are two different thought experiments. If some substance is in all respects and under any conceivable science identical to water, yet somehow compositionally different from it, I think the plausible response among normal language communities would be to extend the concept of water — subsuming XYZ under the concept, analogous to heavy water when it was discovered. We are generally prepared to expand the reach of concepts when there is no compelling reason not to do so. Whether a potential expansion takes hold probably varies by context. We are — a point that generally fits on the externalist side of the ledger — more willing to accept expansion when the revised conceptualization would not deviate too far from a basic alignment of natural kind concepts to scientifically reasonable classifications. We can readily extend "water" to D_2O because the two substances are compositionally very similar. We are less likely to accept conceptual mergers when they seem to violate our natural-kind pictures, even if they are functionally plausible: we do not accept "agave" as a subconcept of "honey", even though the two are physically rather similar and functionally very similar. Nor does physical form alone drive conceptual boundaries: we know full well that water vapor and ice are the same stuff as liquid water, but we recognize a conceptual distinction between them.

But these are not hard and fast rules: we may be inclined in many contexts to treat frozen-concentrate juice as conceptually subsumed under "juice" (as in "juice on sale"), and we will often accept almond milk or cashew milk as "milk", despite physical differences which we certainly acknowledge. In short, conceptual boundaries tend to be drawn to honor, albeit without excess granularity, both physical and functional factors — neither physical/compositional similitude alone, in the absent of functionalv resemblance (see water/ice) tends to earn concept dilation, nor vice-versa, but a mixture of functional and physical similarity even with *some* differences in both aspects tend to be likelier drivers of concept-expansion (see water vs. chlorinated water, or red wine vs. white wine). By these rules, expanding "water" to include XYZ — if XYZ is functionaly identical to *but* compositionally different from water — would be abnormal, like expanding "milk" to — without any qualification — include almond milk. But these rules are approximate, and on the idiosyncratic case where XYZ is *completely* functionally like water but (stipulated to be) physically different (though by functional identity we could not detect as much), I think the normal "conceptual dilation" rules would side with the functional identity and ignore the physical differences.

On the other hand, if XYZ has real discoverable differences from water, then the potential exists for twin earthers' concept of water to diverge from our own, even if at any point in time the concepts are identical. The time "points" don't need to be simultaneous: we can compare one country's concept of water in the year 1800 with a different county's in the 16th century. It is plausible that different people at different times have effectively the same conceptual attitudes toward concepts that, with the benefit of hindsight and more science, we know have potential for differentiation. I think the mere potential for differentiation warrants our identifying conceptual differences even if the parties involved are not aware of this potential. I am prepared, for example, to accept that a child's water-concept in our time can be different from a medieval child's water-concept merely by virtue of the modern child potentially learning about deuterium, hypersalinity, and other scientific nuances that complicate the modern conception of water relative to our forebearers.

1.1 *"Divorse or Dilate"? On Widening or Narrowing Concepts*

We certainly accept that people may have different understandings of a concept and, on that basis, may judge that what two people are entertaining are two different concepts — though we may also feel that they entertain two variations of *the same* concepts. There's room for most concepts to "diversify", subsuming subconcepts and variations; hence there's room for a concept to expand (see water to heavy water) without fragmenting. But sometims we *do* insist on splitting concepts — or, eqivalently, refuse to accept a concept-enlargement — and *the reasons for this refusal may be external to some peoples' use of the concepts.* Current political discourse in the United States, for example, is driven by turns of phrase that are rather haphazardly defined: *Border Wall*, *Green New Deal*, *Free Tuition*, etc. Suppose a health policy expert observes that Bernie Sanders's use of the term "Medicare for All" is different from Kamala Harris's. She may conclude that Sanders's concept "Medicare for All" is different from Harris's concept — and the rationale for this conclusion need not take into account whether the two candidates are aware of the differences. Suppose, as an expert, she has to mentally track the differences — she has a well-informed judgment that each of the "Medicare for All" plans have different ramifications due to policy differences; as a result when discussing "Medicare for All" she needs to note in her own mind which version of that idea is under discussion at any moment in a discourse. That is to say, she needs to subsume them under different concepts. Moreover, we endorse that she *should* do so, even if she thereby makes a distinction that the politicans or their supporters themselves do not realize. In this kind of case we may defer to expert opinion when adjudicating a potential conceptual divorce, even if there is only minimal differences in the role of the concepts vis-à-vis the conceptual systems of many relevant parties.

The possibility that "Medicare for All" may play the same *role* in a Sanders supporter's and a Harris supporter's conceptualizations does not preclude our judging that they are nonetheless different concepts — if by virtue of more information and more access to expert counsel we can understand that there are potential differences in their conceptualizations that *could* drive the conceptual roles to diverge. I think this is analogous to a "twin earth XYZ" scenario in that the thought experiment is set up as if we have access to expert confirmation that twin earth's XYZ is not physically the same substance as water. Projecting from earthly practice, we accordingly accept that "externalist" considerations may need to come to bear, and "XYZ" may need to be classifid as a different concept that water *notwithstanding* the lack of any conceptual role difference between XYZ for twin earthers as compared to water for us. This is consistent with our tolerance for including factors beyond just conceptual roles in more mundane circumstances: we accept that sufficiently divergent notions of "Medicare for All" *could* be most appropriately classified as two different concepts. Such is not mandated — we could certainly describe the Sanders and Harris platform as "two different Medicare for All plans", subsuming them under one concept but acknowldging their differences — as token differences, like the conceptual difference between this apple and that apple, rather than concept-differences like apple vs. cherry. Analogously, we *could* subsume XYZ under the concept *water* — XYZ being a kind of water insofar as samples of XYZ (tokens of the XYZ-concept) bear some physical differences to tokens of ordinary water (like heavy-water samples do), but we can handle this variation on a token-token level (analogous to comparing two apples). But we can *also* split rather than expand the conceps — *divorce* rather than *dilate* — making XYZ a different concept than water, just as we can make Sanders supporters' Medicare for All a different concept that Harris supporters'. The key point is that our choice of "divorce or dilate" may be driven by factors wholly external to some concept-bearers' internal concept-uses. Two different concepts — recognized by us as different — may play identical conceptual roles for some people.

This stance is at least minimally Externalist in that I don't insist on internal conceptual-role similitude being an immovable criteria selecting "dilate" over "divorce". We as a language community can and sometimes should override the tendency for concepts to expand under role considerations. As I pointed out earlier, a corkscrew and even a hammer can sometimes satisfy the role "bottle opener" in specific contexts. Usually we distinguish context-specific conceptual role-playing from general concept dilation — I think this is the gist of Zhaohui Luo's analysis of "situations" and "Manifest entries". We can adopt a temporary frame of reference wherein, say, hammers are bottle openers — or in Luo's example (in a single zoo exhibit) all animals are snakes — without mutating the concepts so wildly that "hammers" become expanded to including anything that may open a capped bottle, or "snakes" become all animals. Yet such situational dilations can recur and eventually spill beyond their situational guard rails. In a vegan cafe I can imagine the staff converging on a usage that soy, almond, and cashew milks are collectively called just "milk". If veganism becomes entrenched in some English-speaking community I can similarly imagine that in their dialect "milk" will mean anything that can be used like milk in a culinary context. The warrants for such expansions seem to be driven by conceptual roles — situations present "slots", like *that which opens this bottle* or *that which I pour on cereal*, and existing concepts tend to expand to fit these slots.

These considerations follow the *internalist* line: we take attitudes based on conceptual role more than external natural-kinds when adjudicating conceptual boundaries. Thus situationally we may present almond milk and agave to satisfy a request for milk and honey. But superimposed on such "centrifugal" tendency for concepts to expand into "under-lexified" conceptual niches we have a counter tendency to question conceptual uses where functional resemblance strays *too far* from common sense. Someone may accept agave in lieu of honey, or a hammer as a bottle opener, in the context of how one situation plays out; but they are less likly to accept these uses becoming entrenched, compared to, say, refiguring "milk" to include almond and cashew milk. And our hesitation to accept concept-expansion in these latter kinds of cases seems to implicitly look beyond conceptual roles — we may insist on limiting concept dilations even if there are many people for whom there will never be situations where the differences between concept referents, over and above functional resemblance, would be important. In short, even if a community could do just fine with some dialect idiosyncracy that ignores a conceptual distinction we would ordinarily make, we don't tend to take this as evidence that our multiple concepts can be merged into one more diverse concept.

Of course we *can* merge concepts, and the fact that many people can live their lives without a conceptual coarsening may render such merger likelier, but it seems we evaluate potential mergers more by reference to entire speech-communities, not isolated parts. Note that I am specifically talking here about merging or splitting concepts, not word-senses or lexemes or any purely linguistic artifacts. Certainly we have variegated "water" concepts — salt, tap, distilled, heavy — but we have an overarching water concept that includes these as subconcepts. We can make a conscious decision to modify concept/subconcept relations — which is different from changing how concepts are mappped to lexemes. So I take it that Conceptual Role Semantics prioritizes role factors in drawing concept/subconcept relations and boundaries, and the consequence is a mostly Internalist intuitive model: we should accept concept maps where concepts are mostly drawn together when there is a functional resemblance between their roles: our concept/subconcept renderings should witness and help us exploit functional analogies.

At the same time, however, I think we instinctively project notions of conceptual role outward from individual perople or subcommunities to the social totality. Even if technically distinct Medicare for All plans play similar conceptual roles in different voters' conceptions, we understand that such similarity may break down as we expand the community outward. Sanders and Haris supporters don't live on thier own islands. There are factors outside their own minds that weigh on whether their functionally similar Medicare for All concepts are indeed *the same concept* from the larger communiy's point of view. But these external factors are not necessarily *extramental*: we can zoom outside the conceptual patterns of one subcommunity and argue that conceptual differences appear in the overall speech community that supercede functional resemblance in some subcommunity. Conceptual roles are not solipsistic: the role of the concept Medicare for All for a Sanders supporter is not just a role in *her* mind, but it bcomes a role in *our* minds if we dialogically interact with her.

Insofar as people can make inferences about other peoples' conceptual role "system" — we can figure out the role which a concept plays in somone else's mind, to some approximation, even if analogous concepts play a different role in our own minds — conceptual roles are not private affairs; they have some public manifestation and there is a need for collective reconciliation of role differences, just as we need to identify when different people are using the same words in different ways and use lexical conventions to diminish the chance of confusion. To the extent that they have this public dimension, conceptual roles are not *internal*. But "externalism" in this sense is waranted because we want to look philosophically at entire speech or cognitive communities — it is not automatically a philosophy of conceptual content being external to "mind in general". Conceptual differences that could *potentially* become publicly observable from the vantage point of the *entire* cognitive community warrant consideration for conceptual divorce over dilation — overriding similar roles in some *part* of the community.

In the case of XYZ, insofar as the twin earth cognitive community and our own could *potentially* become part of a single overarching cognitive community, we have potential grounds for drawing comparisons between water and XYZ. Merely by contemplating their planet here on earth we are performatively drawing twin earthers into our cognitive community. By postulating that twin earthers think about XYZ the same way that we think about water — and that we know this — we implicitly assume that their conceptual role patterns are public observables in the context of our own community. If conceptual roles are observable, then there is a concept of a conceptual role: pundits can conceptually analyze how "Medicare for All" plays identical conceptual roles for Sanders and Harris supporters even if the candidates' plans are consequentially different. But this merely says that there are latent differences in two people's conceptual roles that they themselves may not actually experience. The public facet of conceptual roles complicates the notion of conceptual role similarity — two people's patterns of conceptual roles may be observably different as public phenoemena even if they lack resources to realize the difference. Conceptual roles are therefore external to individual minds — but this is by scoping outside individual minds to holistic cognitive communities who can publicly observe our cognitive tendencies. We are still reasoning "internalistically" in the sense of considering cognitive patterns at the scale of an overall cognitive community.

In short, I will take the mantra of an "Externalist" when passing from individual minds and subcommunities to the public nature of conceptual roles and overaching cognitive communities. Once we get to the maximal possible community, however, I am inclined to revert to Internalism: if there is no broadening of communal scope that could make putative external diffrences meaningful to *anyone's* conceptual roles, I see no reason to account for *these* erstwhile externalities in a theory of concepts. If XYZ has *some* not-water-like qualities that a sufficiently large cognitive community could confront — even if XYZ-conceptual-role and earthly-water-conceptual-role is identical for the two isolated communities — I am happy to accept that twin earthers' XYZ-concept is a different concept than earthers' water-concept. Similarly, I accept that Sanders supporters' Medicare for All concept may be a different concept than Harris supporters'. But in both cases I accept concept splitting to ovrride role-similarity because I believe in an overarching cognitive community which has an interest in detecting differences or potential differences in conceptual roles qua public observables, which transcendes our own internal awareness of what our conceptual roles entail. The fact that earthers and twin-earthers might never "discover" a water/XYZ difference is a contingent fact, not an essential structure in policing conceptual maps. When establishing how we should consider redrawing thse maps, we should work from the picture of an overarching comunity — that can subsume isolated communities — as an abstract posit; the parts of the twin earth story that imply earthers and twin earthers could never actually discover their differences are not, I think, compelling as intrinsic features of the analysis. In short, if water and XYZ have some potentially observable differences, then we need to proceed as the community which is aware that these differences exist and that therefore, for us, water and XYZ need different conceptual slots. The only analysis then is how to reconcile the fact that we have multiple conceptual slots whereas twin earthers (and earthers who have not read Hillary Putnam) have just one.

But if we take a *maximal* cognitive community — the sum total of earthers and twin earthers and philosophers — this community *does* distinguish XYZ from water (surely XYZ plays a different role in Putnam's mind than water). And we should scope to the maximal community when determining whether smaller communities' conceptual roles are truly identical, because conceptual roles are, in part, potential public obervables for any possible supercommunity.

On the other hand, if XYZ is so much like water that *no* community would *ever* have reason to contrast twin-earthers's XYZ-conceptual-role with our water-conceptual-role, then I think these roles are not just *internally* identical for each (twin-) earther, but *publicly* identical for any conceivable cognitive community for whom public observations of (twin-) earthers' conceptualizations are consequential givens. And in *that* case I think XYZ is the same concept as water notwithstanding putative compositional differences.

The whole idea that conceptual roles can be *public* complicates the Internalist/Externalist distinction, because each person's conceptual patterns can be evaluated from a vantage point external to *their* mind but still within the proclivities of a "maximal" cognitive community. Conceptual roles are not private to each person, but are private inclinations that get reshaped, corrected, influenced, or reinterpreted by a larger community. If we understand conceptual roles to include the totality not just of each person's conceptual role attitudes but the totality of how these attituds are observed by others, then we should consider that concepts are not "external" to the *maximal* cognitive comunity. Externalism about *individual* minds can be wrapped inside Internalism at the *maximal* inter-cognitive level.

But, complicating matters further, the maximal community's observations of conceptual-role attitudes is often driven by at least our *beliefs* about external (i.e., extramental, natural-kind) criteria. For example, some companies want to rechristen "corn syrup" as "corn sugar", to make it seem more like a sugar-subconcept. Meanwhile, some dairy companies want laws restricting the use of "milk" for vegan products. In both cases our larger community has a chance to weigh the proper conventions for how our conceptual maps should be drawn. As I argued earlier, both functional and naturalistic criteria play a role in such deliberations. We are poised to distinguish transient situation-specific roles — that one time someone used a hammer as a bottle opener — from functional parallels that stretch across many contexts. Within the parameters of that contrast, we are receptive to redrawing maps on role criteria — allowing milk to subsume vegan milk-substitutes, for instance. But this tendency is balanced by a respect for some notion of coherent natural kinds — the distinct biological properties of vegan milks work against a *maximal* community subsuming them under "milk" outside of special contexts.

Both the Externalist and Internalist points of view have some traffic in the considerations that cognitive communities bring to bear on which conceptual maps should be enorsed by convention. Because ad-hoc conceptual roles can be established for particular situations, we can be conservative about *conventionalizing* concept maps driven by functional correspondancs too far removed from (what we think to be) scintifically endorsed, natural-kind boundaries. In other words, I think we *do* and *should* allow "naturalistic" considerations to be a factor in what concept maps we endorse. But this is not a claim about Externalism as a philosophical paradigm shaping how we should construe the triangulation between mind, world, and language, as a matter of metaphysical ideology. Rather I believe that "externalist" factors should and do come to bear on the deliberations *internal* to cognitive communities' (sometimes but not always explicit) evaluations of how to draw concept and subconcept boundaries and relations — when to split concepts and when to dilate them. Dilate-or-divorce options are pulled by both externalist and internalist considerations, sometimes in competing ways.

As as case-study, the wording "corn sugar" — which implies a "redistricting" wherein the concept "corn syrup" becomes part of the territory "sugar" — may be credible on purely biochemical grounds. But our community may feel that there is enough functional difference between sugar and corn syrup from a commercial and nutritional sense to reject a proposed merger — here functional considerations trump natural-kind ones. Conversely, the community may be sympathetic to claims that milk substitutes should be labeled to clearly indicate how they are are not *literally* milk — here natural-kind considerations trump functional ones.

If we consider language — and communally-endorsed conceptualizations — evolving in practice, then, by light of my claims until here, there is material for both Externalist and Internalist readings. This perhaps leaves room for a theory which accepts that both are partially true — each being logically founded under consideration of two different aspects of how concepts evolve. I will explore this possibility further, but first I want to shore up my account of conceptual roles themselves.

One complication I have glossed so far is that *functional* roles in an enactive and "pragmatic" (in the everyday-world sense) spheres are not *ipso facto* the same as either conceptualizations (conceptual-role-attitudes) or lexicosemantic conventions. These three are interrelated, but we need social and cognitive practices to get situational understandings entrenched in language and in communal concept-maps. Without a theory of this process, to speak of functional roles like *hammer* for *bottle opener* is not a substitute for speaking of conceptual roles *per se*. How to properly link "functionality" in an enactive quotidian sense — the data that various natural and man-made artifacts are used by people for concrete tasks, and we often talk about this — to the cognitive realm of concepts (and their boundaries and subconcept relations)? This is the main theme of Section 2. I will however conclude the present section by reviewing a useful critique of the conventional Externalism/Internalism dialectic. I will focus in on Orlin Vakarelov's "Interface Theory of Meaning", developed over several recent papers, which I will also (somewhat indirectly) use as a kind of metatheoretic guide when presenting my own thoretical attachments later on.

1.2 *Orlin Vakarelov's Interface Theory of Maning*

Vakarelov's theory (which I'll abbreviate to ITM) both critiques and suggests ways around the Externalism/Internalism impasse:

> An externalist theory focuses on constraints outside of the user of the informational state. Particularly, it focuses on the relation between the informational state and the sources or object of the information. The meat of the semantic connection derives from some nomic (or teleonomic) connection between the source system and the information medium (receiver) system. The focus of semantics for an externalist theory is the determination of the way the world is. ... An internalist theory, on the other hand, considers as the primary constraint of meaning what the information state does for the user. The model of the internalist account is not reference fixation and fact determination, but message interpretation. The question that an internalist asks is not *what m means*, but *what m means to a given user*. Of course, for m to be informative about the world, it better be sufficiently correlated with a source, but this is not a constitutive condition of the meaning of m. It is a condition of a good interpretation system. ... One strategy for reconciling externalism and internalism is to take a hybrid account of meaning/content. Such hybrid theories are motivated by an observation that external or internal considerations are not sufficiently fine grained. ... Such hybrid theories of meaning have targeted cognitive information media — languages, mental states (beliefs), etc. This analysis of meaning cannot easily transfer to the domain of dynamical semantic information. In the case of dynamical semantic information, the externalist and internalist conceptions of meaning collapse into a single notion. The reason for this is the codetermination of macro-state structure of informational systems. [94,

pp. 13-14]

He then presents his ITM alternative (for terminological clarification, his symbol M roughly matches what I have called "cognitive frames", and S roughly matches our environing situations):

> It follows that neither an external relation between M and S, nor an internal function of "selecting conditional readiness states" is sufficient to provide a general notion of meaning, for they don't even fix the syntax of the information system independently. To specify the meaning of a state m we must do something different. What does M really do in the information system? It acts as an *interface* between the (external) world and the control system. It structures influences to allow focused purposeful control. If any sense of significance can be given to a particular state m of M, it must be related to this interface function. The significance of m is neither that it tracks something external nor that it can affect the control mechanisms of the system, but that it can connect one to the other. ... Let us go back to the observation that the definition collapses the external and internal conception of meaning. Specifying the differential interface function of a state requires looking at the entire system/environment complex. We can think of the datum state m as participating in a process of interaction where causal effects from the environment are channeled through the internal M-P control pathway to produce actions, which actions modify the system's behavior, and which in turn changes the state of the environment (including the relations between the system and other external systems). [94, pp. 15-16]

Finally he extends this definition of *meaning* toward language itself:

> The story gets more interesting when ... the system utilizes different sub-systems that act as information media. The system may have [different] media, each with different roles and interface connections. Some media may be connected to different external systems or different aspects of the same systems, others may interface with other media, yet others may be connected with effectors or control the states of other media, etc. When the system is organized as a complex network of information media, complex interface (sub-)functions can emerge. Some can depend almost exclusively on external connections to outside sources, others can be analyzed entirely in terms of their control role or effects on other media. I conjecture that the canonical examples of information media that shape many of our intuitions about semantics are media that exist (within an information system) as only one of a large network of other information media that jointly control the system's behavior. Thus, to take correspondence theories of meaning as an example, it is tempting to say that the word 'chair' means a property of external objects. Thus, in the expression, "This is a chair", the meaning is given by some fact in the world that the object depicted by the indexical has the property of chairhood. In an information system using language we can analyze this idea in a different way. The language medium, whose datum may be some structural equivalent to the expression "This is a chair", interacts with other nonlinguistic media connected to perception, allowing the system to identify and interact with patterns in the world that can be clustered through some data state of some internal media. To make Fodor happy, we can assume that there is a single medium that gets in an information state uniquely correlated with chairhood — a kind of a concept of "chair". The language system, in this picture, is not interfaced with the world (or some abstract realm of propositions). It is interfaced with other information media. The properties of the interface relations look a lot like the properties that a correspondence semantics may have, but these interface relations do not capture the true interface roles of the language datums for the information system. To determine the true interface role, we need to link all local interfaces and see how the entire complex participates in the purposeful behavior. [94, p. 17]

Interestingly, Vakarelov speaks not of "prelinguistic" cognition but of "precognitive" systems. This is partly, I belive, because Vakarelov wants to understand cognition as adaptation: "Nature, in its nomic patterns, offers many opportunities for data systems that can be given semantic significance, it offers ubiquitous potential datums, but it does not offer any well-defined and complete data sets" [94, p. 4]. As I read it, Vakarelov conceives cognitive systems as dynamic systems that try to adapt to other dynamic systems — these latter being the environments where we (taking humans as example cognitive systems) need to act purposefully and intelligently. The "nomic patterns" are latent in our surroundings, and not created by intellect. So *this* kind of worldly order lies "outside" cognition in an ontological sense; it is not an order which exists (in itself) in our minds (though it may be mirrored there). Consciousness comports to an "extramentally" ordered world. However, "precognitive" does not necessarily mean "extramental": there is a difference between being *aware* of structural regularities in our environment, which we can perhaps deem a form of pre-cognitive mentality, and trying to *interpret* these regularities for practical benefit (and maybe a subjective desire for knowledge).

When distinguishing "cognitive" from "precognitive", however, we should also recognize the different connotations that the term "cognitive" itself has in diffrent academic communities. In the context of Cognitive Linguistics, the term takes on an interpretive and phenomenological dimension which carries noticeably different implications in the "semantics of the theory" than in, say, conventional AI research. Vakarelov's strategy is to approach *human* cognition as one manifstation of structured systems which we can visualize as concentric circle, each ring implying greater sophistication and more rigorous criteriology than its outer neighbor:

> What is the function of cognition? By answering this question it becomes possible to investigate what are the simplest cognitive systems. It addresses the question by treating cognition as a solution to a design problem. It defines a nested sequence of design problems: (1) How can a system persist? (2) How can a system affect its environment to improve its persistence? (3) How can a system utilize better information from the environment to select better actions? And, (4) How can a system reduce its inherent informational limitations to achieve more successful behavior? This provides a corresponding nested sequence of system classes: (1) autonomous systems, (2) (re)active autonomous systems, (3) informationally controlled autonomous systems (autonomous agents), and (4) cognitive systems. [95, p. 83]
>
> The most rudimentary design problem begins here: if there is cognition, there must be a system. Without a condition allowing a system to exist as an entity discernible from its environment and persisting sufficiently long as that same entity to allow qualification of its dynamical behavior, the question of cognition does not arise. The first design question that must be examined is: What allows systems to persist as individual entities? More specifically: For which of those systems that persist is a capacity of cognition relevant? [95, p. 85]

But this intuition that human cognition can thematically extend out to other "cognitive systems" and then other structured systems — out of which *cognition* emerges by adding on criteria: is the system autonomous; reactive; information-controlled — suggests we are dealing with a different concept than in Cognitive Linguistics or Cognitive Phenomenology. For Vakarelov, "cognition, like most other biological categories, defines a gradation, not a precise boundary — thus, we can at best hope to define a direction of gradation of a capacity and a class of systems for which the capacity is relevant; [and] cognition is an operational capacity, that is, it is a condition on mechanisms of the system, not merely on the behavior of the system — to say that a system is cognitive is to say something general about how the system does something, not only what it does" (p. 85). Conversely, the qualities that make "grammar", say, "Cognitive" seem uniquely human: our sociality in the complexity of social arrangements and cultural transmission; our "theory of other minds". Certainly animals can have society, culture, and emapthy, but the human mind evidently takes these to a qualitatively higher level, making language *qua* cognitive system possible.

This argument does not challenge Vakarelov's programme directly, but perhaps it shifts the emphasis. Our cognition may be only one example of cognitive systems — which in turn are examples of more general autonomous/reactive/information-controlled systems —

but there may still be distinct phenomenological and existential qualities to how *we* achieve cognition, certainly including human language. I think there are several distinct features we can identify with respect to *human* "cognitive frames", which call for a distinct pattern of analysis compared to generic "M" systems, in Vakarelov's terms.

I'll mention the following:

Multi-Scale Situationality We understand situations as immediate contexts for our thoughts and actions, but we also recognize situations as parts of larger contxts, and connected to each other in chains stretching into past and future. For example, as a train pulls into a subway station, our immediate situation may be needing to determine if this is the train we need to board. But this is linked to the larger situation of traveling to our destination; and situations are strung together as enactive episodes: once I determine which is the correct train, I need to enact the process of boarding and getting comfortable on the train, then get ready to reverse the process and disembark at my station. All of this inter-situational orchestration can be planned and facilitated, to the degree that multiple people are involved, through language.

Conversational Frames Our *cognitive* frames modeling situations and our immediate environments include models of ongoing *conversations*. I think this is an example of what Vakarelov calls "sub-systems": within our intellectual "systems" that track outside reality, there is a part that specifically tracks what people are saying — so that we can take note of what they believe, how they are using different words, what they consider or would deem relevant to the current topic (or situation) — all of which helps us use language to reason through situations intersubjectively. I will discuss the architecture of conversation frames more in Section 3.

Conceptual Roles We have, I believe, a unique ability to fuse perceptual and conceptual detail in understanding situations. That is, we identify objects perceptually while also placing them in a contextual matrix, where functional properties may be foregrounded above directly perceptual ones. If, say, we hear someone ask for a glass of water and see someone else hand her one, we understand the glass not only through its sensate qualities — or even through our pragmatic/operational interpretations, like believing that the solidity of the glass prevents the water from leaking out — but we also intrpret people's practical intensions and mental attitudes. We infer that the first person was thirsty and the second cooperated by providing her with water to quench her thirst. Interpreting the situation at that interpersonal level, not just at a sensory/perceptual or a force-dynamic level, enables us to understand situational variations, like responding to requests for a *glass* of water by bringing a *bottle*.

In short, to undrstand *how* our cognitive frames align with environing patterns we have to understand the role language plays in this process: a role which can be intersubjective, empathic, context-sensitive, defined by conceptual substitutions and interpersonal cues as much as by rigid rules.

And yet, I think Vakarelov's larger point remains in force: we need to get beyond both Externalism and Internalism in the sense that we need to get beyond a debate as to whether *words* have "intramental" or "extramental" *meanings*. For instance, we need to think past an apparent choice between deciding that the word "water" has a *meaning* which is either intramental (determined by the sum of each person's beliefs and dispositions about water) or extramental (determined by how our water-experiences are structured, even beyond our knowldge, by the physical nature of water). In place of either option, we should say that the meaning of the word *water* — or *chair*, in Vakarelov's example — depends on all the cognitive systems interacting with linguistic understanding. The word or concept does not exist in our "language-processing system" in isolation; so its meaningis not just *linguistic* meaning but how word-tokens and concept-instances become passed from system to system.

Insofar as we have a token of the word *water* — presumably tied to a concept-instance — the specific fact of our hearing the word is joined in with a plethora of other perceptual and rational events. Say, we hear someone ask for water, and soon after see someone bring her a glass. We instinctively connect our perceptual apprehension of the glass of water with the word heard spoken before, and we presumably remain vaguely aware of the situation as things unfold — if we see her drink from the glass, we connect this to our memory of her asking for water, indicating thirst, and then getting a glass in response. We do not need to track these affairs very attentively — it's not like we should or need to stare at her intently while she drinks — but it fades into the background rationality that we tend to attribute to day-to-day affairs. Her glass of water — how it continues to serve a useful purpose, how she and maybe others interact withbit — becomes a stable if rather mundane part of our current situation.

In Vakarelov's words,

> To determine whether a particular macro-state of S is informationally relevant, i.e. whether it is differentially significant for the purposeful behavior of the system, we must trace the dynamical trajectories of the system and determine ... whether the microstate variation within the macro-states is insignificant for the purposeful behavior.... Let us call such macro-states *informationally stable*. [94, p. 15]

An intrinsic dimension of situational models, surely, is that they recognize the relatively stable patterns of situations: a glass placed on a table will typically remain there until someone moves it. Situations are, in this sense, large compilations of distinct quanta of relative stability: in a dining context, every glass or plate or knife, every chair or table, every seated person, is an island of relative stability, whose state will change gradually if at all. So a large part of our cognitive processing can be seen as recognizing and tracking these stabilities. Stability is the underlying medium through which situational models are formed.

Utlimately, many cognitive systems contribute to such models: quanta of stability lie in the cross-hairs of multiple cognitive modalities. So we connect the water spoken about to water in a glass. If we have our own glass we connect both the linguistic and visual content to the tactile feel of the glass and the kinaesthetic intentionality exercised as we pick it up. We can imagine concepts like *this water* pinging between these various cognitive registers.

I take Vakerlov's ITM model (or metatheory, maybe) as saying that we should look at *meaning* through the interstices between systems, not as some semiotic accounting summed up either "inside" or "outside" the mind. The meaning of a broad concept like *water* is subsidiary to the meaning of more context-bound concepts like *glasss of water*, *body of water*, *running water*: and to excavate conceptual meanings in these situationally anchored cognitions we need to think through the *conceptual roles* we instinctively pin onto the concept-exemplified: whether manifest as an element of language or perception/enaction, or both.

2 Truth-Theoretic Semantics and Enaction

Corrolary to the idea that roles often determine concepts, is the recognition that we tend to logically evaluate situations in functional terms, through the lens of what we (or any of our peers) are *doing*. Suppose my friend says this, before and after:

- (20) Can you put some almond milk in my coffee?
- (21) Is there milk in this coffee?

Between (20) and (21) I do put almond milk in his coffee and affirm "yes" to (21). I feel it proper to read (21)'s "milk" as really meaning "almond milk", in light of (20). Actually I should be *less* inclined to say "yes" if (maybe as a prank) someone had instead put real (cow) milk in the coffee. In responding to his question I mentally substitute what he almost certainly *meant* for how (taken out of context) (21) would usually be interpreted. In this current dialog, the *milk* concept not only includes vegan milks, apparently, but *excludes* actual milk.

It seems — on the evidence of cases like this one — as if when we are dealing with illocutionary force we are obliged to subject what we hear to extra interprtation, rather than resting only within "literal" meanings of sentences, conventionally understood. This point is worth emphasizing because it complicates our attempts to link illocution with propositional content. Suppose grandma asks me to close the kitchen window. Each of these are plausible and basically polite responses:

- (22) It's not open, but there's still some cold air coming through the cracks.
- (23) It's not open, but I closed the window in the bedroom.
- (24) I can't — it's stuck.

In each case I have not fulfilled her request vis-à-vis its literal meaning, but I *have* acted benevolently in terms of conversational maxims. Many linguists seem to analyze hedges like “could you please” as merely dressing over crude commands: we don’t want to come across as giving people orders, but sometimes we do intend to ask pople to do specific things. As a result, we feel obliged to couch the request in conversational gestures that signal our awareness of how bald commands may lie outside the conversational norms. These ritualistic “could you please”-like gestures may have metalinguistic content, but — so the theory goes — they do not *semantically* alter the speech-act’s directive nature.

The problem with this analysis is that sometimes directive and “inquisitive” dimensions can overlap:

(25) Do you have almond milk?

(26) Can you get MsNBC on your TV?

(27) This isn’t a screw-cap bottle: I need a corkscrew.

These *can* be read as bare directives, and would be interpreted as such if the hearer believed the speaker already knew that yes, he has almond milk, and yes, he gets MsNBC. In (27), if both parties know there’s one corkscrew in the house, the statement implies a directive to fetch *that* corkscrew. But, equally, (25)-(27) can *also* be read as bare questions with no implicature: say, as fans of almond milk and MsNBC endorsing those selections, or pointing out that opening the bottle will need *some* corkscrew. And, meanwhile, (25)-(27) can *also* be read as a mixture of the two, as if people expressed themselves like this:

(28) I think the window is open, can you close it?

(29) I see you have almond milk, can I have some?

(30) If you get MsNBC, can you turn on Rachel Maddow?

(31) If there is a corkscrew in the house, can you get it?

I think the mixed case is the most prototypical, and pure directives or inquiries should be treated as degenerate structures whre either directive or inquisitive content has dropped out. After all, even a dictatorial command includes the implicit assumption that the order both makes sense and is not impossible. On the other hand, we don’t ask questions for no reason: “do you have almond milk” may be a suggestion rather than a request, but it still carries an implicature (e.g., that the addressee *should* get almond milk).

Ordinary requests carry the assumption that addressees can follow through without undue inconvenience, which includes a package of assumptions about both what is currently the case and what is possible. “Close the window” only has literal force if the window is open. So when making a request speakers have to signal that they recognize the request involves certain assumptions and are rational enough to accept modifications of these assumptions in lieu of literal compliance. This is why interrogative forms like “can you” or “could you” are both semantically nontrivial and metadiscursively polite: they leave open the possibility of subsequent discourse framing the original request just as a belief-assertion. Developments like “can you open the window” — “no, it’s closed” are not ruled out. At the same time, interrogative forms connote that the speaker assumes the addressees can fulfill the request without great effort: an implicit assumption is that they *can* and also *are willing to* satisfy the directive. This is an assumption, not a presumption: the speaker would seem like a bully if he acted as if he gave no thought to his demands being too much of an imposition — as if he were taking the answer to “can you” quesions for granted. This is another reason why requests should be framed as questions. So, in short, “commands” are framed as questions because the speaker literally does not know for sure whether the command is possible; given this uncertainty a command *is* a question, and the interrogative form is not just a non-semantic exercise in politesse.

Sometimes the link between directives and belief assertions is made explicit. A common pattern is to use “I believe that” as an implicature analogous to interrogatives:

(32) I believe you have a reservation for Jones?

(33) I believe this is the customer service desk?

(34) I believe we ordered a second basket of garlic bread?

(35) I believe you can help me find computer acessories in this section?

These speakers are indirectly signaling what they want someone to do by openly stating the requisite assumptions — *I believe you can* in place of *can you?*. The implication is that such assumptions translate clearly to a subsequent course of action — the guest who *does* have that reservation should be checked in; the cashier who *can* help a customer find accessories should do so. But underlying these performances is recognition that illocutionary force is tied to background assumptions, and conversants are reacting to the propositional content of those assumptions as well as the force itself. If I *do* close the window I am not only fulfilling the request but also confirming that the window *could* be closed (a piece of information that may become relevant in the future).

In sum, when we engage pragmatically with other language-users, we tend to do so coopratively, sensitive to what they wish to achieve with language as well as to the propositional details of their discourse. But this often means that I have to interpret propositional content in light of contexts and implicatures. Note that both of these are possible:

- (36) Do you have any milk?
- (37) Yes, we have almond milk.
- (38) No, we have almond milk.

A request for milk in a vegan restaurant could plausibly be interpreted as a request for a vegan milk-substitute. So the concept "milk" in that context may actually be interpreted as the concept "vegan milk". As Luo points out in [], particular concept-maps are admissible as in force in specific situations even if they deviate noticeably from typical usage (Luo does not talk about concept "maps" but about subtyping and various inter-type relations, yielding a type-theory of situations I think is relevant to Conceptual Role theories of situations). In any case, responding to the force of speech-acts compels me to treat them as not *wholly* illocutionary — they are in part statements of belief (like ordinary assertions). One reason I need to adopt an epistemic (and not just obligatory) attitude to illocutionary acts is that I need to clarify what meanings the speaker intends, which depends on what roles she is assigning to constituent concepts.

If a diner asks for milk in a vegan restaurant, a waiter may plausbily infer that the customer believes the restaurant *only has* vegan milk, so there is no need to make that explicit; and/or she assumes that everyone in the restaurant will hear "milk" as "vegan milk". In other words, the waiter infers that "vegan milk" for her plays the same role as "milk" for a non-vegan. This inference is not produced by any speech-act subtleties: a related inference would be involved in

- (39) Is there milk in this coffee?
- (40) Yes, almond milk.

Part of reading propositional content is syncing our conceptual schemas with our fellow conversants. The illocutionary dimension of a request like "can I have some milk?" makes this interpretation especially important, because the addressee wants to make a good-faoth effort to cooperate with the pragmatic intent of the spech-act. But cooperation requires the cooperating parties' conceptual schemas to be properly aligned. I therefore have to suspend the illocutionary force of a directive temporarily and treat it as locutionary statement of belief, interpret its apparent conceptual underpinnings in that mode, and then add the illocutionary force back in: if I brought *real* milk to a vegan customer who asked for "milk" I would be *un*-cooprative.

The upshot is that conversational implicatures help us contextualize the conceptual negotiations that guarantee our grasping the correct propositional contents, and vice-versa. This means that propositionality is woven throughout both assertive and all other modes of language, but it also means that propositional content can be indecipherable without a detailed picture of the current context (including illocutionary content). The proposional content of, say, "there is milk in this coffee" has to be judged sensitive to contexts like "milk" meaning "vegan milk" — and this propagates from a direct propositional to any propositional attitudes which may be directed towards it, including requsts like "please put milk in this coffee".

Suppose the grandkids close grandma's bedroom window when she asks them to close the kitchen window. The propositional content at the core of grandma's request is that the kitchen window be closed; the content attached to it is an unstated belief that this window is open. Thus, the truth-conditions satisfying her implicit understanding would be that the kitchen window went from being open to being closed. As it happens, that window is already closed. So the truth-conditions that would satisfy grandma's initial belief-state do not obtain — her beliefs are false — but the truth conditions satisfying her desired result *do* obtain. The window *is* closed. Yet the grandkids should not thereby assume that her request has been properly responded to; it is more polite to guess at the motivation behind the request, e.g., thay she felt a draft of cold air. In short, they should look outside the truth conditions of her original request taken literally, and *interpret* her request, finding different content with different truth-conditions that are both consistent with fact and address whatever pragmatic goals grandma had when making her request. They might infer her goal is to prevent an uncomfortable draft, and so a reasonable "substitute content" is the proposition that *some* window is open, and they should close *that* one.

So the grandkids should reason as if translating between these two implied meanings:

- (41) I believe the kitchen window is open — please close it!
- (42) I believe some window is open — please close it!

They have to revise the simplest reading of the implicit propositional content of grandma's *actual* request, because the actual request is inconsistent with pertinent facts. In short, they feel obliged to explore propositional alternatives so as to find an alternative, implicit request whose propositional content *is* consistent with fact and also meets the original request's illocutionary force cooperatively.

In essence, we need to express a requester's desire as itslf, in its totality, a specific propositional content, thinking to ourselves (or even saying to others) things like

- (43) Grandma wants us to close the window.
- (44) He wants a bottle opener.

But to respond politely we need to modify the parse of their requests to capture the "essential" content:

- (45) Grandma wants us to eliminate the cold draft.
- (46) He wants something to open that bottle.

We have to read outside the literal interpretation of what they are saying. This re-reading is something that may be appropriate to do with respect to other forms of speech also — sometimes the true gist of what someone wants to communicate is not stated directly:

- (47) I think you could do excellent work in this class, and I think you are doing pretty well.
- (48) I am not going to talk about the refs because I don't want to get fined.
- (49) If she wants to win the nomination she needs to be as charismatic on the campaign trail as she was during the debate.

But our conversational responsibilty to infer some unstated content is especially pronounced when we are rsponding to an explicit request for something.

Certainly, in any case, meanings are not literal. But how then do we understand what people are saying? Trying to formulate a not-entirely-haphazard account of this process, we can spculate that interpreting what someone is "really" saying involves systematically mapping their apparent concepts and references to some superimposed inventory designed to mitigate false beliefs or conceptual misalignments among language users in some context. That means, we are looking for mappings like *milk* to *almond milk* in (50) from a vegan restaurant, or *kitchen window* to *bedroom window* in (51) if it is the latter that is open:

- (50) Can I have some milk?
- (51) Can you close the kitchen window?

The point of these "mappings" is that they preserve the possibility of modeling the *original* propositional content by identifying truth conditions for that content to be satisfied.

A *literal* truth-condition model doesn't work in cases like (50) and (51): the diner's request is *not* satisfied if it is the case that there is now (real) milk in her coffee, and grandma's request is not necessarily satisfied if it is the case that the kitchen window is closed. The proposition "the kitchen window is closed" only bears on grandma's utterance insofar as she believes that this window is open and causing a draft. So if we want to interpret the underlying locutionary content of (50) and (51) truth-theoreticaly, we need to map the literal concepts appearing in these sentences to an appropriate translation, a kind of "coordinate transformation" that can map concepts onto others, like milk/almond milk and kitchen window/bedroom window.

Simultaneous with propositional content, of course, are attitudes: the difference between asserting and wanting that the window is closed. It is hard to deny that *some* propositional content is involved with each linguistic expression, because simply by being a structured mental activity the effort to formulate sentences must be extended with some purpose. We say (and write) things to help make something or other the case. But there are several challenges to disentangle the role that propositional content actually plays in meaning. One problem I just considered is that the right propositional content does not always come from *literal* meaning: the vegan *doesn't* want real milk in her coffee. The idea of "mapping" is one way to address this: in place of "literal" meaning we can substitute meanings under "coordinate" transforms, where concepts transition from their literal designation to their roles. The vegan wants the product that plays the *conceptual role* of "milk" in her own frame of reference (at least in the context of, say, dining, as opposed to a context like checking whether her Staffy is lactating). But there are two other concerns we should have about propositional content, which I will discuss to close out this section.

2.1 *The Problem of Opaque Truth Conditions*

My analysis related to conceptual "transforms" assumed that we can find, substituting for *literal* propositional content, some *other* (representation of a) proposition that fulfills a speaker's unstated "real" meaning. Sometimes this makes sense: the proposition that the *bedroom* window is closed can neatly, if the facts warrant, play the role of the proposition that *the kitchen window is closed*. But we can run the example differently: there may be *no* window open, but instead a draft caused by non-airtight windows (grandma might ask us to put towels by the cracks). Maybe there is no draft at all (if grandma is cold, we can fetch her a sweater). Instead of a single transform, we need a a system of potential transforms that can adapt to the facts as we discover them. Pragmatically, the underlying problem is that *grandma is cold*. We can address this — if we want to faithfully respond to her request, playing the role of cooperative conversation partners (and grandkids) — via a matrix of logical possibilities:

- (52) If the kitchen window is closed, we can see if other windows are open.
- (53) If no windows are open, we can see if there is a draft through the window-cracks.
- (54) If there is no draft, we can ask if she wants a sweater.

This is still a logical process: starting from an acknowledged proposition (grandma is cold) we entertain various other propositional possibilities, trying to rationally determine what pragmas we should enact to alter that case (viz., to instead make true the proposition that *grandma is warm*). Here we are not just testing possibilities against fact, but strategically acting to modify some facts in our environment.

The kind of reasoning involved here is not logical reasoning per se: abstract logic does not tell us to check the bedroom window if the kitchen window is closed, or to check for gaps and cracks if all windows are closed. That is practical, domain-specific knowledge about windows, air, weather, and houses. But we are still deploying our practical knowledge in logical ways. There is a logical structure underpinning grandma's request and our response to it. In sum: we (the grandkids) are equipped with some practical knowledge about houses and a faculty to logically utilize this knowledge to solve the stated problem, reading beyond the *explicit* form of grandma's discourse. We use a combination of logic and background knowledge to reinterpret the discourse as needed. By making a request, grandma is not expressing one attitude to one proposition, so much as *initiating a process*. This is why it would be impolite to simply do no more if the kitchen window is closed: our conversational responsibility is to enact a process trying to redress grandma's discomfort, not to entertain the truth of any one proposition.

For all that, there is still an overarching logical structure here that language clearly marshals. We read past grandma's explicit request to infer what she is "really saying" — e.g., *that she is cold* — but we still regard her speech act in terms of its (now indirect) propositional content. But once we converge on the "language initiates a process" model, we can find examples where the logical scaffolding gets more tenuous. Consider:

- (55) My colleague Ms. O'Shea would like to interview Mr. Jones, who's an old friend of mine. Can he take this call?
- (56) I'm sorry, this is his secretary. Mr. Jones is not available at the moment.

It sounds like Ms. O'Shea is trying to use personal connections to score an interview with Mr. Jones. Hence her colleague initiates a process intended to culminate in Ms. O'Shea getting on the telephone with Mr. Jones. But his secretary demurs with a familiar phrase, deliberately formulated to foment ambiguity: (56) could mean that Mr. Jones is not in the office, or that he is in a meeting, or he is, unwilling to talk, or even missing (like the ex-governor consummating an affair in Argentina while his aides thought he was hiking in Virginia). Or:

- (57) Mr. Jones, were you present at a meeting where the governer promised your employer a contract in exchange for campaign contributions?
- (58) After consulting with my lawyers, I decline to answer that question on the grounds that it may incriminate me.

Here Mr. Jones neither confirms nor denies his presence at a corrupt meeting.

As these examples intimate, the processes language initiates do not always result in a meaningful logical structure. But this is not necessarily a complete breakdown of language:

- (59) Is Jones there?
- (60) He is not available.

The speaker of (60) does not provide any prima facie logical content: it neither affirms nor denies Jones's presence. Nonetheless that speaker is a cooperative conversational partner (even if they are not being very cooperative in real life): (60) responds to the implicature in (59) that what the first speaker really wants is (for instance) to interview Jones. So the second speaker conducts what I called a "transform" and maps "Jones is here" to "Jones is willing to be interviewed". Responding to this "transformed" question allows (60) to be (at least) linguistically cooperative while nonetheless avoiding a response at the *logical* level to (59). (60) obeys conversational maxims but is still rather obtuse.

So one problem for theories that read meanings in terms of logically structured content — something like, the meaning of an (assertorial) sentence is what the world would be like if the sentence were true — is that the actual logical content supplied by some constructions (like "Jones is not available") can be pretty minimal — but these are still valid and conversationally cooperative. To be sure, this content does not appear to be *completely* empty: "Jones is not available" means the conjunction of several possibilities (he cannot be found or does not want to talk or etc.). So (60) does seem to evoke some disjunctive predicate. But such does not mean that this disjunctive predicate is the *meaning* of (60). It does not seem as if (60) when uttered by a bodyguard is intended first and foremost to convey the disjunctive predicate. Instead, the bodyguard is responding to the implicature in the original "Is Jones there?" query — the speaker presumably does not merely want to know Jones's location, but to see Jones. Here people are acting out social roles, and just happen to be using linguistic expressions to negotiate what they are able and allowed to do.

Performing social roles — including through language — often involves incomplete information: possibly the secretary or bodyguard themselves do not know where Jones is or why he's not available. We could argue that there is *enough* information to still ground *some* propositional content. But this is merely saying that we can extract some propositional content from what speakers are supposed to say as social acts, which seems to make the content (in these kinds of cases) logically derivative on the enactive/performative meaning of the speech-acts, whereas a truth-theoretic paradigm would need the derivational dependence to run the other way. By saying "Jones is unavailable" the speaker is informing us that our own prior speech act (asking to see or talk to him) cannot have our desired effect — the process we initiated cannot be completed, and we are being informed of that. The person saying "Jones is unavailable" is likewise initiating a *new* process, one that counters our process and, if we are polite and cooperative, will have its own effect — the effect being that we do not insist on seing Jones. The goal of "Jones is unavailable" is to create that effect, nudging our behavior in that direction. Any *logic* here seems derivative on the practical initiatives.

And moreover this practicality is explicitly marked by how the chosen verbiage is deliberately vague. The declaration "Jones is unavailable" does not *need* logical precision to achieve its effect. It needs *some* logical content, but it exploits a kind of disconnect between logicical and practical/enactive structure, a disconnect which allows "Jones is unavailable" to be at once logically ambiguous and practically clear — in the implication that we should not try to see Jones. I think this example has some structural analogs to the grandma's window case: *there* we play at logical substitutions to respond practically to grandma's request in spirit rather than *de dicto*. *Here* a secretary or bodyguard can engage in logical substitution to formulate a linguistic performance designed to be conversationally decisive while conveying as little information as possible. The logical substitution in grandma's context *added* logical content by trying alternatives for the window being closed; here, the context allows a *diminution* in logical content. We can strip away logical detail from our speech without diminishing the potency of that speech to achieve affects. And while the remaining residue of logical content suggests that some basic logicality is still essential to meaning, the fact that logical content can be freely subtracted without altering practical effects suggests that logic's relation to meaning is something other than fully determinate: effect is partially autonomous from logic, so a theory of effect would seem to be partially autonomous from a theory of logic. I can be logically vague without being conversationally vague. This evidently means that conversational clarity is not identical to logical clarity.

This pattern of logical evasiveness might seem to be endemic only to slippery human language, but analogous examples can be found even in the strict milieu of computer programming. Computer programming involves passing instructions around, and that any one segment of code is typically dealing with incomplete information, like the bodyguard who does not know *why* Jones is unavailable. Given such partiality, it is misleading to assume that *instruction networks* are conduits for logical content pe se. My first rsponsibility as a programmer, at any point in code, is to call the right functions, depending on types, ranges, values, and any contingent environmental factors relevant to what the local code needs to do. Therefore, insofar as several functions might be candidates to call at any one code-location — there are scenarios where one function should be called, and others where a different one, etc. — I have to ensure the correct one is called in each scenario. But, as I will argue, the structures determining how this multiplicity is resolved are not logical structures. They have formal (e.g., type theortic) aspects, but these are not the *kinds* of formal aspects that simply manifest a logical systm.

As a quick example, while implementing a function that compares two lists, I may need to call different secondary functions in different cases like "which list is longer?" or "is either list empty?". There are various program-flow or type-theoretic models to rigorously describe this kind of branching as a computational phenomenon. But these are not logical models, in the sense that they can be fully specified in formal terms without explicit appeals to formal logic machinery (substitution axioms and so forth). In short, *structured systems of instruction-passing* are not *metaphysically* speaking logics — even if one can actually give them a logical model, which then becomes a *reductive analysis* (like Chemistry providing reductive analyses for Biology, which does not thereby *metaphysically* become Chemistry).

Analogously, imagine the bodyguard and secretary as both part of a conversational network which circulates the visitors' request to see Jones, and eventually the response that Jones is unavailable (which implies a counter-request that the visitors leave). Perhaps neither bodyguard nor secretary know all details about Jones's location; but they can still route messages as part of the overall cycle where we ask to see Jones and they ask us to leave. If this "message-passing cycle" is, in its most endemic analysis (outside of any retraoctive reductionism), *not* a logical system — but is rather some other kind of structured system — then the (properly non-reductive) semantics is a "message-passing semantics" or "instruction-network semantics" rather than a "truth-theoretic semantics" — *even if* these models *do* have a reductive analysis to some logical axiomatics. The analogy is again that Biology is not a Chemistry *even if* Biological models have a reductive analysis as chemical models.

Suppose I am writing a function which counts the number of non-blank, non-comment lines in a file. My implementation might start like this (in pseudo-code):

(61) File f = File.open(path, File.READ_ONLY);

(62) if f.isEmpty() return 0;

So the first line tries to open a file with the specified path, and the second line checks if the file is indeed open and non-empty. If not, it returns the number zero, meaning that there are no non-blank non-comment lines in the file.

In a typical application framework a file will be opened if it exists and if the current user has permission to read and/or write to/from the file (here the necessary permission is read-only). For sake of presentation I assume that a file is considered non-empty only if it is open and has some content (i.e., you can read something from the file). So if the file *is* empty, that can mean several things: either it does not exist; or it cannot be opened because of inadequate permissions; or it *can* be opened but has no content. My function is noncommital and returns zero in each of these cases. In particular, I gloss over some information: the zero return value is analogous to Mr. Jones being "unavailable" for an interview.

On this basis, it seems as if the "meaning" of my call to open the file is not a matter of ascertaining or bringing about certain truth conditions. It is true that my instruction may bring about certain truths (specifically, make it true that the file is open). But we should not conclude that this potential state of affairs is what the instruction *means*. As the programmer, I do not "want" the file to be opened; I have no vested interest (this is not like my wanting milk for coffee, or wishing to open a beer bottle). Instead, I am an intermediary between application-users and the system kernel: my role is translating what *users* want into system instructions. Granted, presumably the *user* wants the file she's interested in to be opened (as an intermediate step toward getting information from that file). But what I contribute as code are *instructions*, and instructions have an effect on the state of the overall computational environment where my application is hosted. In the general case I am not aware of which new state obtains. Attempting to open a file may cause it to be opened, but it may also cause the software representation of that file — a so-called "handle" — to acquire a flag indicating that the referenced file does not exist (i.e., its path descrribes a nonexistent location), or that it does exist but cannot be opened due to insufficient permission, or that the permissions are satisfactory but there is a temporary lock from another application writing to the file. If needed I could attempt to ascertain the file's state at this level of detail, but it turns out to be irrelevant to my own algorithm. In short, insofar as the "meaning" of computer code are the instructions it emits, these meanings correspond to state-changes only in coarse-grained ways. There may be propositional content associated to each possible state — there are propositions that the file is open, or nonxistent, or inaccessible, or temporarily locked — but the code does not engage the question of *which* proposition is (or becomes) true.

2.2 *Meanings and State-Change*

Underlying both these formal and natural language examples is the idea that the meanings of expressions are associated with changes of something's state: computer statements are instructions to change state and a large class of linguistic expressions are requests to do so. In this vein, meanings are "tools" to effectuate state change or to initiate state-change processes. This perspective is probably incompatible with a notion of "meanings as propositions", because it is hard to see how propositions (or even propositional contents) could be *tools*. The meaning of a hammer is not prima facie the fact that the nail is now in the board.

Granted, whenever there is a state-change there is a corresponding proposition to the effect that something now in state S_2 whereas it was before in S_1. And even if an instruction/request cannot be fulfilled, there is the concordant proposition that something is still in S_1 and can *not* be brought into S_2. So it is trivial to read logical structures onto linguistic eventualities, by leveraging the idea that for any conceivable state of any conceivable state-bearer there exists a proposition that such bearer is in such state.

The problem for truth-theoretic semantics, as I see it, is that these trivial state-to-proposition conversions are just that — theoretically trivial. We should not care about a *trivial* truth-semantic theory. If we have a semantic theory wherein, let's say, "meanings" are really *initiators of state-change processes*, then we can trivially convert this into a truth-theoretic theory. But that is not an intersting truth-theoretic semantics; it is a trivial truth-theoretic theory grafted onto an interesting "state change" theory.

So much is not to call truth-theoretic semantics uninteresting. But for us to take truth-theoretic semantics seriously we need to accept the idea that this paradigm can *motivate* analysis which leads to interesting results, taking us somewhere we may not arrive otherwise. The fact that a given semantic theory has some formulaic translation into truth-thoretic terms does not guarantee that truth-theoretic intuitions actually play an important role in that other theory.

To give a concrete example, I have mentioned Zhaohui Luo's type-theoretic semantics in a couple of contexts here. I think Luo's models are convincing and important, but I also (for what it's worth) have a slight metatheoretical objection, which is that Luo's type theory is (like most academic type theory) presented as a kind of logical system. (I would be similarly curmudgeonly vis-à-vis Shan's monadic analyses, that I mention later, and other applications of theoretical computer science to studies of natural — actually, even programming — languages).

The motivation seems to be that logical type theory can define the logical conditions regulating natural-language semantics, as a way to leverage type-thoertic structures to explain natural-language meaning. But this methodology forecloses an analysis wherein logical conditions are tangential to language per se.

We can equally, I believe, develop a type-theoretic semantics as a theory of *typed instructions* or *typed messages* or *typed side-effects*: type theory works in a message-passing or side-effect or instruction-network semantics as well as a truth-theoretic semantics. The difference is that in the first case we are dealing with side-effects or instructions as phenomena to which types can be ascribed, whereas in the second case we *define* types by fully articulating their axiomatic constraints. The latter is more complete than the former, because in a mathematical type theory we do not take "messages", "instructions", or "side effects" as theoretical primitives. Analogously, a mathematical type theory is more complete than applied type theory as in, say, the C++ type system, which takes the basic structures of the C++ language as untheorized givens (like biological analysis taking medical data as givens). But this is an example of where logical completeness does not necessarily confer greater explanatory merit.

Let's assume that understanding language involves some sort of "messages" communicated between different cognitive processing systems, so the "units" of linguistic processing are embodied in whatever neurological substrata realize cognitive dynamics in general. A type-theoretic semantics would accordingly conceive that there is an architecture of types which we can attach to units of a neurologically realizable cognitive system — analogous to how C++ assigns types to values digitally realized in binary data structures (in practice, byte-sequences). Type theory is not a theory of the substrata that *bear* types. Applied type theory does not *need* to encompass analysis of how digital or cognitive processing works, because that physicalistic demystification is the labor of other sciences. Mathematical completeness is a desirable quality of theories about abstract systems, but both language and computer software are physically realized systems (however abstract their specifications). As concrete in that sense, they are best treated as vehicles of multi-scientific explanatory combinations, where each theory is intermediary between others. In that metascientific sense, as I intimated earlier, completeness is *not* a merit if it isolates a theory from other theories which ontologically complete it.

For truth-theoretic intuitions to be legitimately consequential toward a semantic theory, we need to ascertain to what degree logical structures actually play a cognitive role in how we use language to accomplish things in the world. Obviously, as rational beings our thought processes will be informed by logic and to some degree can be retroactively modeled via logical complexes. But "logic" appears to play a role in these cognitive operations only indirectly. *There seems to be some medium — perhaps conceptual roles, or state-changes — that "carries" logic into the cognitive realm.* We should reject truth-theoretic semantics if it seems to proceed as if that "medium" can be sidetracked — that we can analyze a logical form in language directly, without analyzing the vehicle by which logical considerations can enter language processing.

2.3 *Truth Conditions are not Polar*

My second quibble with truth-theoretic semantics is that it relies on a certain *façon de parler*. We (in the context of analysis, not at her house) might say something like:

- (63) Grandma wants the proposition "the kitchen window is closed" to be true.
- (64) Grandma wants the proposition "I am cold" to be false.

My prior analysis focused on the fact that the more relevant proposition is that in (64), and we have to read (64) from (63). But it should also be obvious that grandma does not care about *propositions*. She only cares about "I am cold" as a *proposition* because she does not want to be cold.

By contrast, sometimes people care about propositions *as propositions*. A mathematician who has staked her reputation on a conjecture may want the conjuecture to be true. But this desire is not like the desire of a Sanders or a Toronto Maple Leafs supporter to want propositions like "Sanders has won" or "Toronto has won" to be true. Assume the mathematician's conjecture lies in an obscure field where there are no apparent real-world consequences with benefits that can proceed from truth rather than falsehood (it's not like, say, the conjecture will allow her to prove the validity of an encryption sheme she can monetize).

One way to put this is that the mathematician desires a *proposition* to be true, whereas the Leafs or Sanders supporters want certain *propostional content* to be true. But if we have to bring in propositional content, our analysis — so it seems — becomes circular. If the propositional content of "the Leafs win the cup" is that the Leafs win the cup, then a fan who wants the Leafs to win the cup obviously wants the propositional content of "the Leafs win the cup" to be true — but that's because the idea of the Leafs winning the cup *is* the propositional content of "the Leafs win the cup", reading the quoted version as an operator to make the sentence into a name for the relevant proposition.

Let's say that there are two inverse operators: one maps an idea onto a proposition, and one maps the proposition back onto the idea, which is its "content". A semantic analysis would be circular if it just immediately reversed one operator with the other. Having said that, the reversal may be *separated* by several steps, making it non-trivial. Suppose the Leafs are playing the Jets:

(65) Are you rooting for the Jets?

(66) Well, I want the Leafs to win.

The second speaker indirectly answers the first in the negative. This is conversationally reasonable — it does not violate any Maxim of Relevance — because the first speaker has available a chain of inference like:

(67) There is a proposition (call it P_1) whose propositional content is that the Jets win and a proposition (P_2) whose content is that the Leafs win.

(68) P_2 entails the negation of P_1.

(69) He wants the content of P_2 to be true.

(70) His wishes are only consistent with P_1 being false.

(71) He wants the content of P_1 to be false.

The interesting steps here are at (68) and (70): in these steps of reasoning the predicate relation between propositions is expressly thematized. In the course of understanding language, there may be occasions when we need to identify logical connectives as implicit to the conceptual framework which a speaker is obviously assuming. In that case we are working with propositions rather than propositional content: there is nothing in the idea of a Leafs victory *a priori* that contains the idea of a Jets defeat. The negative entailment relation only arises in particular situations — when the two teams play each other (and implicitly further restrictions, like there are no draws or suspended games).

It is, in short, a *feature* of a specific situation that the idea "Leafs win" entails the negation of "Jets win"; ergo, logical connectives are one facet of situational models *sometimes* relevant to linguistic processes. Similarly, speaker sentiment is *sometimes* relevant. But there is a structural isolation between these "systems": those "processing units" that can bear speaker sentiment (polarity) are different from those that can bear logical connectives (except in unusual cases, like the mathematician rooting for her conjecture).

When we analyze a fan's sentiment *wanting* the Leafs to win, we are analyzing polarity vis-à-vis propositional *content*. When we observe negative entailment, we are analyzing relations among *propositions*. The proposition "encapsulates" the content so it can be part of logistic structures, where connectives like entailment and disjunction make sense. In computer science, the technical pattern of such "encapsulation" is often called a "monad", and monadic analysis has been adopted in linguistics as well, following Chung-Chieh Shan. We can say that logical propositions *per se* are monadic packages that "wrap" propositional content, subject it to some logical manipulation, and at some later point in processing "retrieve" the content from the proposition. This is not circular because the content is not *immediately* extracted from the monad. In (71), the content wrapped in P_1 is held through several processing steps before yielding the final interpretation (viz., that he wants the Jets to lose). The final extraction corresponds to transforming "He wants the proposition that the Jets lose to be false" to "He wants the Jets to lose". Stated side-by-side, this transform is redundant. The difference is that here the original proposition P_2 is not directly asserted as a linguistic meaning; it rather falls out of a logical process.

On this analysis, there is a *part*, or *substructure*, of linguistic processing that involves wrapping propositional content into propositions. But these wrappings are only meaningful when there is some "delay" between processing steps — essentially, when there is some explicit sense that a given idea stands in some well-defined logical reoation to some other idea. Computer programers can crate "trivial" monads whose behaviors do not deviate at all from an imperative style of programming, but any code written with "trivial" monads can be refactored such that the monads disappear. This is analogous to the circularity between propositional content and propositions: the *meaning* of a proposition *is* its content, so the proposition "monad" has processing significance only when the meaning itself needs to be "held" awaiting the resolution of some logical nexus. If there is no processing structure that demands the content to be "held", then the proposition just "decays" to its content, and essentially disappears.

These points suggest that while modeling linguistic meanings in terms of propositions is *sometimes* appropriate, in the general case it is merely circular or tautological. We certainly should not put forth a theory that the "meaning" of an idea is its proposition — the turth is more the opposite. The meaning of a proposition is its propositional content. So, if we want a truth-theoretic semantics that is applicable for general cases — not just especially logically ordered situations, like a winner-take-all sporting match — we need a truth-conditional theory of propositional *content* separate and apart from a theory of propositions.

I am discinclined to believe that such a theory is possible, since I think we can give a theory of propositional content but I don't think logic would figure strongly in it. Having said that, I should now explain what such a theory of propositional content *should* look like, and I'll leave it as a (mostly) rhetorical question whether this theory does or does not leverage logic or something else.

3 Cognitive and Environmental State-Change

Last section I hinted that I consider meanings somehow bound up with state-changes. This point seems obvious when we openly express state-change desires, like for the window to be closed, but of course a lot of discourse is more about establishing facts or syncing concepts. Compare between:

- (72) Remember that wine we tasted on the Niagara Peninsula last summer? Can you find it in our local liquor store?
- (73) Remember that wine we tasted on the Niagara Peninsula last summer? What varietal was that again?

The first sentence in each pair attempts to establish a common frame of reference between addresser and addressee — it does not, in and of itself, request any practical (extramental) action. The second sentence in (72) *can* be read as requesting that the addressee buy a bottle, though an alternate interpretation is to learn for *future reference* whether someone *could* buy that bottle. The second sentence in (73) carries no directive implicature at all, at least with any directness; it asks for more information.

Despite these variations, it seems reasonable to say that language is always performed in an overarching setting where concrete (extralinguistic) activity will *evetually* take place. If in (73) I intend to recommend that grape variety to a friend, I may not be making a direct request of him, but I *am* proposing an eventual action that he might take. If in (72) I am not issuing a directive, I am however establishing (and reserving the future possibility) that such a directive would be reasonable. As a result, some extralinguistic state change seems to be lurking behind the linguistic content: I want my friend to go from having never tasted that varietal to having tasted it. Or I want to go from not having a bottle of that wine to having one. Or, if I do not want these things at the moment, I want to confirm intellectually that these wishes are plausible. We seem to use language to set up the interpersonal understandings needed to *eventually* engage in (usually collective) practical activity, which means effectuating some (extralinguistic) change.

Having said that, most expressions are not direct requests or suggestions of the "close the window" or "let's get some wine" variety. We may have a *holistic* sense that meanings orbit around extralinguistic and extramental state-change, but at the level of particular sentences most changes that occur, or are proposed, tend to be changes in our conceptualization of situations. Nevertheless, we can pursue a semantic theory based on state-change if we stipulate that — even if many changes which occur in the course of linguistic activity do not have immediate, apparent physical effects — there are still multiple kinds of changes that can occur. Dialogs themselves change: the first sentences in (72) and (73) modify the discursive frame so that, for example, a particular wine becoms available as the anaphoric target for "that" and "that wine" — and also, metonymically, "that varietal", "that grape", "that winery". Conceptual frames can change: if we are discussing a visit to Ontario and I mention one specific winery, one effect is to (insofar as the conversation follows my lead) refigure our joint framing to something narrower and more granular that the prior frame (but still contained in it; I am not changing the subject entirely). We can pull a frame out as well as in — e.g., switch from talking about one winery visit to the whole trip, or one Leafs game to the entire season. Moreover, our beliefs can change/evolve: if you tell me the wine was Cabernet Franc, I have that piece of info in my arsenal that I did not have before.

I am now in position to develop a theory that linguistic manings are grounded in state-changes, assuming that the "register" where the changes occur can vary over several cognitive and extramental options: actual change in our environment (the window closed, milk in the coffee, the bottle opened); changes to the dialog structure (for anaphoric references, pronoun resolution, metalinguistic cues like "can you say that again", etc.); changes to conceptual framings (zoom in, zoom out, add detail); changes to beliefs. Each of these kinds of changes deserve their own analysis, but we can imagine the totality of such analyses forming a robust semantic theory.

During the course of a conversation — and indeed of any structured cognitive activity — we maintain conceptual frames representing relevant information; what other people know or believe; what are our goals and plans (individually and collectively); and so forth. We update these frames periodically, and use language to compel others to modify their frames in ways that we can (to some approximation) anticipate and encode in linguistic structure.

In the simplest case, we can effectuate changes in others' frames by making assertions they are likely to believe to be true (assuming they deem us reliable). In general, it is impossible to extricate the explicit content of the relevant speech-acts from the relevant cognitive, linguistic, and real-world situational contexts:

(74) That wine was a Cabernet Franc.

(75) Those dogs are my neighbor's. They are very sweet.

Although there is a determinate propositional content being asserted and although there is no propositional attitude other than bald assertion to complicate the pragmatics, still the actual words depend on addressees drawing from the dialogic conext in accord with how I expect them to (as manifest in open-ended expressions like "that wine", "those dogs", "they"). Moreover, the open-ended components can refer outward in different "registers": in "that wine" I may be referencing a concept previously established in the conversation, while "those dogs" may refer to pets we saw or heard but had not previously talked about. Of course, the scenarios could be reversed: I could introduce "that wine" into the conversation by gesturing to a bottle you had not noticed before, and refer via "those dogs" to animals you have never seen or heard but had talked about, or heard talk about, in the recent past.

Surface-level language is not always clear as to whether referring expressions are to work "deictically" (drawing content from the ambient context, signified by gestures, rather than from any linguistic meaning proper), "discursively" (referring within chains of dialog, e.g. anaphora), or "descriptively" (using purely semantic means to establish a designation, like "my next-door neighbor's dogs" or "Inniskillin Cabernet Franc Icewine 2015".

Let's agree to call the set of entities sufficiently relevant to a discourse or conversation context the *ledger*. By "sufficiently relevant" I mean whatever is already established in a discourse so it can be referenced with something less that full definite description (and without the aid of extralinguistic gestures). I assume that gestures and/or descriptions are communicative acts which "add" to the ledger. The purely linguistic case — let's say, *descriptive additions* — can themselves be distinguished by their level of grounding in the current context. A description can be "definitive" in a specific situation without being a *definite description* in Russell's sense (see "that wine we tasted last summer").

So, descriptive additions to the ledger are one kind of semantic side-effect: we can change the ledger via language acts. I will similarly dub another facet of cognitive-linguistic frames as a *lens*: the idea that in conversation we can "zoom" attention in and out and move it around in time. "That wine we tasted last summer in Ontario" both modifies the *ledger* (adding a new referent for convenient designation) and might alter the *lens*: potentially compelling subsequent conversation to focus on that time and/or place. Finally, I will identify a class of frame-modifications which do directly involve propositional content: the capacity for language to promote shared beliefs between people whose cognitive frames are in the proper resonance, by adding dtails to conceptual pictures already established: *those dogs are Staffordshires*, *that wine is Cabernet Franc*, *we have almond milk*, etc.

For sake of discussion, I will call this latter part of the "active" cognitive frame, for some discussion — the part concerning shared beliefes or asserted facts — the *doxa inventory*. This "database"-like repository stands alongside the "ledger" and "lens" to track propositional content asserted, collectively established, or already considered as background knowledge, vis-à-vis some discourse. Manipulations of the lens and ledger allow spakers to designate (using referential cues that could be ambiguous out-of-context) propositional contents which they wish to add to the "doxa inventory". I'll also say that modifying this inventory *can* be done through language, but participants in a discourse are entitled to assume that everyone formulates certain beliefs which are observationally obvious, and can therefore be linguistically presupposed rather than reported (the likes of that a traffic light is red, or a train has pulled into a station, or that it's raining).

So, I will assume that the machinery of frames is cognitive, not just linguistic. We have analogous faculties for "refocusing" attention and adding conceptual details via interaction with our environment, both alone and with others, and both via language and via other means. Some aspects of *linguistic* cognitive framing — like the "ledger" of referents previously established in a conversation — may be of a purely linguistic character, but these are the exception rather than the rule. In the typical case we have a latent ability to direct attention and form beliefs by direct observation *or* by accepting others' reports as proxies for direct observation.

When we are told that two dogs are male, for instance, we may not perceptually encounter the dogs but we understand what sorts of preceptual disclosures could serve as motivation for someone believing that idea. We therefore assume that such belief was initially warranted by observation and subsequently got passed through a chain of language-acts whose warrants are rooted in the perceived credibility of the speaker. Internal to this process is our prior knowledge of the parameters for judging statements like "this dog is male" observationally.

True, sometimes such observational warrants are less on display. If I had never heard of Staffies (Staffordshire pit bulls), I would be fuzzier about observational warrants and could end up in conversations like:

- (76) Those dogs are Staffordshires.
- (77) What's a Staffordshire?
- (78) It's a breed of dog.

Here I still don't really have a picture of what it is like to tell observationally that a dog is a Staffordshire. There may not be any visual cues — at least none I know of — which announce to the world that some dog's a Staffy (compared to those announcing that it is male, say). But insofar as I am acquainted with the concept *dog breed*, I also understand the general pattern of these observations. For instance I may know breeds like poodles or huskies and be able to identify *these* by distinctive visual cues. I also understand that dogs' parentage is often documented, allowing informed parties to know their breeds via those of their forebearers. That is, I am familiar with how beliefs about breeds are formed based on observation rather than just accepting others' reports, so I know the extralinguistic epistemology anchoring chains of linguistic reports in this area to originating observations — even if I cannot in this case initiate such a chain myself.

My overall point is that language enables us to formulate beliefs based on the beliefs of others, but this is possible because we also realize what itis like to formulate *our own* beliefs, and envision that sort of practice at the origin of reports that later get circulated via language. If we can't sufficiently picture the originating observations, we don't feel like we are grasping the linguistic simulacrum of those reports with enough substance. If I never learn what Stafforshire is, an assertion that some dogs are Staffordshires has no real meaning for me — even if I trust the asserter and do indeed thereby believe that the dogs are Staffordshires. Notice that merely knowing Staffordshire is a breed of dog does not expand my conceptual repertiore very much — it does not tell me how to recognize a Staffordshire or what I can do with the knowledge that a dog is one (it cannot, for instance, help me anticipate his behavior). Nevertheless even (only) knowing that Staffordshire is a breed of dog seems to fundamentally change the status of sentences like "those dogs are Staffies" for me: I do not *have* the conceptual machinery to exploit that knowledge, but I understand what *sort* of machinery is involved.

In short, the *linguistic* meaning of concepts is tightly bound to how concepts factor in perceptual observations anterior to linguistic articulation. As a result, during any episode wherein conversants use language to compel others' beliefs, an intrinsic dimension of the unfolding conversation is that people will form their own (extralinguistic) beliefs — and can also imagine themselves in the role of originating the reports they hear via language, whether or not they can actually test out the reports by their own observations.

This extralinguistic epistemic capacity is clearly exploited by the form of language itself. If a tasting organizer hands me a glass and says "This is Syrah", she clearly expects me to infer that I should take the glass from her and taste the wine (and know that the glass contains wine, etc.). These conventions may be *mediated* by language — we are more likely to understand "unspoken" norms by asking questions, until we gain enough literacy in the relevant practical domain to understand unspoken cues and assumptions. But many situational assumptions are extralinguistic because they are (by convention) not explicitly stated, even if they accompany content that *is* explicitly stated. "This is Syrah" acccompanied by the gesture of handing me a glass is an indirect invitation for me to drink it (compare to "Please hold this for a second?" or "Please hand this to the man behind you?").

I bring to every linguistic situation a capacity to make extralinguistc observations, and to understand every utterance in the context of hypothetical extralinguistc observations from which is originates. My conversation peers can use language to trigger these extralinguistic observations. Sometimes the "gap" — the conceptual slot which extralinguistic reasoning is expected to fill — is direcly expressed, as in "See the dog over there?". But elsewhere the "extralinguistic implicature" is more indirect, as in "This is Syrah" and my expected belief that I should take and taste from the glass. But in any case the phenomenon of triggering these extralinguistic observation is one form of linguistic "side effect", initiating a change in my overall conceptualization of a situation by compeling me to augment beliefs with new observations.

All told, then, the language which is presented to me has the effect of initiating changes in what I believe — partly via signifyimg propositional content that I could take on faith, but partly also via directing my attention and my interpretive dispositions to guide me towards extralinguistic observations. If this gloss is credible, it remains to be discussed whether side-effects like these are just side-effects of linguistic meaning, or are in some sense *constitutive* of meaning. I can understand the intuitive appeal of the former idea, but I think the latter may be closer to the truth. I will discuss these alternatives in the next two subsections.

3.1 *The co-framing system and the doxa system*

It may be argued that a "change-initiation" semantic theory such as I have laid out is, in fact, circular. The meaning of my assertion that this wine is Cabernet Franc is, by that theory, the change that occurs in your cognitive frame as and if you trust my claim. But presumably the only reason you do this is because you understand my enunciation as presenting some proposition, which you can accept to be true. In order for my language to update your beliefs (or indeed to fail to do so, if you doubt me), you have to entertain propositional attitudes to the content of my language. Indeed, your propositional attitudes have to structurally integrate with mine: I am evoking that wine's being Cabernet Franc as an assertion and not a question or request. So you have to identify my attitude to some proposition and on that basis formulate your own attitude to the same proposition. This can only work if my language signifies some proposition — so why can't we call that proposition the "meaning" of my utterance, rather than the effect which my declaring said proposition in some attitudinal package has on you?

The rationale for this challenge would seem to be that propositional content does not belong exclusively to one or another person, or even to the participants in a conversation. Sure, many referential and conceptual details *are* context-specific. But our joint process of cognitive framing seems intended to align our respective frames so that a genuine propositional content can emerge — as we resolve all pronouns, follow all anaphora, and agree on all conceptual roles. Hence from "that wine is Cabernat Franc" we can arrive at a content that thematizes the viniferous properties of some particular liquid. Our interpersonal negotiations may be required to converge our attention on *that particular* liquid, but — once we are there — the fact of its being Cabernat Franc (and any other culinary, chemical, physical) properties is independent of our collective and individaul framing.

That is, there is a nugget of propositional content that can be designated in a context-neutral way. That content is expressed *in conversation* using "locally significant" terms, for convenience, but those details of *naming* the proposition involved are arguably tangential to the proposition itself. We can, for sake of discussion, imagine a more neutral naming: imagine we could give GPS coordinates for one glass at one stretch of time and thereby refer to the wine in the glass thereby located (call it W) and declare that W is Cabernet Franc. (Meanwhile, let's agree that the concept "Cabernet Franc" refers to a wine with a specific genetic profile — some property "CF" — i.e., *being CF* is an unambiguous biological property that exists outside of any branding or vinological contingencies). It would seem as if my linguistic performance in terms like "that wine is Cabernet Franc" works because you recognize me to be claiming "W is CF". And the only obvious way that can happen is if what I say somehow *means* "W is CF".

Here I am recognizing the intuition that the effect which an asserting act has on addessees is (skepticism aside) to accept the asserted content as true. The intuition seems to be that the assertion is posed in the guise of something whose truth is independent of the effect it has on the addressee — it's not as if you *make* it true by aggreeing to it. An implicit assumpion is that any competent person would also deem it true — a sommelier and a chemist would confirm that W is, yes, CF. So the idea that meanings are propositional content — motivated by the intuition that assertorial effects depend on all parties' grasping a propositional content that can be lifted outside the immediate context — seems driven by the idea that parties *outside* the conversation would be equally disposed to view the assertions as truthful.

There is, of course, vagueness and context-sensitivity in language. But that does not preclude massaging linguistic content to reduce or eliminate those contingencies — as if there is some subset of linguistic expression that has a basically pristine referential structure, one which allows a certain mathematical precision at least in the areas of designating natural kinds (and designating physical objects via spacetime regions). So, "W is CF", involving only globally meaningful spatiotemporal and genetic designations, would be an example of such "pristine" language. And while people do not actually *talk* in that kind of language, we can argue that when our cognitive frames are correctly aligned, we communicate *as if* we were using pristine language.

The implication of this possibility is that semantics may indeed be logically transparent: the contextual complexities evident in surface-level language are byproducts of our cognitive autonomy, instead of intrinsic to language. They are facets of the minds which are the *vehicles* for language, and so from the perspective of linguistics proper they are "implementation details" rather than theoretical problems. That is, we need to exert conscious effort to synchronize our attentional foci and conceptual mappings with others', given the private nature of our perceptual observations and "inner thoughts": this is why we have both linguistic and extralinguistic signifiers of perceptual frames (*this*, *that*, *there*, *last summer*, pointing), and a social infrastructure to conventionalize lexical and natural-kind meanings (why, for instance, usage like "corn sugar" is regulated, not only even by convention, but sometimes by law). But *above and beyond that* we have semantic faculties which trade in propositional contents once we have achieved a proper alignment with our conversational peers. The "alignment process" may itself involve language, but language in a different register, meta-discursive more than semantic. Linguistics proper, some can argue, prioritizes the study of communication *after* alignment.

One way to describe this is to posit that what we call "language" is really two different systems: one that effectuates frame-alignment to compensate for the "centrifugal" force of cognitive autonomy, and a different architecture for signifying activity in the context of neatly aligned cognitive frames. For convenience — to avoid debating whether this distinction merely reciprocates, say, prgamatics vs. semantics — let's call this the *coframing* system and the *doxa* system. We could also guess that the hard part of AI-driven Natural Language Processing is the co-framing system; the "doxa" system has enough logical polish that computers can play the game as well as people. A robot in a testing room could geolocate some glass, take a sample to a DNA analyzer, test its profile against a database of cultivars, and conclude that "W is CF". Sure, we need human ingenuity to communicate effectively in the *absence* of "context-stripping" possibilities: we do not talk in terms of GPS coordinates and laboratory-testable property-ascriptions. But how do we deny that our context-dense language is possible only because there is a logical kernel that *could*, in principle, be solicited in context-neutral terms?

If I say that "the meaning of *this wine is Cabernet Franc* is its side-effect" — how it initiates a procss whose telos is your believing *W is CF* — I can be accused of circularity because I seem to presume what needs to be explained: that my language contains within it a signification of *W is CF* as propositional content. On that objection, if my language did not carry that content, it would not cause the desired effect. And if it *does* carry that content, such would seem logically prior to the side-effect, since the side-effect can happen only because of the carried content. Ergo, apparently, the *real* meaning is the content, not the side effect (or the process or initiation of the process that has the side-effect).

My rejoinder to this objection will cover several steps. It is a line of argument that starts by observing the conceptualization whereby the objection can be articulated. Specifically, to formulate the objection, I have tried to imagine a competent language-understander who responds to "pure" or de-contextualized propositional content. My specific example was a robot who tests a wine sample to confirm *W is CF*. In the robot's computational capabilities, language only exists as logical structures: spacetime references are defined as geolocations and timestamps; adjectival qualities are defined as scientific properties computable in the relevant metrics (a genetic profile, a chemical signature, etc.). We can imagine a cohort of intelligent robots listening in on our conversations and translating from our human context-sensitive language to their computable context-stripped representations. By this thought experiment we can — or we can contemplate that we can — imagine robots for whom language communicates propositional content directly. We can imagine sentences "naming" propositions the same way that first and last names identify people.

But is that what is happening? If the robot wants to confirm *W is CF* it has to effectuate certain actions: roll to the right place, take the wine sample, test it, match the results to a database. And even if the robot taks our ascriptions on faith — maybe it has a database that matches glasses to both GPS locations and wine styles, to record facts like "this glass has Cabernet Franc" — responding to my assertion still involves some activity (updating the database). So even though we have attributed power to the robot to traffic in logically pure expressions of propositional content, we have not shown that the robot lies outside the side-effect cycles of language.

Let's suppose that there is indeed a "doxa" system within language, so there is a space of logically pristine meanings conveyed via language. As I proposed earlier, a "doxa" inventory — a set of provisional beliefs — forms part of each cognitive frame. When our language-processing faculties encounter linguistic artifacts which express — or within the context of suitably constructed cognitive frames can be translated to — the "doxa system", we respond to those stimuli by (evaluating and then, often) adding the "signified doxa" to the "doxa inventory". But this is still a side-effect: the logical structure of the doxa has a role to play in this overall process, but this is far from authorizing us to reify the doxa as the philosophical core of linguistic meaning overall.

To put it differently, th claim of circularity that I acknowledged is itself circular. Yes, a side-effect due to newly believing P would seem to depend on P being expressed as propositional content by any act initiating the side-effect. And P is a propositional content that can inspire belief-change side-effects because it has the form of a trans-personal articulation: any reasonable person (even a robot) should accept it. The circularity here is that the "work" is done by P, not by the side-effect per se. But in order to theoretically posit P outside the side-effect, we have to posit a kind of decontextualized rational community: P is logically distinct from the side effect because other people and robots should engage it too. But their getting thus engaged is also *for them* a side-effect: to believe or test P the robot has to perform certain acts — i.e., whatever software runs its language-comprehension modules has to call some function than run its database and/or motor-location modules. The enunication of "that wine is Cabernet Franc" is still *initiating a process.*

Insofar as my assertive speech-acts are rationally performed, their side-effects on *one* addressee should resemble their side-effects on others, including other hypothetical or potential addressees (even robots). There is clearly then a kind of "publicness" or "communalization" of side-effects, and language seems logical if we get the impression that its effects on different listeners will be mostly the same. If there is circularity here, it seems to go two ways: arguably, side-effects can be similar because there is a logical nexus in language that fixes content across minds. Surely "Sanders is a presidential candidate" (stated as a simple fact, without polarity) evokes similar effects because it is objectively true (he has formally declared he's running). So language can guarantee effect-similarity because it has the resources — sometimes albeit not always utilized — to formulate assertions that are relatively transparent, logically (of course, it can also produce provocations like "Sanders is a terrible presidential candidate" or "Sanders is an unelectable presidential candidate").

So communality of side-effects depends on (sometimes, potential) logicality of language. But conversely, it is hard to define the logicality of language without pointing out that logically transparent language (like "Sanders is running") evokes different kides of side effects than polarizing language (like "Sanders is unelectable"). After all, the effect of some logically transparent enunciation is to introduce some propositional content into a public arena. But communication only happens when the content thereby publicized is considered and maybe deemed true, which requires certain cognitive processes in a community of addressees. The logical content of language only "exists" insofar as logically reasonable utterances trigger logically guided cognitive operations.

Even if we accept that linguistic expressions can signify propositional content, this does not mean that a sentence is like a djinn which conjures propositions into material form. Logical structures do not float around like snowflakes: if they exist, they do so as regulatory structures or specifications guiding the behavior or implementation of physically realized, dynamically changable systems. A computing platform can exemplify a Typed Lambda Calculus or Adjoint Tensor Logic or Modal Process Algebra by *implementing* such a system, but this does not mean a software artifact can *be* a logical system (or even can be a *token* of a logical system). But the implementation of the system establishes an Ontological gap between the system as abstract Category and its physical realization.

Let's say, for sake of argument, that someone develops a C++ Functional-Reactive Programming library (a not-too-ambitious enhancement of existing software) which fully realizes Jennifer Paykin's version of Tensor Algebra. It would be entirely possible for most (even expert) C++ programmers to use that library without understanding or even being aware that their code was embodying some logical structure, separate and apart from the system of side-effects and function-calls that they orchestrate. Similarly, developers can create C++ types that are functionally identical to Haskell monads, without being aware of the monadic logic thereby exmplified. To say that logical systems are implemented in software is to say that the totality of all function-calls — both actually observed at runtime and theoretically possible for any run of a program — span an abstract space that is fully and adequately specified by the logic. So we can say that a signal-slot connection causing some function-pointer to be followed represents the concrete manifestation of an abstract "temporal-monadic modality". This means that the pattern of signal-slot connections does and will always conform to regulations that can be modeled via Adjoint Tensor Logic. It also means that this coformance is a result of deliberate design — the logic exerts a normative effect on the software; it is not just a pattern retroactively discoverable in observed function-calls. But what actually exists are the function-calls themselves, and there are many ways to comport to them without considering or being aware of the logic (we can enumerate function calls as a debugger trace, or study them in conventional C++ terms without the added logical details). The logic is manifest as a regulatory and emergent pattern and influence, but is also only one facet of the full ontological status of the vehicles (e.g., function-calls) wherein the logic is realized.

Insofar as Natural Language is logical, I would argue that its logic is manifest analogously: it is realized in the pattern of whatever cognitively corresponds to "function calls"; e.g., the tendency of external (linguistic and otherwise) stimuli to trigger cognitive processes.

My point in this argument is not that linguistic abstraction is wrong: after all, linguistics is not neuroscience, and the theoretical arsenal of linguistics can rightly neglect to target such topics as the neurophysical encoding of linguistic processes. I can accept some form of truth-theoretical semantics if it provides a broad abstract description of linguistic processes that can be "handed off" to other disciplines, like psycholinguistics and language-acquisition studies. This would be a reasonable "division of labor" if we believed that at the *abstract* level language is really about propositional content, and that notions like "message passing between processing units" are attempts to introduce theoretical concepts at the "realization" level. That is, something like truth-theoretical semantics would be apropos if the *abstract* formulation was mostly logical, even if some formally rigorous (but not in a manner amenable to symbolic logic) model was a better paradigm for studying the *concrete* implementation of the logical architecture.

However, the de facto assumption that "everything abstract is logic", and that any sub-logical details are the tangential impurities of concreteness itself, is a prejudice that isn't borne out even in highly formal milieus. For example, the digital encoding of typed values are a concrete detail counterposed to the mathematical abstractions of type theory, but it's not as if there is a single line between "abstract" types and "concrete" binary-electrical codes. Programming language theory recognizes digital encoding as byte-sequences, and so for any typed value there is a mapping of that value to a string of base-256 integers (the value in runtime computer memory). Moreover, any string of base-256 integers can potentially be interpreted as a typed value (for example, by derefencing a non-correctly-initialized pointer). These are still abstract posits: it requires some abstraction to model electrical signals in disk drives or CPU registers as "base-256 integers". However, this represents a layer of abstraction which stands between the more "mathematical" abstractions of formal type theory and the bare metal of computer hardware.

One feature of this "intermediary" abstraction is that the abstract posits are more likely to be mathematically opaque. In functional programming, for example, we can associate each type with an algorithm that can construct every element of that type, and also often run that construction "backward" to analyze properties of type-instances (which is called "pattern matching"). The canonical example is a list: any list of size n can be derived from a list of size $n-1$ by adding one element to the end of the list. Starting from an empty list we can therefore build any arbitrary list by a sequence of these "constructors". Working in the reverse direction, we can then calculate values — such as, the largest element in the list — by calling a function on every smaller list in the "chain" of constructors: the largest value is the maximum of the *last* value and the largest value of the "predecessor" list wherein that last value is not appended; the largest value of the predecessor is the maximum of *its* last value and the largest value of *its* predecessor, and so on. The recursive structure here is directly tied to the arithmetic encoding (influential in early analytic philosophy) wherein the number 1 is the successor to 0, 2 is the successor to 1, etc. This gives numbers a logical form rather than leaving them as a kind of prelogical Platonic given. The analogous formulation in type theory is that any type is isomorphic to the set of algorithms which generate each of its values — for instance, every list can be associated with the algorithm which builds the list iteratively, starting from the empty list. This introduces a logical structure on types amenable to logical analysis — we can prove properties about functions on types by analyzing how those functions operate on values given the specific construction-chain that produce them. Continuing the example, I can prove something about my implementation of a function on lists if I prove it for the empty list and then prove that, if I know my function works for a list of length $n-1$, and I then append a value, it will still work for the length-n list.

The problem with these functional-programming techniques in the context of programming language theory in general is that many applied type systems do not have this kind of isomorphism between types and construction-chains. In C++, say, I can get a list by dereferencing a pointer, and I have no way of knowing the provenance of the pointed-to memory. There are many ways to construct C++ values *other* than by going through construction-chains. It *may* be that values have properties consistent with their being built up by an incremental, logically regulated proess. However, a C++ programmer often cannot *assume* that types have this logical orderliness. In short, C++ types are more logicallly opaque than, say, Haskell types. This does not make the C++ type system less "abstract" than Haskell's; it just means that there is less information embedded in C++ types which would make them amenable to analysis from a mathematical perspective.

An interesting question is then which language is a better metaphor for *human* language — a functional language like Haskell, which enforces logical rigor by design? Or a procedural language like C++, whose operational dynamics is essentially concerned with properly orchestrating function calls, even in the absence of logical guarantees? The theory I intend to dvelop here, some variation on an "interface theory of meaning", is probably closer in spirit to C++ than Haskell.

3.2 *The illogic of syntax*

Let us agree that — beneath surface-level co-framing complexity — many language acts have a transparent content as "doxa" that gets conveyed between people with sufficiently resonant cognitive frames. This is still not enough to elevate doxa to the *meaning* of such language-acts. For a logic-driven theory, we have to thematize not only *that* expressions refer to or convey propositional content, but *how* they do so. It is not only the content itself but the "how" that should be analyzed through a logical structure.

Since it is widely understood that the essence of language is compositionality, the clearest path to a logic-based theory would be via the "syntax of semantics": a theory of how language designates propositional content by emulating or iconifying propositional structure in its own structure (i.e., in grammar). This would be a theory of how linguistic connectives reciprocate logical connectives, phrase hierarchies reconstruct propositional compounds, etc. It would be the kind of theory motivated by cases like

- (79) This wine is a young Syrah.
- (80) My cousin adopted one of my neighbor's dog's puppies.

where morphosyntactic form — possessives, adjective/noun links — seems to transparently recapitulate predicate relations. Thus the wine is young *and* Syrah, and the puppy if the offspring of a dog who is the pet of someone who is the neighbor of the speaker. These are well-establishd logical forms: predicate conjunction, here; the chaining of predicate operators to form new operators, there. Such are embedded in language lexically as well as grammatically: the conjunction of husband and "former, of a prior time" yields ex-husband; a parent's sibling's daughter is a cousin.

The ineteresting question is to what extent "morphosyntax recapitulates predicate structure" holds in general cases. This can be considered by examining the logical structure of reported assertions and then the structures via which they are expressed in language. I'll carry out this exercise vis-à-vis several sentences, such as these:

- (81) The majority of students polled were opposed to tuition increases.
- (82) Most of the students expressed disappointment about tuition increases.
- (83) Many students have protested the tuition increases.

There are several logically significant elements here that seem correspondingly expressed in linguistic elements — that is, to have some model in both prelinguistic predicate structure and in, in consort, semantic or syntactic principles. All three of (81)-(83) have similar but not identical meanings, and the differences are manifest both propositionally and linguistically (aside from the specific superficial fact that they are not the same sentence). I will review the propositional differences first, then the linguistic ones.

One obvious predicative contrast is that (81) and (82) ascribes a certain *quality* to students (e.g., disappointment), whereas (82) and (83) indicate *events*. As such the different forms capture the contrast between "bearing quality Q" and "doing or having done action A": the former a predication and the latter an event-report. In the case of (82), both forms are available because we can infer from *expressing* disappointment to *having* disappointment. There may be logics that would map one to the other, but let's assume we can analyze language with a logic expressive enough to distinguish events from quality-instantiations.

Other logical forms evident here involve how the subject noun-phrases are constructed. "A majority" and "many" imply a multiplicity which is within some second multiplicity, and numerically significant there. The sentences differ in terms of how the multiplicities are circumscribed. In the case of "students polled", an extra determinant is provided, to construct the set of students forming the predicate base: we are not talking about students in general or (necessarily) students at one school, but specifically students who participated in a poll.

Interrelated with these effects are how the "tuition increases" are figured. Using the explicit definite article suggests that there is *some specific* tuition hike policy raising students' ire. This would also favor a reading where "students" refers collectively to those at a particular school, who would be directly affected by the hikes. The *absence* of an article on "tuition increases" in (82) leaves open an interpretation that the students are not opining on some specific policy, but on the idea of hikes in general.

Such full details are not explicitly laid out in the sentences, but it's entirely possible that they are clear in context. Let's take as given that, in at least some cases where they would occur, the sentences have a basically pristine logical structure given the proper contextual framing — context-dependency, in and of itself, does not weaken our sense of language's logicality. In particular, the kind of structures constituting the sentences' precise content — the details that seem context-dependent — have bona fide logical interpretations. For example, we can consider whether students are responding to *specific* tuition hikes or to hikes in general. We can consider whether the objectionable hikes have already happened or are just proposed. Context presumably identifies whether "students" are drawn from one school, one governmental jurisdiction, or some other aggregating criteria (like, all those who took a poll). Context can also determine whether aggregation is more set- or type-based, more extensional or intensional. In (81)-(83) the implication is that we should read "students" more as a set or collection, but variants like *students hate tuition hikes* operates more at the level of students as a *type*. In "students polled" there is a familiar pattern of referencing a set by marrying a type (students in general) with a descriptive designation (e.g., those taking a specific poll). The wording of (81) does not mandate that *only* students took the poll; it does however employ a type as a kind of operator on a set: of those who took the poll, focus on students in particular.

These are all essentially logical structures and can be used to model the propositional content carried by the sentences — their "doxa". We have operators and distinctions like past/future, set/type, single/multiple, subset/superset, and abstract/concrete comparisons like tuition hikes *qua* idea vs. *fait accompli*. A logical system could certainly model these distinctions and accordingly capture the semantic differences between (81)-(83). So such details are all still consistnt with a truth-theoretic paradigm, although we have to consider how linguistic form actually conveys the propositional forms carved out via these distinctions.

Ok, then, to the linguistic side. My first observation is that some logically salient structures have fairly clear analogs in the linguistic structure. For instance, the logical operator for deriving a set from criteria of "student" merged with "taking a poll" is brought forth by the verb-as-adjective formulation "students polled". Subset/superset arrangements are latent as lexical norms in senses like "many" and "majority". Concrete/abstract and past/future distinctions are alluded to by the presence or absence of a definite article. So "*the* tuition increases" connotes that the hikes have already occurred, or at least been approved or proposed, in the past relative to the "enunciatory present" (as well as that they are a concrete policy, not just the idea), whereas articleless "tuition increases" can be read as referring to future hikes and the idea of hikes in general: past and concrete tends to contrast with future and abstract.

A wider range of logical structures can be considered by subtly varying the discourse, like:

- (84) Most students oppose the tuition increase.
- (85) Most students oppose a tuition increase.

These show the possibility of *increase* being singular (which would tend to imply it refers to a concrete policy, some *specific* increase), although in (85) the *in*definite article *may* connote a discussion about hikes in general.

But maybe not; cases like these are perfectly plausible:

- (86) Today the state university system announced plans to raise tuition by at least 10%. Most students oppose a tuition increase.
- (87) Colleges all over the country, facing rising costs, have had to raise tuition, but most students oppose a tuition increase.

In (86) the definite article could also be used, but saying "*a* tuition increase" seems to reinforce the idea that while plans were announced, the details are not finalized. And in (87) the plural "increases" could be used, but the indefinite singular connotes the status of tuition hikes as a general phenomenon apart from individual examples — even though the sentence also makes reference to concrete examples. In other words, these morphosyntactic cues are like levers that can fine-tune the logical designation more to abstract or concrete, past or future, as the situation warrants. Again, context should clarify the details. But morphosyntactic forms — e.g., presence or absence of articles (definite or indefinite), and singular/plural — are vehicles for language, through its own forms and rules, to denote propositional-content structures like abstract/concrete and past/future.

Other logical implications may be more circuitous. For instance, describing students as *disappointed* implies that the disliked hikes have already occured, whereas phraseology like "students are gearing for a fight" would have the opposite effect. The mapping from propositional-content structure to surface language here is less mechanical than, for instance, merely using the definite article on "the tuition increases". Arguably "dissapointment" — rather than just, say, "opposition" — implies a specific timeline and concreteness, an effect analogous to the definite article. But the semantic register of "dissapointment" bearing this implication is a more speculative path of conceptual resonances, compared to the brute morphosyntactic "the". There is subtle conceptual calculation behind the scenes in the former case. Nonetheless, it does seem as if via this subtlety linguistic resources are expressing the constituent units of logical forms, like past/future and abstract/concrete.

So, I am arguing (and conceding) that there are units of logical structure that are conveyed by units of linguistic structure, and this is partly how language-expressions can indicate propositional content. The next question is to explore this correspondance compositionally — is there a kind of aggregative, hierarchical order in terms of how "logical modeling elements" fit together, on one side, and linguistic elements fit together, on the other? There is evidence of compositional concordance to a degree, examples of which I have cited. In "students polled", the compositional structure of the phrase mimics the logical construct — deriving a set (as a predicate base) from a type crossed with some other predicate. Another example is the phraseology "a/the majority of", which directly nominates a subset/superset relation and so reciprocates a logical quantification (together with a summary of relative size; the same logical structure, but with different ordinal implications, is seen in cases like *a minority of* or *only a few*). Here there is a relatively mechanical translation between propositional structuring elements and linguistic structuring elements.

However, varying the examples — for instance, varying how the subject noun-phrases are conceptualized — points to how the synchrony between propositional and linguistic composition can break down:

- (88) Student after student came out against the tuition hikes.
- (89) A substantial number of students have come out against the tuition hikes.
- (90) The number of students protesting the tuition hikes may soon reach a critical mass.
- (91) Protests against the tuition hikes may have reached a tipping point.

Each of these sentences says something about a large number of students opposing the hikes. But in each case they bring new conceptual details to the fore, and I will also argue that they do so in a way that deviates from how propositional structures are composed.

First, consider "student after student" as a way of designating "many students". There's a little more rhetorical flourish here than in, say, "a majority of students", but this is not just a matter of eloquence (as if the difference were stylistic, not semantic). "Student after student" creates a certain rhetorical effect, suggesting via how it invokes a multiplicty a certain recurring or unfolding phenomenon. One imagines the speaker, time and again, hearing or encountering an angry student. To be sure, there are different kinds of contexts that are consistent with (88): the events could unfold over the course of a single hearing or an entire semester. Context would foreclose some interpretations — but it would do so in any case, even with simpler designations like "majority of students". What we *can* say is that the speaker's chosen phraseology cognitively highlight a dimension in the events that carries a certain subjective content, invoking their temporality and repetition. The phrasing carries an effect of cognitive "zooming in", each distinct event figured as if temporally inside it; the sense of being tangibly present in the midst of the event is stronger here than in less temporalized language, like "many students". And then at the same time the temporalized event is situated in the context of many such events, collectively suggesting a recurring presence. The phraseology zooms in and back out again, in the virtual "lens" our our cognitively figuring the discourse presented to us — all in just three or four words. Even if "student after student" is said just for rhetorical effect — which is contextually possible — *how* it stages this effect still introduces a subjective coloring to the report.

Another factor in (88) and (89) is the various possible meanings of "come out against". This could be read as merely expressing a negative opinion, or as a more public and visible posturing. In fact, a similar dual meaning holds also for "protesting". Context, again, would dictate whether "protesting" means actual activism or merely voicing displeasure. Nonetheless, the choice of words can shade how we frame situations. To "come out against" connotes expressing disapproval in a public, performative forum, inviting the contrast of inside/outside (the famous example being "come out of the closet" to mean publicly identifying as LGBT). Students may not literally be standing outside with a microphone, but — even if the actual situation is just students complaining rather passively — using "come out against" paints the situation in an extra rhetorical hue. The students are expressing the *kind* of anger that can goad someone to make their sentiments known theatrically and confrontationally. Similarly, using "protest" in lieu of, say, "criticize" — whether or not students are actually marching on the quad — impugns to the students a level of anger commensurate with politicized confrontation.

All these sentences are of course *also* compatible with literal rioting in the streets; but for sake of argument let's imagine (88)-(91) spoken in contexts where the protesting is more like a few comments to a school newspaper and hallway small-talk. The speakers have still chosen to use words whose span of meanings includes the more theatrical readings: "come out against" and "protest" overlap with "complain about" or "oppose", but they imply greater agency, greater intensity. These lexical choices establish subtle conceptual variations; for instance, to *protest* connotes a greater shade of anger than to *oppose*.

Such conceptual shading is not itself unlogical; one can use more facilely propositional terms to evoke similar shading, "like very angry" or "extremely angry". However, consider *how* language like (88)-(91) conveys the relevant facts of the mater: there is an observational, in-the-midst-of-things staging at work in these latter sentences that I find missing in the earlier examples. "The majority of" sounds statistical, or clinical; it suggests journalistic reportage, the speaker making an atmospheric effort to sound like someone reporting facts as established knowledge rather than observing them close-at-hand. By contrast, I find (88)-(91) to be more "novelistic" than "journalistic". The speaker in these cases is reporting the facts by, in effect, *narrating* them. She is building linguistic constructions that describe propositional content through narrative structure — or, at least, cognitive structures that exemplify and come to the fore in narrative understanding. Saying "a substantial number of students", for example, rather than just (e.g.) *many* students, employs semantics redolant of "force-dynamics": the weight of student anger is described as if a "substance", something with the potency and efficacy of matter.

This theme is also explicit in "critical mass", and even *tipping point* has material connotations. We can imagine different versions of what lies one the other side of the tipping point — protests go from complaining to activism? The school forced to reverse course? Or, contrariwise, the school "cracking down" on the students (another partly imagistic, partly force-dynamic metaphor)? Whatever the case, language like "critical mass" or "tipping point" is language that carries a structure of story-telling; it tries tie facts together with a narrative coherence. The students' protests grew more and more strident until ... the protests turned aggressive; or the school dropped its plans; or they won public sympathy; or attracted media attention, etc. Whatever the situation's details, describing the facts in force-dynamic, storylike, spatialized language (e.g. "come *out* against") represents an implicit attempt to report observations or beliefs with the extra fabric and completeness of narrative. It ascribes causal order to how the situation changes (a critical mass of anger could *cause* the school to change its mind). It brings a photographic or cinematic immersion to accounts of events and descriptions: *student after student* and *come out* invite us to grasp the asserted facts by *imagining* situations.

The denoument of my argument is now that these narrative, cinematic, photographic structures of linguistic reportage — signaled by spatialized, storylike, force-dynamic turns of phrase — represent a fundamentally different way of signifying propositional content, even while they *do* (with sufficient contextual grounding) carry propositional content through the folds of the narrative. I don't dispute that hearers understand logical forms via (88)-(91) similar to those more "journaslistically" captured in (81)-(83). Nor do I deny that the richer rhetoric of (88)-(91) play a logical role, capturing granular shades of meaning. My point is rather that the logical picture painted by the latter sentences is drawn via (I'll say as a kind of suggestive analogy) *narrative structure*.

I argued earlier that elements of propositional structure — for example, the set/type selective operator efficacious in "students polled" — can have relatively clean morphosyntactic manifestation in structural elements in language, like the verb-to-adjective mapping on "polled" (here denoted, in English, by unusual word position rather than morphology, although the rules would be different in other languages). Given my subsequent analysis, however, I now want to claim that the map between propositional structure and linguistic structure is often much less direct. I'm not arguing that "narrative" constructions lack logical structure, or even that their rhetorical dimension lies outside of logic writ large: on the contrary, I believe that they use narrative effects to communicate granular details which have reasonable logical bases, like degrees of students' anger, or the causative interpretation implied in such phrases as "critical mass". The rhetorical dimension does not prohibit a reading of (88)-(91) as expressing propositional content — and using rhetorical flourishes to do so.

I believe, however, that *how* they do so unzips any neat alignment between linguistic and propositional structure. Saying that students' protests "may have reached a critical mass" certainly expresses propositional content (e.g., that enough studnts may now be protesting to effectuate change), but it does so not by mechanically asserting its propositional idea; instead, via a kind of mental imagery which portrays its idea, in some imaginative sense, iconographically. "Critical mass" compels us to read its meaning imagistically; in the present context we are led to actually visualize students protesting *en masse*. Whatever the actual, empirical nature of their protestation, this language paints a picture that serves to the actual situation as an interpretive prototype. This is not only a conceptual image, but a visual one.

Figurative language — even if it is actually metaphorical, like "anger boiling over" — has similar effect. Alongside the analysis of metaphor as "concept blending", persuasively articulated by writers like Gilles Fauconnier and Per Aage Brandt, we should also recognize how metaphor (and other rhetorical effects) introduces into discourse language that invites visual imagery. Sometimes this works by evoking an ambient spatiality (like "come out against") and sometimes by figuring phenomena that fill or occupy space (like "students protesting" — one salience of this language is that we imagine protest as a demonstrative gesture expanding outward, as if space itself were a theater of conflict: protesters arrayed to form long lines, fists splayed upward or forward). There is a kind of visual patterning to these evocations, a kind of semiotic grammar: we can analyze which figurative senses work via connoting "ambient" space or via "filling" space, taking the terms I just used. But the details of such a semiotic are tangential to my point here, which is that the linguistic structures evoking these visual, imagistic, narrative frames are not simply reciprocating propositionl structure —- even if the narrative frames, via an "iconic" or prototype-like modeling of the actual situation, *are* effective vehicles for *communicating* propositional structure.

What breaks down here is not propositionality but *compositionality*: the idea that language signifies propositional content *but also* does so compositionally, where we can break down larger-scale linguistic elements to smaller parts *and* see logical structures mirrored in the parts' combinatory maxims. In the later examples, I have argued that the language signifies propositional content by creating narrative mock-ups. The point of these imagistic frames is not to recapitulate logical structure, but to have a kind of theatrical coherence — to evoke visual and narrative order, an evolving storyline — from which we then understand propositional claims by interpreting the imagined scene. Any propositional signifying in these kinds of cases works through an intermediate stage of narrative visualization, whose structure is holistic more than logically compositional. It relies on our faculties for imaginative reconstruction, which are hereby drafted into our language-processing franchise.

This kind of language, in short, leverages its ability to trigger narrative/visual framing as a cognitive exercise, intermediary to the eventual extraction of propositional content. As such it depends on a cognitive layer of narrative/visual understanding — which, I claim, belongs to a different cognitive register than building logical models of propositional content directly.

In the absence of a compelling analysis of *compositionality* in the structural correspondance between narrative-framed language and logically-ordered propositional content, I consequently think we need a new theory of how the former signifies the latter. My own intuition is that language works by trigering *several different* cognitive subsystems. Some of these hew closely to predicate logic; some are more holistic and narrative/visual. Cognitive processes in the second sense may be informed and refined by language, but they have an extralinguistic and prelinguistic core: we can exercise faculties of narrative imagination without explicit use of language (however much language orders our imaginations by entrenching some concepts more than others, via lexical reinforcement).

I'm not just talking here about "imagination" in the sense of fairy tales: we use imaginative cognition to make sense of any situation dscribed to us from afar. When presented with linguistic reports of not-directly-observable situations, we need to build cognitive frames modeling the context as it is discussed. In the terms I suggested earlier, we build a "doxa inventory" tracking beliefs and assertions. Sometimes this means internalizing relatively transparent logical forms. But sometimes it means building a narative/visual account, playing an imaginary version of the situation in our minds. Language could not signify in its depth and nuance without triggering this *interpretive-imaginative* faculty. Cognitively, then, language is an *intermediary* to this cognitive system, an *interface*. To put it as a slogan, *language is an interface to interpretive-imaginative cognitive capabilities.*

If this claim about *language* seems plausible, it has some ramifications for *linguistics*: insofar as language has a formal articulation, it is the formality of an *interface*, which is not necessarily the same thing as the formality of a *logical system*. Insofar as linguistics is a science, it would then be the science of the intermediate space between grammatical plus lexical observations and interpretive-imaginative cognition. Framing linguistics in these terms is, I believe, analogous to describing Biology as the interface from medicine to chemistry and physics — with analogous philosophical justifications and metatheortical consequences. Both can be seen as a larger metascientific exploration of what it means — as a philosophical claim, on the one hand, and as a normative proscription on scientific practice, on the other — for a *science* to be an *interface*.

In the specific context of linguistics, one consequence is that any linguistic structuring element becomes an intermediary eventually handed off to interpretive-imaginative cognitive processes — analogous, in the computational realm, to application-level function implementions setting up kernel system calls. On this comparison, intermediate structures of language understanding are like source code, and interpretive-imaginative cognition corresponds to the system kernel. Insofar as intermediate linguistic structures are analyzed via type theory, we can accordingly model this situation as type properties modulating how language elements carry over to the interpretive-imaginative cognitive "kernel" — which is a faithful analogy to how types work when applied to, say, C++ coding structures. Insofar as linguistic understanding is viewed through the lense of Conceptual Roles, we can analyze how the *conceptual role* which some referent plays — more than its specific referenced nature — determines how it is "communicated" to the "interpretive-imaginative kernel". In fact, this last topic is an analysis I will now consider further.

4 Conceptual Space Theory and the Interface Theory of Meaning

The phraseology that language is an "interface" — to some (at least partly) prelinguistic cognitive faculties — is inspired by Vakarelov's "interface theory of meaning", which I described at the end of Section 1. Here I want to explore something like an ITM as an extension to (or perhaps a foundation for) older language-philosophy paradigms, like Cognitive Grammar and Conceptual Role Semantics. I'll spend this section forecasting how that might work.

Conceptual Space Theory, on the other hand, originates with Peter Gärdenfors's books and articles — especially 2000's *Conceptual Spaces: The Geometry of Thought* — but has branched from linguistics to disciplines like computer science and the Philosophy of Science. Conceptual Space Theory emerges from Cognitive Linguistics, and therefore resists simple AI paradigms of language following essentially mechanical rules, or logically decoding and processing symbols. But at the same time, Gärdenfors argues that we can find some *quantitative* structure in conceptual structures — including identifying axes of variation where notions of prototype and exemplars can be formally modeled; and representing perceptual and spatial features through numeric measures, like the color double-pyramid (which grounds the Hue, Saturation, Value color space widely used for computer graphics).

To the extent that perceptual and spatial features can be quantified, it is easy to develop intuitions for prototype theories and conceptual similarity: for example, an exemplary *red tablecloth* would have a certain almost-red hue and rectangular dimensions. Varying the color or making the shape too large or small, or oblong, corresponds to moving from the "prototypical" space of the concept to borderline cases. These examples are appealing because they suggest that conceptual dispositions can be systematically modeled; the behind-the-scenes mental gears that classify something as *tablecloth* or *knife* seem to have some scientifically tractable lawfulness, not just a cognitive black box that linguistics takes for granted.

As I see it, the challenge for Conceptual Space Theory is how to generalize outside the intuitively trenchant but rather narrow examples of conceptual "quantification", like color and shape, to model the full range of details — including functional and conceptual roles as well as perceptual form — which influence conceptualization. After all, while there *are* spatial differences between a *tablecloth*, *placemat*, and *ribbon* — or between a *knife*, *sword*, and *cleaver* — these represent different *concepts* because the objects serve different enactive ends. Their various spatial morphologies are byproducts of practical design, and do not *cause* differences in conceptualization, although it is often via spatial form that we *recognize* an object as a knife, etc. Integrating Conceptual Spaces into a multifaceted *cognitive* linguistics would seem to call for examining Conceptual Spaces not just as vehicles for *object recognition* but within the spectrum of interpersonal, enactive, and situational understanding that lies behind linguistic signification and performance.

Research in the overall context of Conceptual Space Theory has, however, examined these more situational and functional dimensions. There are several tactics for cashing the basic "Geometry of Thought" metaphor outside the obvious geometric model of, say, prototypical tablecloths having prototypical rectangular dimensions.

One option is to consider conceptual "space" as encompassing enactive dimensions as well as spatial/perceptual ones. We can do certain familiar things with tablecloths: place them over a table, fold them, launder them; and with knives: place them on a table, sharpen them, wash them under running water, use them to cut food. The more that two objects share a similar set of affordances, the more that they are likely to be conceptually similar. As such, conceptual *roles* can substitute for "metrizable" dimensions (like color and shape, which can be directly quantified in a distance space) as a ground for modeling similarity and prototypicality.

Another idea is to consider the kind of (canonically perceptual) attributes which via Conceptual Spacs we can analyze quantitatively as *triggers* to more multi-faceted cognitive activity. When we see an object which *looks* like a prototypical knife or tablecloth, this spurs further conceptualizations — and/or enactive engagement with the object — that thematize the object more functionally and situationally. The perceptual triggers then need to be analyzed as part of the overall cognitive process. In that case the "geometric" space where concepts can be situated represents not so much the definitive cognitive stature of the object, but a *provisional* conceptualization which unfolds into more complex (and less directly perceptual) machinations.

This latter model actually integrates well with Vakarelov's ITM: as I already argued in Section 1, language is best viewed as an integration of multiple cognitive subsystems. One such subsystem, which acts like a perceptual-cognitive interface, maybe well-served by a Conceptual Space model that stays close to Gärdenfors's original geometric metaphor. Other subsystems, engaged more with the list of affordances embodied in a concept (and, concretely, in its tokens) needs to be modeled with a more abstract/functional kind of "space".

Given this possibility, I believe that the systematizing gambits of ITM and Conceptual Space Theory can be integrated. In this section I will argue that formal attempts to implement Conceptual Spaces in computational settings are consistent with the ITM architecture. This does not mean, however, that a Conceptual Space/ITM hybrid can be unproblemmatically lifted to a computational model for human cognition. The idea that our overall cognition *integrates* many subsystems means that a computational theory of any one subsystem is not necessarily a step toward genuine AI. It may be that there is something salienty human about how we *integrate* the totality of our cognitive dispositions into socialized, context-sensitive, empathic behaviors.

So in this section I will generally approach efforts to *operationalize* Conceptual Spaces — and look back to Vakarelov's paradigm as well — with a mixture of critique and endoresement. In general I think that these thories ar useful models — or at least useful starting-points — for understanding components within cognitive systems which are *locally* structured and formalizable. This does not mean I endorse a *holisitic* picture of human cognition as simplistically computational or simulatable. In any kind of "interface theory", there is an implicit distinction between *local* analysis and *global* systematic qualities. An interface is, canonically, poised between two other structures: it can be analyzed internally through the lens of its own structures — how it effects translations and routing between the structures of other systems which the interface interconnects — but this "local" analysis does not address how local structures fit into the "semantics" of the whole.

The "semantics of the whole" is often where science gives way to Philosophy of Science — or even to Phenomenology. The "local" language of chemistry, for example, principally describes phenomena at the molecular level, like chemical bonds and intermolecular forces. Analogously, the local language of biology describes phenomena at the cellular level, like compounds diffusing in the blood stream. The chemistry-scale phenomena may provide causal-explanatory grounds for the biological — chemical properties of blood and alchohol, for example, dictate how alchohol enters the blood stream. But we need a holistic integration to perceive this at a higher level, as an empirical phenomenon affecting the organism as a whole: alchohol enters the bloodsteam and can impair our normal cognitive functioning, even causing harm if consumed at toxic levels. We need the everyday concepts and language — e.g., describing someone as *drunk* or *posioned* — to orient the biological and chemical languages to empirical reality. Biology and chemistry are not abstract systems; they are intended to explain phenomena in the world, but *which* phenomena they are explaining is not something captured "locally" in either biological or chemical language.

To the degree, then, that we can ("metascientifically") analyze the interaction between biological and chemical laws/properties as an *interface*, an "interface theory" of this relationship — of biology supervening on chemistry, for instance, goes hand-in-hand with a *holistic* theory of the worldly phenomena which biology and chemistry (and their interaction/reuction) explain. The interface theory is not a self-contained explanation, but a *local* analysis which needs an overarching holistic picture to cement its explanatory value.

I believe this biology/chemistry case is a good metaphor for cognitive science in relation to Cognitive Linguistics and to phenomnology. We can theorize various cognitive subsystems, analogous to chemistry and biology — suppose we take both perceptual and affordance-based Conceptual Space models, Vakarelov's M and S subsystems, and the proto-computational frameworks like *feature vectors* or *expectations* developed in a Conceptual Space framework as I will mention below — so these thories become analogs in the explanation of human *mind* to chemistry and biology in explanations of the human *body*. But these are still local analyses, and we need an overarching account of how different cognitive subsystems "interface together" to yield, as an emergent totality, what we experience as human mind and consciousness.

Ultimately, I believe this holistic picture needs to be developed at a philosophical level, rooted in fields like phenomenology and Cognitive Grammar. This means that these fields should recognize the formal merit of scientific — even computational — analyses of *aspects* of cognition while arguing against reductive theories of cognition and consciousness as a holistic reality. In the absense of a phenomenological paradigm which is willing to both engage and transcend subsystem analyses, our *holistic* picture of mind tends to be dominated by AI and logical or computational reductionism. That's a subject for the next section; my goal here is to look at Conceptual Space theory as a useful but partial "subsystem" theory.

4.1 *Conceptual Space Theory and Phenomenology*

Towards the end of Section 1 I noted the contrast between how the word "cognitive" itself seems to do different "theoretical work" in Cognitive Linguistics compared to, say, AI research. I also argued that the differences are not necessarily irreconcilable: while humans are not the only cognitive system, there is a distinctly human way of *being* a cognitive system. Analogously, while humans are not the only communicative species — actually, we are not the only *linguistic* species; it seems counter-productive not call bird sounds or cetacean and primate vocalizations as a kind of language — there is however a distinctly human way of *being* linguistic. Not all language is *human* language; but language which *is* human absorbs the specificity of human sociality and consciousness into its signifying processes. It is on *that* level, I would argue, that we should read the "cognition" in Cognitive Grammar, Cognitive Linguistics, or Cognitive Phenomenology.

Taking Langacker's Cognitive Grammar as canonical, I think scholars in that tradition would agree that we instinctively reach for cognitive frames to interpret linguistically-encoded situations. Research can uncover structural features of linguistic understanding by identifying frequent structural primitives of these frames: consider the landmark-trajector structure in (92), the force-dynamic contrast in (93) vs. (94) and (95) vs. (96), and the spatial/geometric variations in (97)-(99):

- (92) Our house is across the lake.
- (93) I poured wine from a decanter.
- (94) Some wine spilled from the decanter.
- (95) I put spackle on the wall with a knife.
- (96) Paint spattered all over the wall after a can droppped.
- (97) There's a purple-and-blue color pattern all over the wall.
- (98) There are drawings all over the wall.
- (99) There's a plastic sheet all over the wall.

There are underlying perceptual gestalts which seem apparent in these examples, and their linguistic expression seems to take these as cognitive-perceptual primitives rather than grist for analysis (compare to a case like wanting the Leafs to win, when asked about the Jets (65, above)). This is consistent with the phenomenological intuition that consciousness includes a primordial structural awareness, and the role of intellect and attention is to focus on local regions of the whole structural cloth of experience, for enactive deliberateness and/or information extraction at a level of precision that "raw" exprience cannot provide. The important phenomenological contrast is not between "sense data", on the one hand, and intellectually filtered or reified world-apprehension, on the other; but rather between a structured cognitive-perceptual complex which we feel as *ambient* experience and, within that, an actively thematized attentional focal-region that we experience ourselves to be forcefully studying and interacting with.

For phenomenology, then, ambient "background experience" is already richly structured and is not really "pre-cognitive", because its structure evinces the "grammar" of cognitive frames. On the other hand, there are other intellectual traditions where "cognitive" carries more of a rational-analytic overtone. I suspect those who identify as Cognitive Linguists understand the word in a more phenomenological mien, whereas the AI and formal logic community places greater emphasis on how cognitive *systems* may be formally tractable. This can yield confusion in linguistics proper, where AI (at least in the sense of Natural Language Processing) and Cognitive Linguistics co-exist. One solution is to qualify "cognitive" in contexts where confusion could arise, e.g. "cognitive-perceptual" as a more phenomenological sense and "cognitive-analytic" as a more computational sense.

Not, however, that the re-occurance of "cognitive" in both terms is accidental: as suggested by the terminological pattern, I think we should see "cognitive-perceptual" and "cognitive-analytic" as part of a spectrum whose "axis" represents attention and dispositional structurality. That is to say, on the more cognitive-percepetual side we may be aware of structural details (cf. Vakarelov's "nomic patterns") but do not consciously attend to them, such that they remain latent as the manner of disclosure of sensate content: for example, the way in which a certain car appears as red is to appear as a metallic red hue with a glinting lighter patch following the length of the car. This perceptual complex has geometric structure — it is not an undifferentiated red-sensation — but I comport to such content specificity in a passive manner. Towards the other (cognitive-analytic) end of the spectrum, I deliberately seek out awareness of structural forms, analyzing them in relation to schemas and prototypes (consider a rock-climber planning how to scale a wall). Within this spectrum I think there are continuous gradations; and such a picture seems more phenomenologicaly well-motivated than a cognitive/pre-cognitive duality.

Concepts qua cognitive tools are influential across this spectrum. An architect analyzing the facade of a historic builing will experience its structure in greater detail and attention than a bystander who's meeting a friend in front of the building. The concept "facade" will nonetheless shape how both people make sense of their surroundings. The bystander may have a more passive acknowledgment that she is before the facade, compared to the architect (but it will nonetheless be part of her relatively deliberate attempt to coordinate with her friend's expectation that they meet in front of the building). Moreover, a child who had not yet learned the word "facade" would see the characteristics of buildings' exterior that fall under the concept, but more passively still. Merely learning the word presumably alters our perception of exteriors qua facades vs. "ordinary" exteriors, even if we are not currently using the word in any conversation — just as the word "hail" sharpens our perception to how hail differs from snow, since we have a compilations of beliefs specific to *hail* (apart from *snow*), and thinking (even if passively) that some precipitation is the former, not the latter, triggers us to activate those hail-specific beliefs. Another analogous case would be identifying milk as actually almond milk, or water as actually salt-water: the more granular our inventory of lexicalized concepts, the more precise becomes the package of prior knowledge we instinctively make on hand in the current situation.

Insofar as knowledge of the word reinforces the concept, we can assume the concept and our disposition to name it lexically is latent in situations where the concept *may* be relevant. Thus the friend might comment on the facade once they have met in front of the building: making explicit something that hitherto the parties, we assume, had just passively noticed. This is an example of the kind of unstated assumptions about others' beliefs that lie beneath explicit linguistic content: "I love this building's facade" presuposses both that the hearer sees the facade and understands the concept.

I use the "facade" example stratgically, to reference Martin Raubal's analysis of this word via Conceptual Space Theory [71]. Raubal proposes a "conceptual vector space" to distinguish *facades* from other spatial arrangements that (for instance) we might encounter outdoors in an urban setting. His apparent goal is to quantitatively model the terrain of "facade" in contrast to other, lexically related words, which would yield a basically mechanical, computationally tractable account of how to recognize a facade — perhaps for programming a robot, or a navigation tool for people, as he proposes.

Such potential applications trade on the possibility that we can reach beneath the nuance of language and uncover logically straightforward encodings of, or critriology for, concepts — not unlike my earlier idea of a genetic/vinological "CF" for "Cabernet Franc". Obviously, finding a logical matrix beneath the surface fluidity of language is an essential first step toward legitimate Natural Language Processing.

But trying to map an everyday (e.g., non-technical) concept to a readily-enumerated "feature vector" is not without problems, I think. Conceptual Space Theory is not the same as a prototype-based semantics, but it could share some of its problems when dealing with shape-shifting everyday concepts; the likes of *house* or *restaurant* or *water*. A prototype (or feature-vector) theory of *house* would need to unify mansions with hovels but exclude hotels, tents, apartments, apartment-buildings, and historical estates that have become museums. The criteria for "house" and "restaurant" seem mostly functional, although we are still aware in English of a conceptual incongruity in extending the concept on purely functional terms. We can acceptably use "house", really, for any place of residence — and restaurant for anywhere to buy prepared meals:

▾ (100) I'm going to a party at my brother's house (suppose he actually lives in an apartment).

▾ (101) This restaurant has the best Hokkien noodles (said of a stall in a Chinatown food court).

These feel (at least to my ears) like idiomatic expressions, however, as if we know not to casually overstretch the concepts. As I proposed earlier, our criteria for concept-mappings seems to be *mostly* functional but to incorporate spatial, configurational, visual, and natural-kind features also as *secondary* criteria. I would argue that a Conceptual Space model intuitively grounded on these latter features would supplement, rather than displace, a Conceptual Role theory (Conceptual Space Theory does account for functional roles, but arguably a little awkwardly).[2]

But setting this objection aside, we can defer to Raubal's analysis to the effect that a "conceptual vector space" can model our disposition to actively or passively identify concept-instances as such. Standing before a

[2]For instance, Raubal says that "Meanings of concepts change over time and depending on the context in which they are used. In a conceptual vector space it is possible to account for these changes by adding or deleting quality dimensions and by assigning different saliencies (as weights) to the existing dimensions" [71, p. 5]. For sure, our readiness to (continuing my example) accept "house" for any place of residence varies with context: the idiomatic usage in (100) is less proper in the contxt of real estate transactions, or assessing property tax (an available apartment should not be called a "house for sale"). But while "assigning different saliencies" may capture the relative weight of functional vs. more prototype-based classifications, attempts to quantify functional dimensions themselves as if they were, say, colors and spatial geometries — which do have convincing quantitative models (e.g. "red" on an HSV color pyramid) — strike me as forced and unpersuasive.

building, the proper synergy between properties of a a facade and my own mental "vector" of the colors, spatial arrangements, patterns, and so forth iconifying the idea "facade" — if the synergy resonates enough — primes me to know instinctively that the exterior is a facade, a pasive belief which could potentially be "activated" should that become relevant. One way this could happen is if a conversation partner says something about "this facade" — entering that referent in the "ledger" of dialogically salient things and topics.

So the efficacy of the concept lies not just in the reality available for us to peceive, nor in our minds, but in a synergy between reality-structures and activatable conceptual models. This kind of partial-but-not-total externalism is perhaps roughly what Vakarelov considers to be "precognitive": the phenomenon of our perceiving an exterior as a "facade" depends on both mental and extramental factors. Gärdenfors Conceptual Space Theory can be seen in this context as an attempt to imagine an "abstract geometry" to quantify (or to suggestively intimate the possibility of quantifying) the world-to-word fit that predetermines (and is witnessed by) well-founded conceptualizations. Gärdenfors's "geometry of thought" can accordingly be seen as an attempt to capture via quantitative intuition an insight Vakarelov's ITM broaches qualitatively: the idea that cognition is a structural *correlation* between the reality out there and what we're equipped to conceptualize.

Perhaps, then, Conceptual Space Theory is (or can be applied for) one example of a Vakarelov-style ITM. Raubal proposes conceptual vector spaces not just as theoretical explanantia but as technological artifacts; he envisions software employing these vectors as assistive technologies capable of some natural-language understanding. A computational system which properly activated the "facade" concept, let's say, given sufficiently proximate feature-vectors, would perhaps exemplify Vakarelov's idea of an "information system" that resembles human cognition, to some functional degree. The fact that such-and-such an environmental given resembles (in the conceptual-space-vector metric) a prototypical facade, or falls in the facade "region" (in a high-dimesnional concept-vector space), acts as a kind of input or signal. For Vakarelov, such quasi-cognitive (or actually cognitive, like the human mind) systems are organized in layers; it is consistent with his subsystem model to say that concept-vector metrics would be recognized by one subsystem, as "effectors", generating signals to be received by other subsystems. One such signal would be, say, a passive awareness that — based on distances in some feature vector — we are now standing before the facade of a building.

Another computational strategy for Conceptual Space Theory is suggested by Kenneth Holmqvist's chapter on "conceptual engineering" (mentioned by Raubal's paper I've cited, but also noteworthy as an unusual attempt to apply computational methods to Cognitive Linguistics). Whereas Raubal skirts around functional-role issues, Holmqvist acknowledges that functionality can be the decisive factor in conceptual frames. He cites the example of a knife, which can on the one hand be prototyped spatially and mereologically (e.g., the relative sizes of blade and handle and the knife's status as the sum of those parts), but also functionally — "Take the lexical unit *knife* as an example ... *blade* and *handle* are clearly parts of *knife* [which also] has *silverware* as a *whole*: *knife* is one of the parts in collections making up silverware. But *knife* can also have *cut* as a whole, because *knife* can be the agent ... of the cutting process" [38, p. 155]. As is clear, Holmqvist adopts mereology as a very broad domain of relations, representing different functional and aggregative connections as special cases of part/wholeness. But more significant is that Holmqvist (given this generality) is prepared to model a broad range of relationships — even if these can in principle be expressed mereologically (like a knife as part of a silverware set), we are not restricted to only visual or physical partonomies.

The parts of Holmqvist's analyses that are more perceptually grounded are also the more prototype-like. He comments, for instance, that "saying ... *blade* is part of *knife* is not sufficient. We must characterize this part-whole relation closer. For instance, the relative sizes of the blade and knife must not deviate outside certain limits. The relative spatial position of the blade and knife must also be correct, i.e., the blade must be correctly attached". This implies that the criteria for classifying something as a knife can be quantified, and regions on certain peceptual axes — say, the shape, length, and position of the handle and the blade — carve out (no pun intended) the conceptual space of *knife* from peer concepts like *sword*, *cleaver*, and *spatula*. Certainly such clusters of related lexemes suggest conceptual "terrains" that can be "mapped" — as in my earlier discussion of concept-mapping for water and milk — and Conceptual Space Theory draws on our intuition that such mappings are particularly elegant when there is a readily quantifiable system of dimensions that can be identified, like blade-length distinguishing knives from swords. Again, however, functional pragmatics, more than spatial form in itself, seems to dictate when and how we identify concept-instances with their concepts.

Holmqvist however recognizes this possibility by talking not only of perceptual part/wholes (like blade/knife) but of mereologies with more functional inflection, like a knife in a silverware set or as part of "cut" insofar as "cutting" something can be a perceptual-operational gestalt, whose "parts" are both the agent and patient of cutting. These more abstract mereologies find linguistic expression in cases like:

- (102) He had to cut the crusty bread with a serrated knife.
- (103) The museum had antique butter knives with intricate carvings.

The implied situational picture in each case is structured, in part, mereologically: a museum-piece knife potentially part of a valuable cutlery set; and when slicing bread with a serrated knife the knife is part of an enactive process. However, I'd say the functional position of the knives in these various situations is the key detail, over and above the partonomic significance of situational wholes. A butter knife rests in a different niche in culinary situations than a bread knife. Their roles are however similar enough that we can subsume them under a common knife-concept, although we can likewise distinguish them, *bread*-knife and *butter*-knife forming two sub-concepts.

We should highlight the functional roles because these dispose us to recognize the concept and the subconcepts. We reach for a butter knife if we want to butter bread; it is that practical goal which primes us to see the butter knife as a knife, in general, and a butter knife, in particular. Insofar as there is a synergy between our mind and our environment, manifest in the adequacy of concepts like "butter knife", this is primarily a matter of — in this case — the object conceptualized as a butter knife being suited for that task. Of course, part of the reason *why* it is so suited is how it is shaped and manufactured. Geometric and physical details are therefore relevant for our inclination to identify (butter) knives. Mostly, however, these details are derivative on functional roles, rather than the preeminent criteria of conceptualizations.

Having said that, an unused butter knife is still a butter knife. Table settings include butter knives so we can conveniently reach for one as needed. Our appreciation that we *might* need a butter knife, or how *some* diners might need one, and how they are used, informs our conceptualizing dispositions. It is true that perceptual details like color and shape provide visual cues to the nature of objects — partly because they need the design and material composition they have to perform their intended purpose. But we don't just troll sense-data looking for cues; our perceptual awareness is not a matter of decontextualized equations like "shiny and sharp means *knife*", "liquid and clear means *water*", etc. Our receptivity to concept-instances depends on our awareness of current situations. It's not like we are prepared to see examples of every kind of object that we are familiar with in every situation. We anticipate finding butter knives on a dining table, or in a kitchen. Situational awareness brings with it a selective anticipation — knowing what kinds of objects are likely to be associated with each situation prevents our having to devote excess thought to identifying objects, or misidentifying similar-looking ones.

So even if we accept features like color and shape as "triggers" for concept-recognition, our receptivity to these triggers is conditioned by situational understanding — which is an example of cognitive frames. These frames, moreover, are defined in terms of functional roles: the salient characteristic of a bread knife is the fact that it can cut bread, and the salient characteristic of a butter knife is the fact that it can spread butter. The situation provides the conceptual slots that objects can fit into.

There is, notwithstaning my suggestions to this point, a version of prototype theory which *is* broadly applicable. Situational understanding, we can say, *does* proceed from *situational* prototypes, so here is a domain where prototype theories are appropriate. Instead of a prototypical *knife* (or house, restaurant, corkscrew, etc.), I think we have *prototypical situations* where knives (etc.) play a role. Any particular knife is conceptualized against such a background: one kind of scenario is someone at the head of the table ceremonially carving a roast, wherein the knife is a "carving knife"; another scenario is someone spreading butter, wherein it is a "butter knife"; etc. Each situation-prototype is an architecture of roles, where for instance there is a person enacting the carving ritual, the instrument she uses, the food being carved, and so on. The building-blocks of these architectures then become solicited within language, for instance via case-markers like benefactive, locative, patientive: "carving *the turkey* for *grandma* with *the knife* at *the counter*".

In practice, our sensitivity to functional roles allows for ad-hoc practical configurations, like using a hammer as a bottle-opener. To the degree that situation-prototypes are *abstract* models, we nonetheless have narrower appraisals of functional roles: the lexeme "bottle opener" covers objects playing that role in *prototypical* situations, which is why it does not cover hammers. This is one reason why we should accept conceptual-role talk as more parsimonious than functional-role talk: conceptual roles *are* functional roles, but tapered down by the prototypicality of situations abstractly conceived.

In practical affairs, of course, we comport to real situations — that may embody situational prototypes, but no real context, with its idiosyncratic details, is entirely prototypical. This concreteness has a pair of distinct implications for my current analysis. First, we accept localized expansions of conceptual roles, like bottle-opener-to-corskcrew or even -to-hammer. Second, conceptual roles offer templates that allow cognitive-perceptual judgments to be passive or instinctive — we reach for a butter knife without being aware of concluding that said instrument is a butter knife, or even really being aware of knowing that a butter knife is there.

So the practical purpose of curating a "library" of conceptual-role accounts is to prime us, given each situation, to identify objects fulfilling conceptual roles *passively*, as part of unattended, background consciousness. Once we become aware of specific enactive needs — the thought that we need a knife or a corkscrew, part of some practical task being now phenomenologically active, a focus of attention — the more passive perceptual details (like a knife's shape and color) are poised to trigger more active conceptual recognition. Now we become consciously aware of the butter knife nearby, and of picking it up and using it.

Perceptual details can certainly be triggers of conceptual recognition, but a complex interleave of situational awareness, situational prototypes, pre-learned conceptual roles, and moment-to-moment enactive needs and processes, all establish an infrastructure within which perceptual content can actually "trigger" determinate conceptualizations. Most of this activity is prelinguistic — it establishes a cognitive baseline that language builds off of. But there is enough commonality between different persons' situational models that we can understand how these cognitive processes are working for other people, and therefore can draft them into the circle of language: if we, holding a slice of bread, ask someone for a butter-knife, we trust they will instinctively grasp both my enactive requirements and have the cognitive resources to help achieve them.

In sum, our ability to convert passive situational awareness and "background consciousness" perception, mediated hy situation-prototypes, into active cognitive-perceptual conceptualizations and pragmatic representations (of the "here's a butter knife I can use" variety) is itself, in total, a cognitive system which can be *targeted* by language, however much it is itself prelinguistic. That analysis, if it holds water, would make language an *interface* to the aforementioned cognitive system. Under that interpretation, my reading, originating in Conceptual Space Theory and then pivoting to Conceptual Roles, also presents as a flavor of ITM. I envision this hybird theory as a kind of synthesis of Conceptual Space Theory, Conceptual Role Semantics, and (at least some variation on) Vakarelov's Interface Theory of Meaning.

Situational awareness, and situationally-mediated object recognition and associated conceptualizations, are highly subtle and multifacted cognitive faculties — especially in our purposeful, socially normative, often emotionally charged human world. Some aspects of this overall architecture may be interestingly modeled or emulated with computers. Examples include Raubal's and Holmqvist's implementations based on Conceptual Spaces, or Holmqvist's approach also intended to present computational models of Langacker-style Cognitive Linguistics, a goal shared by some other work, like Matt Selway's [79]. To this we could add certain models embraced by phenomenologists like Barry Smith and his collaborators (notably [13]) and Jean Petitot. I am skeptical that computer implementations will ever achieve more than a rough approximation of human enaction or language understanding — valuable perhaps as a research case-study and for specific useful tools, but nothing like robotic substitutes for human bodies and minds. But computer tools can still play an important role in research, by giving formal outlines to cognitive architectures which appear to have some formal dynamics, even if the raw materials of cognition — like sensation, situational awareness, and empathy — may not be formally tractable.

4.2 *The Chinese Room Revisited*

John Searle's "Chinese Room" argument — about someone who behaves like he understands Chinse by matching characters to responses from a vast table — is often understood as claiming that "symbol processing" by itself can never produce real understanding, which is *semantic* and *conceptual*. Modern technology makes this thought-experiment less hypothtical: automated telephone systems often use a template mechanism that is practically like Searle's Chinese Room, understanding a limited range of sentencs and producing a limited range of responss. But there are two different kinds of questions we can ask in relation to Searle's argument: some more philosophical and some more practical.

On the philosophical side, we should properly assess the important questions as being qualitative and not quantitative: it's not as if a synthesized phone system is just not a very *good* conervsationalist; it's that a software machine simply isn't the *kind of thing* that we can say actually understands language. This is plausible if we say that emotions and empathy are intrinsic to language; that we can't properly understand language if we do not grasp the emotions residing behind expressions. Indeed, as the case of Grandma's window shows, our status as comptent interlopers depends on reading intentions behind expressions, and it sems hard to do this if we can't experientially empathize with our linguistic partners.

Maybe we are now just pushing the important questions back to reappear: Ok, can computers be programmed to feel emotions? Is there a meaningful distinction between meaningfully, experientially having emotions and just behaving as if you hav them? Are emotions themselves somehow functionalizable apart from their chemical/hormonal substrate so that systems with very different physical realization than ours be said to have emotions? I can see how this dbate can go different ways. But I'd also argue that any ell-organized dialog about these questions will be only tangentially about language — in which case, neither linguistics nor philosophy of language themselves can answer questions about what kind of systems (on metaphysical criteria) actually "do" language. That would imply that affirming a computer's linguistic capabilities as *real* linguistic understanding is a disciplinary non-sequitor for linguistics proper. Nothing in the linguist's arsenal either dmeonstrates or depends on AI agents actually *being* part of our linguistic community or just mimicking language-use to some (sometimes helpful) degree.

The more practical questions raised by Searle's Chinese Room come into play to the degree that the philosophical trail I just sketched turns many analyses into a non-starter. Consider these two questions to a hypothetical automated telephone service:

- (104) What time does the office open?
- (105) What time does train 100 depart from Newark?

While we can see a template holding canned responses for both cases, (105) needs to do more than just fit the input to the nearest pattern; it has to pull out the dynamically variant details (train *100* from *Newark*) and use those to fill in details in the response. This is something like *parsing* the original question. So we can add bits and pieces of genuine linguistic processing to a minimal response-template system — a real version of what Searle appeared to imagine in the Room. With enough added features the primitive template-driven kernel can evolve into a complex AI-powered Natural Language Processor.

In that case we may imagine that "language understanding" exists on a spectrum. The primitive telephone service and an erudite bard may lie on opposite ends of a spectrum, but they share a spectrum between them. In this case, their differences are quantitative more than qualitative. The bard just has more *features* we associate with total linguistic behavior.

However, this quantitative view still leaves open the question of where among the "features" do we have something that actually drives language competence? Searle's Chinese Room helps point out these questions: it's reasonable to say that the simplest template-response system does not really understand language at all, since it is a pattern-matching system that does not have any structural relation to language itself. Analogous capabilities can be developed for a system which matches any kind of input to a pattern directing an output, based on any metric of similarity. The patterning reflects an actual *linguistic* parse only insofar as it selects elements via syntactic criteria, like grasping the non-template variables as *100* and *Newark*. So, even if the holistic behavior different systems lies on a linguistic-competence sclae, not all *parts* of the system seem to bear the weight of actually *realizing* linguistic competence equally.

One reading of the Chinese Room is that *no* part of a system is truly linguistic. This includes the argument that holistically the Chinese Room *does* speak Chinese: Searle's discussion suggests that no *part* understands Chinese, but if we can imagine the entire room as a single system this "entity" can be treated as a fluent Chinese speaker. Even if we reject that analysis, we could agree that, even among humans, *parts* of our language system arguably do not understand language: not nerve cells, not neural clustes for auditory processing, or sytax, or conceptualization, etc. It is us, the whole system, that uses language. The reason why "holistic" claims that "the entire room" speaks Chinese sound dubious may not be because something is *structurally* lacking in that whole system, but because it's not the kind of whole system — with one body, one consciousness, one personhood — that we think of as a conversant.

Those who find Searle's analysis compelling probably believe that there *is* some meaningful difference between us (or at least people fluent in Chinese) and the Chinese Room. A further alternative, however, is that *we* are not language-usrs, at least not in the way we think we are. This claim can be expounded as follows: the philosophy of language, interactively with linguistics, seems to be looking for some essntial kernel of linguistic capability that distinguishes us from AI engines or template-response system. That is, AI-skeptics want to sift through all the models of processes within languages, the central domains in linguistics, and find the few genreas of linguistic processing that are unique to human language — and computationally intractable. These would be the smoking gun evidnce that no artifical system can equate to human language-use because there is some essential stage in the linguistic pipeline that computers computationally can't realize.

However, even if we accept premises that the Chinese Room case suggests this analysis and moreover it agrees with our underlying intuitions, there remains the possibility that computers are indeed lacking some stage associated with language — but it is not a *linguistic* stage. If something like an Interface Theory of Meaning is correct, all linguistic processing is intermediary to some other cognitive layer: and perhaps the human quintessence lies on the far side, so it both limits what computers can linguistically achieve and lies outside of linguistics proper.

4.3 *Distinguishing Computational Models From AI*

I contend we need to tease apart the pursuit of valuable computational tools and models from an (often reductionistic) paradigm of seeking artifical, computationally engineered replicas of human cognition. *Computational* does not have to equal *AI* [100].

Holmqvist's and Selway's research that I have cited are good examples of paradigm-overlap between cognitive and computational linguistics. I will cite other scholarship which also finds philosophical inspiration in cognitive linguists like Langacker, Gärdensfors, George Lakoff, and Eleanor Rosch, but which also target cognitive-science formalizations and "cognitive architecture": [52], [101], [44], etc. A recurring pattern in this scholarship is to *first* propose a structural intermediate representation — a model of intellectual structures which plausibly embody the processing of language and cognitive-perceptual content, partly abstracted from surface-level sensory or signifying details — and *second* propose algorithmic or software models of how our minds translate linguistic and perceptual givens to abstract, or partly-abstract, schema.

I have argued that we bring abstract situational prototypes to bear on understanding all of the world and social situations around us, and that language taps into these models so that people can coordinate situation-appropriate activity. Given that there is an abstract and scehmatic dimension to how we understand situations, we should expect a partially abstract sheen to how we intellectually engage objects and concepts once they are situationally "located". Having identified objects as butter or carving knives, pitchers or glasses of water, wine or beer bottles, corkscrews and bottle openers — identifications themselves mediated by situational awareness, viz. if we are hosting or attending a dinner party — we no longer often attend actively to sense-perceptual minutiae. Our mental map of our surroundings — there's the corkscrew, there's the carving knife — pulls these referents outside the register of sensate consciousness and into the pragmatic hum of worldly activity. Insofar as they nestle in our intellectual faculties in that semi-abstract state, it seems fair to capture the schematic, structural appearance they have in this intellectual register — phenomena without the full-cloth phenomenology.

This in turn seems to invite us to imagine how the structural essentials of such "pragmatic appearance" may be captured by computers. We do not need to endow computers with human consciousness or emotions, because our mental traffic with the corkscrew or carving knife at some point evolves outside the sensate and passionate fabric of momentary consciousness. There is a schematic and mechanical dimnsion of human action, and we can imagine computers simulating human intelligence at least on *that* theatrical level.

Or at least, such seems to be the intuition behind attemps to model our human representations of objects and concepts in terms of abstract structures. But even a feasible theory of these semi-abstract layers of cognitive processing is only half the story. Suppose we agree that there are legitimate cognitive insights in Holmqvist's model of cognitive frames, incorporating (but also extending, including in a more pragmatist direction) Conceptual Space Theory — employing a generalized mereology that renders objects and concepts as *parts* of situations (I have suggested a more conceptual-role account for analogous phenomena). Suppose also we find plausible cognitive-frame models in Selway's intermediate representation for natural language, via which his proposed implementation can potentially map natural language to formal specifications. In these cases we have potentially valuable Intermediate Representations which capture cognition, in effect, mid-stream, or in-the-act: neither conscious phenomenology nor neurophysical hardware.

However, Holmqvist's and Selways' work appears to operate in an environment where these Intermediate Representations are valued primarily because and insofar as they allow human cognition to be mechanically recapitulated. This of course demands not only that compuers *represent* IR models, but also *create* them — that is, when presented with an artifact of natural language, or the visual data of a scene, that computers should *automatically* map these givens to the theorized IR models, as if retracing the steps of human intelligence.

But just because IR models can be given computational form and representations, it does not automatically follow that automated generation of IRs is possible or effective. We can and should thereby distinguish the computational *study* of cognitive Intermediate Representation from the AI vision of programming computers not just to *host* but to *derive* Intermediate Representations. For instance, given a theory of the correct model for parsed Natural Language sentences, we can use computers to *study* and *present* parses — but this is separate from attempting to program computers to parse NL samples to such models on their own, without human intervention. I am sympathetic to the former methodology but skeptical of the latter.

I also believe that most research in, e.g., computational linguistics, ends up conflating those two goals. In that case, IR models are judged based on whether they facilitate automated, AI-driven generation of IR, not on whether the IRs are insightful suggestions of how human cognition itself builds an intermediary cognitive register — paricularly if we accept Vakarelov's overall picture of language as an interface between speech-givens and prelinguistic cognitive faculties. Interface theories and Intermediate Representations tend to go together — the IR is the representation of some input during intermediate processing yielding an output; a structure between two other structures, where the role of the interface is to bridge the structures as well as to activate the correct capabilities via the output. This is the architecture of an "interface theory", in science or computer programming; it carries over to linguistics if we take Vakarelov's ITM seriously.

An equally intrinsic aspect of interface theories, however, is that the processes operative at the intermediate level are theoretically distinct from the realms which the interface bridges. For example, the theory of programming-language compilers and runtimes is distinct both from the theory of programming-language parsers and specifications, and from the theory of CPU architecture and system-kernel development. Runtime engineers can work through the medium of IR models, and compiler design itself is split between parsing surface-level source code *to* IR and mapping IR structures to their proper runtime paths of execution. It would be a breach of design architecture to attempt to solve source-to-IR problems within modules devoted to IR-to-runtime engineering.

Unfortunately, I get the sense that AI research does not respect a comparably disciplined Separation Of Concerns. There are multiple parts to a typical AI platform — modules for representing information (or knowledge/facts/beliefs, or the state of the system's physical or digital environs, etc.); for populating these representations with data deliberately introduced by human users or absorbed via some real-time engineering from the outside world; for analyzing representations to glean insights or calculate a course of action. Individual parts of the overall architecture can evince noteworthy engineering achievements, separate from the goals of the overall system. In this sense the pursuit of AI can yield positive contributions in other branches of computer science and other disciplines, without the stated rationale of AI realizing (and monetizing) systems that exhibit humanlike intelligence.

So perhaps "AI" is best understood as shorthand for a suite of research agendas across several aspects of computer science, not restricted to the fields — like Machine Learning, Robotics, and Artificial Neural Networks — that are publicly associated with the term. This is not, however, how AI seems to be represented by companies and institutions (including in academia) who have a vested interest in the products AI may yield. A benevolent reading would be that institutions understand the diversity of research that can be loosely aggregated under the AI umbrealla, but use the particularly science-fictional facets of this science to excite public support: visions of humanoid conversationalists and robots provide a compact story that is more meaningful to non-experts than technical outlines of the intermediate machinery beneath the hopefully-intelligent surface. However, a more cynical interpretation is that AI is valued as a cash cow, and residual disciplines which contribute to the engineering infrastructure that AI requires — but are agnostic as to the AI vision itself — are appreciated only so much as needed to keep the AI project moving forward. On that interpretation support for AI-agnostic research becomes lukewarm and transactional, and actual innovation in such areas may not be properly celebrated.

Whatver the reality, the technological infrastructure affording support for cognitive science/linguistics, or cognitive humanities/phenomenology, and so forth, is led by frameworks that seem to fall into one of two categories. On the one hand, there are "Cognitive AI" projects that realize different theortical/proposed models of mental architecture as software systems, emulating our rational behaviors — Natural Language Processing, classification, judging similarity, optimizing problem-solving, and so on — to various degrees; simulative success or failure then becomes a litmus test for warranting or revising the implemented theory of intlligence. In the domain of linguistics, these projects serve as a paradigmatic complement (and sometimes testing-ground) for thories of how linguistic processes are computationally tractable.

On the other hand, there are technologies that fall under the rubrick of "proof assistants", like Coq and Agda, which allow programmers to specify data structures with mathematical precision and potentially prove structural properties. Such technologies have computational models and type theories which overlap with general-purpose programming languages, like Haskell and Idris, and in that guise serve as linguistic research tools. That is, linguists have used tools like Coq directly or have achieved comparably rigorous analyses by developing linguistic models in rigorous languages like Haskell (representative are [6] and [47], respectively). These applications trade on the parable of language as *formal system*, and allow theories of *what* formal structures actually apply to language to be tested in environments well-established in other formal sciences, like mathematics and systems engineering.

In the specific context of linguistics, these two groups of technologies — AI platforms, and proof-assistants (or modeling frameworks in mathematically inspired programming languages) — reflect *computational* and *formal* analogies respectively: language *qua* computational or *qua* formal system. This generalizes to other applications buttressing cognitive science: most concrete technology deployed in a research-oriented context projects either or both of these analogy/paradigms.

I believe that both analogies are flawed, although they may have value as indirect, theortically productive models for *parts* of language and human intelligence. I think there are several theoretical frameworks, with at least partial realization in computational settings, that *do* avoid the reductive ideologies of bpth formalism and computationalism which yielding rigorous technological models: Barry Smith and colleagues' Granular Partition models [13], David Spivak's "Ologs" ("Ontology Logs") [89], Conceptual Space Markup Language [3], or the "Image-Schema Language" described in [4]. But in general there is a lack of adequate tooling which embraces *computational* representations of cognitive processes — for example, models of Intermediate Representations and Interface Theories — while simultaneously, mostly, rejecting both the formal and the computational metaphors. How this absence of "non-AI computational" projects may be explained, and what such projects might look like, is a question that will inform my discussions in the next section and then Section 7.

5 Phenomenology, AI, and Holism

As I suggested last section, we need to distinguish computational models of *aspects* of cognitive systems from AI-driven paradigms about intelligence as a holistic reality. I called for "non-AI computational platforms": theories or concrete tools to study, in a computational spirit, *parts* of intelligent (e.g., linguistic) behavior while rejecting formal or computational metaphors for *holistic* cognition. The proper role for cognitive-computational theories, I would argue, is as *local* analyses, targeting subsystems or parts thereof, remaining agnostic to overarching claims about the AI tractability or realizability of "mind" in total.

This is indeed how a lot of practical AI works: developers do not try to emulate all of human intelligence, but to implement practical tools with intelligent behavior in some narrow domain, like facial recognition or medical diagnosis.

However, philosophers and many linguists and computer scientists appear to move beyond this "limited" AI. This may be for reasons even phenomenologists can sympathize with: pursuing AI research solely in predictable, circumscribed fields like medicine and transportation may seem to reduce human intelligence to a suite of problem-solving rituals: here's the system we use to drive a car; here's what we use to identify a familiar face. To counter that reductive instinct, researchers embrace something like an "Artificial General Intelligence" which recognizes how distinct rational abilities have to be holistically woven together to create truly humanlike intelligence. As I have intimated, I think this leads any cognitive-computational research into something like an Interface Theory, where the "meaning" of cognitive systems lies in their interaction with other systems, not just their local structural properties.

However, projecting AI paradigms up to the "holistic" reaches of consciousness threatens to be equally reductive, I believe, as a platform of "limited" or domain-specific AI achievements. The proper paradigm is something like cognitive-computational models theorized as local, subsystem-level structures. But there are a couple of reasons why AI sympathizers may struggle against the limitations of that notion of computationality. Both of these issues I have addressed already in this paper to some extent.

The first issue is that an Interface Theory is a theory of *local structures*, and it can be hard to reconcile such "localness" with logico-mathematical or truth-theoretic intuitions. Recall Vakarelov's critique of both externalist and internalist analyses of a concept like "chair": as he argues, it is problemmatic *either* to assume that this concept is an intramental entity that encapsulates in some useful ways ideas and beliefs about chairs; *or* to assume it is some extramental correlation between our conceptual attitudes (e.g., our inclination to classify things as chairs) and external reality. Both these accounts are flawed because they seem to start from some logically ordered picture of "chairness" — in Vakarelov's words quoted above, "some fact in the world that the object depicted by the indexical has the property of chairhood". Whether the logical "picture" is sited in the mind, or as a Platonic given latent in the world-order — chair qua *universal* — which we mentally reach out to, the *meaning* of the concept is still figured as a kind of logical frame or combination, something like a logical "theory" of what chairs are and how they act. But this picture seems to discredit the polymorphic and partial nature of cognitive *subsystems* on a subsystem-oriented model.

The concept *chair* — or, reprising one of my earlier discussions, *glass of water* — and their concrete instances, lie at the nexus between multiple systems (perceptual, kinaesthetic/enactive, linguistic, intersubjective). The concept itself is like a quantum of conceptualization that gets passed from system to system, but at no one point in its trajectory do we necessarily have a neat logical model of "chairhood" or glass-of-water-ness set forth in a propositional or semantic-frame manner. In other words, *chair* and *glass of water* do not directly map to a *logical frame* internally in any one subsystem — not perceptual, where we would attend to visual and sensory qualities rather than pragmatic considerations that would be intrinsic to a useful "frame" for the concept; not kinaesthetic-enactive, where we would be focused on motor-operational gestures to do things like drink from a glass; not intersubjective, where we would attend to how functional affordances of chairs and glasses intersect with others' wishes. Nor linguistic, because conversation about chairs and glasses can touch on any of these registers (even raw perceptual; consider discussions about a glass's artistic coloring). In short, at no one *local* (sub)system as the glass- or chair-concept traverses different cognitive registers does the "logical", or *semantic frame* model of the concepts actually operate as a local structure. This, I have argued, is analogous to the partiality of information during the implementation of software systms, especially at the intermediate level; for example, the ambiguity as to whether a call to open a file has suceeded or failed (see 61).

At most, a logical, semantic-frame-like account of everyday concepts emerges from the interplay of different subsystems: I don't dispute that at some holistic level we comport to a chair or a glass of water as if we have some structured, and mostly logically sound, background beliefs and dispositions which act in effect like a *logical frame*, encapsulating the logical coherence of the respective concepts. However, to the degree that this frame has explanatory place in analyses of cognition, it is not directly thematized in any concrete, operational register where cognitive processes actually occur. It is more like a phantom hovering behind local structures, like drunkeness is a phenomenal gestalt hovering behind biochemical events whose macro-scale existence is what we would call someone being drunk.

There is nothing wrong with pursuing logical semantic-frame models in this sense, or appreciating them as emrgent rationalities binding the fabric of consciousness. But, at that holistic level, we are treating these rationalities as philosophical doxa, not as computable or logico-mathematical systems. An Interface Theory would instead compel us to analyze the *formal* and *computational* structures in cognition as "local" subsystem structures, where emergent ratioanlity is only on the philosophical horizon. These may be on reason why ITM-like paradigms may conflict with AI-influenced — or even Analytic Philosophy influenced — linguistic or cognitive-scientific intuitions.

The second possible intuition conflict is the "Artificial General Intelligence" paradigm where AI formalisms are projected from local subsystem structures to the holistic, integrative terrain of consciousness or intelligence on the highest, most lived scales. On this intuition, as I claimed at the end of last section, "local" subsystem models become valued primarily in terms of how they enable overall platforms — like language-processing engines designed to mimic human behavior. Taking such a stance toward localized models can potentially both overestimate the prospects of holistic AI and underestimate the value of localized models which have emerged in AI contexts (some of which, like Link Grammar and hypergraph data representations, I will mention later in this section).

This situation is not irrelevant to either linguistics or to Cognitive Phenomenology. In Computational Linguistics, for example, linguistic IR models seem to be valued based on their utility in AI-driven Natural Language Processing. This presents a disciplinary bifurcation, where potential computational models are *either* connoted rather informally as part of a thoretical investigation among linguists (or philosophers of language, etc.), *or* concretely implemented, in some kind of software package, but then measured as components in a Natural Language Processing system: assessed on the basis of how the system overall approximates human language understanding via artifical means. Another genre of formal models, such as the type- or monadic theories I have alluded to here, may also have potential software incarnations but tend to be developed instead in a mathematical style, effectively "programming" in the abstract space of theorems and syllogisms rather than actual compuers. Each of these methodologies skirt around the potential intermediary tie: concrete computational systems that are designed as exemplifications of semantic, grammmatical, or pragmatic theories, presented as hands-on software to anchor theoretical discussion but also intended as tools to advance the human study of language, rather than as steps toward synthetic avatars.

At the same time, there is another side to the story:

software implementations offer a focal center for research, something tangible that scholars can experiment and collaborate on. The AI story provides a target goal; it helps developers understand the local, technical code they are working on by connecting it to a larger system. Whatever philosophical objection one may have to AI initiatives, we should recognize the value of expanding academic and institutional practice beyond just writing and reading research papers. Insofar as part of one's scholarly modus operandi can include writing computer code, and studying code repositories developed by others, we can benefit from a hands-on, even trial-and-error kind of experimentation.

In effect: software which can be given concrete tasks — if it does *this* properly (whatever *this* is), then there is some larger thoretical point that is demonstrated — and then, incrementally, evolves to realize those tasks, provides a distinct form of intellectual engagement. We get *that* to work, then *that*, then fix *that*. This kind of "code-and-fix" cycle is quicker than conventional research, especially in the humanities, where the routines of authorship and publication and conferences can feel like they are unfolding in slow motion.

Perhaps for this reason, some of the most interesting cognitive models have come from computational and academic environemnts informed by ambitious "Artificial General Intelligence" programmes, like Carnegie Melon University's OpenCog, and the "LMNtal" project at Waseda University in Tokyo. These projects both employ formal-semantically expressive, hypergraph-oriented data systems that embody both the structural and procedural dimensions of computer systems — manifesting theories of both the execution of computational processes and the representation of formalized information. These are important models even outside the Artificial General Intelligence ideology.

In fact, these are models which in linguistics and phenomenology may deserve more attention than Artificial General Intelligence *qua* philosophy. But we should not discredit the role that Artificial General Intelligence may provide as a kind of intellectual compass helping scholars and engineers reason through the interstitial machinery which may in fact be more real than the philosophical vision, but also less effective as theoretical *vie ferrate*. Metaphors can triangulate research whereas analogies guide transfers of theories or methods between fields — i.e., analogies are more trustworthy landmarks than metaphors for surveying the envisioned future of a science — but metaphors can still be intuitive guides; maybe AI and Artificial General Intelligence can stabilize into our overall science and philosophy as a modest but suggestive metaphor.

So I have no desire to lob critiques at Artificial General Intelligence inspired projects in their role as unifying research communities, and I want to list certain computational models that emanate from AI research as valuable tools applicable to many (including non-AI) areas. However, I *do* believe that AI's integrative and holistic vision would be more persuasive if it seemed less reductionistic as a vision of *total* human intelligence, and was historically grounded in the phenomenological rather than Analytic track of 20th-century philosophy. Insofar as Analytic Philosophy exerted a greater influence on mathematics, computer science, and formal linguistics than "Continental" thought — including phenomenology — the legacy of this influence can clearly be traced in AI research. Now that some scholars in the phenomenological tradition are considering a reconciliation or methodological hybrid with Analytic Philosophy, what does this imply for, say, AI, computational linguistics, and other cognitive-computational sciences?

5.1 *Phenomenology and the Limits of Formalization*

Considering how Analytic and Continental Philosophy has diverged, it is easy to forget that the early mature works of Husserl — arguably the root stock of 20th-century "Continental" thought — emerged from the same circle of logico-mathematical questions and evolutions as the ideas of Frege, Russerl, Wittgenstein, et. al. that would evolve into "Analytic Philosophy". Nor is it necessarily true that analytic philosophers have remained closer in spirit to the unfolding horizons of mathematical knowledge in the 20th century.

The perpetuation of 20th-century philosophical tropes — Analytic vs. Continental Philosophy; humanities vs. logicao-mathematics — perhaps diagnoss something incomplete in 20th century thought that the 21st century needs to transcend, but it also bears witness to intellectual structures that directly abut phenomenology itself.

The idea, for example, that logico-mathematical analysis is distinct from cultural-humanities theory — that works of art, for example, do not have logical or mathematical forms; that the structures evinced by cultural and artistic productions (and any system of signs and communication necessarily has *some* rigorous structure) does not itself have a logical and mathematical dimension, or a structural form that if specified in isolation from its signifying context would reveal logical and/or mathematical properties. A parallel assumption is that logical and mathematical structures need to be expressed —and indeed *located* — via a few canonical theories, such as first-order predicate logic, first-order quantification, and (perhaps modally inflected) set theory. So 20th-century Analytic Philosophy unfolded in a kind of semi-explicit dialog with disciplines such as linguistics and computer science which promoted, from the full spectrum of mathematical domains, a handful of specific paradigms — like Zermelo-Frankel Set Theory, Tarskian quantificational-predicate logic, and Hindley-Milner type theory — that in turn became equally paradigmatic in fields like formal language analysis and "knowledge enginering". This is not to imply that linguists and computer scientists took their marching orders from philsophers — it's probably equally true that Analytic Philosphers gravitated to these kinds of mathematical frameworks because they were proving empircally useful in other fields. But we can say that a group of disciplines aiming to technically examine subjects at the intersection between human thought and formal systems — language, knowledge, valid inference, Artificial Intelligence — collectively progressed toward a vision of what logicomathematical structure *is*, a paradigm (or network of paradigms) which undergirds any reception of phenomenology insofar as a "Naturalizing Phenomenology" project seeks to initiate dialog and comparisons between how phenomenology and Analytic Philosophy, respectively, treat logic, mathematics, or formal-systematic explanations in general.

Interestingly, the logico-mathematical formulations that arguably have come to dominate methodology on the scholarly *frontier* between science and humanities — lingustics, cognitive science, computer science — are different from those that seem to dominate mathematics and physical sciences themselves. Of course, some logical form is intrinsic to any formal method since formal systems cannot be blatantly self-contradictory. But the vehicles by which criteria of logical consistency are expressed in, say, linguistics and philosophy — presenting sentence-meaning via first-order logical glosses of their predicate (locutionary, assertorial) semantics, for instance, or equating meanings to the conditions in the world (or possible worlds) that would make linguistic expressions true — these first-order and set-theoretic intuitions do not necessarily coincide with working mathematicians' visualization of the spaces where their own axioms and formulae are in force. Category theory, for example, recognizes that set and predicate logic are in a sense emergent properties of the different formal domains where mathematics is enacted — sheaves, topoi, manifolds, sites, and so on — which are not isomorphic, propagating to variation in how logic itself is understood. Insofar as there is no single formalization to specify what a *predicate* is, or a *set*, we are on shakier foundation if we want to apply these notions to conceptual or linguistic investigations — to consolidate the concept "cat", say, as the set of all *felix catus*, or the meaning of *Hugo is sleeping on the sofa* as a particular state of affairs pertaining wherein a certain tabby cat sleeps on a certain piece of furniture. The problem with this sort of logico-mathematical gloss is that it either employs sets and predicates in an informal manner — which brings us back to the circularity problems I analyzed earlier, since an honest assertion that Hugo is sleeping on the sofa obvious intends to report, modulo the imperfections of informal logic, that as a point of fact Hugo is sleeping on the sofa — or it tries to elevate the logic from informal to formal, which legitimately then adds explanatory value to our technical grasp of the sentence, but then we get tangled in questions like what *sets* are.

To put it differently, it certainly seems as if the sentence "Hugo is sleeping on the sofa", as an intended and sensed artifact in a human world, in some fashion encapsulates and *designates* a proposition, and/or the state of affairs, that this tabby cat is in repose on that piece of furniture. The sentence (deliberately produced sound patterns, perhaps) provides us with mental access or handle to that proposition, making it an unitary and isolated object of thought, as well as a thought that can be shared between people via language. There is a predicate there that seems to be *intended* in the phenomenological sense by the sentence as a linguistic gestalt, just as Hugo is intended in our visual consciousness when we explicitly see him on the couch, or at least analogous to that regime of intentionality insofst as Husserl finds both parallels and contrasts between *apophantic* and perceptual-integrative analysis. That is, the predicate or fact of Hugo's sleeping at that spot is the noema to the sentence's phenomena, just as Hugo is the noema to our seeing-Hugo. In this sense it is non-circular to proceed with "Hugo is sleeping on the sofa" to mean the fact of Hugo's sleeping on the sofa, since we are exploiting the seemingly reundant repetition of the sentence to designate indirectly a predicate which we have no way of expressing except through the sentence. So there is *something* there that seems to have a logical form we need (at least if our goal is theoretical completeness) to cast light on.

But when we then pass from informal to formal logic we encounter the gap separating mathematics circa 2019 from mathematics circa 1919. Hugo, for example, is a cat, which (in the precincts of informal logic, i.e. a logic solid enough to shape communication and coordinations of thought but backgrounded as only one of many structural parameters delimiting how thoughts and the world avolves) means that Hugo is a member of the set of all cats. But what is a set? Garfield (a fictional, comic-strip cat) is also a cat but he does not "exist", so the set of all cats cannot be enumerated just by (even as a mental exercise) pointing to them one-by-one. Moreover, what is referenced by the word or idea "Hugo" in the thought that Hugo belongs to the set of cats? We can look at and point to Hugo to get a rough idea; but the fur Hugo just shed is not a member of the set of cats, even though it is (or was) a part of Hugo. It is by no means obvious that we can, even as another mental exercise, define "Hugo" by an enumeration (metaphysically possible even if logistically infeasible) of hairs, or cells or molecules, that via mereological summation grounds the name in a logically well-established referential framework.

On course, it is possible to logically restate a sentence like "Hugo, who is a cat, sleeps on the couch" in first-order logic, which seems to be arriving at a formal exposition of the predicate informally intended by the sentence — the noema to the sentence's phenomena. But formal machinery only papers over the logical incompleteness of concepts like "set" and "predicate": a logical denotation of the sentence *seems* to refer to the state of affairs that the sentence tokens (and not just the sentence itself) via quantifier symbols and other logic artifacts. I'd argue, however, that these elements are meta-discursive cues rather than theoretical posits: they invite us to entertain the thought of the predicate lurking beyond the sentence via a departure from discursive norms, the same way that simply repeating the sentence does. In short, it may be non-circular to gloss "Hugo, who is a cat, sleeps on the couch" via formations like $\exists X : Hugo(X) \wedge Cat(X) \wedge Sleeps(X, on - the - couch)$ and the logical form gets us closer to apprehending the abstract predicate, but this is not because of logical symbols like "$\exists$" in themselves, but because of their rhetorical effects as interrupting the flow of conventional philosophical writing. Symbols of quantification, set membership, or part/whole inclusion only carry the imprimateur of logical rigor insofar as we can synchronize what flavor of mathematics we are using with which to theorize quantification or parthood.

We can, for example, argue that Hugo is an extended three-dimensional thing (or maybe a four-dimensional perdurant, since he's still here day after day), and any reasonably compact and continuous n-dimensional manifold can potentially be designated in thought and language. This is reasonable, but it positions our infrastructure for the semantics of proper names (and a large class of referring expressions) against a topological backdrop in which we can talk about sets of points, or perhaps regions spanned by extremum points (Hugo's fur as the convex hull of Hugo's solid mass) or just reasons as first-class posits in a point-free algebraic topology. We can then present a case for the semantics of "Hugo" as a conventionalized sound adopted by a small group of humans to designate a particular four-dimensional manifold — at least if we have a sufficient topological or Categorical foundation to give logical exactitude to concepts like "four-dimensional manifold". This still neglects mereological problems, like Hugo losing some fur but still being himself; either the manifold Hugo is scattered wherever his fur (and, well, peepee and poopie) are or the Hugo manifold has fragmented into lots of disjoint other manifolds, only one of which is "Hugo". This latter option suggests that we need to identify the "essential parts" of Hugo, not the inessential parts like those in the litter box; then the Hugo manifold is the one that contains those parts — i.e. we need a mereological formalization to embed in the topological one.

It is certainly possible that by patching philosophical incompletions and importing mathematical vocabularies we can piece together a reasonably compelling theory of mereological/topological complexes, maybe with graded sets (some parts are more essential than others), to logically model the semantics of singular referents. By taking sets of such complexes, maybe with a modal machinery (for, say, fictional cats) or graded membership (some things are only partially subsumed by their concept: is a pet malawolf a dog?) we can similarly flesh out a set-theoretic semantics, and combining the singular and set analyses perhaps achieve a logically inflected semantics applicable to a broad class of linguistic events. But have we therefore truly surpassed informal logic, coiled within dialogic conventions, toward a rigorous theory of linguistic meanings via formal logic? Do we need topology, mereology, graded sets, and modal logic because these are intrinsic to the epistemic domain where signification happens, or are we just grabbing an assortment of mathematical tools to plug the leaks in a philosophical attitude wherein there is a relatively straightforward formalization of quantifier-predicate logic that can polish the informal logic of language, but which perhaps failed to anticipate the mathematical complexities of formalizing what exactly are the "thises" that quantifiers can quantify over?

These questions are directly relevant to phenomenology — and to Analytic Philosophy's reception of and dialog with phenomenology — because a phenomenological account of issues like manifold synthesis and mereological essentialism can easily bring forward formulations that overlap with a "logistic" paradigm in some details but not others, and profitably pursuing the dialog depends on identifying both similarities and differences. The story of Hugo as a four-dimensional manifold might not be told in a phenomenological context, but we might study our visual episodes involving Hugo in terms of perceptual synthesis: seeing Hugo from the front we anticipate that we *could* see Hugo's tail if we were standing behind him and it was not as much tucked beneath him; this anticipation is also a formula for how we integrate successive impressions as our gaze travels from his ears to his tail that we see partially. There is a certain continuity and topography of our accumulation of successive visuals that retraces a sort of manifold, even if now we're talking not about Hugo (or his body) himself but rather the interplay between the space where he's laying and my own perspctive and vantage. So, even on a phenomenological basis we encounter fragments of analysis that point toward something like a mathematical treatment — but that doesn't mean we are necessarily committed to a quantitative-predicate logical theory of perception, or equally important, of the communicative acts that perception yields.

In pursuit of logical rigor, 20th-century Analytic Philosophy (plus, say, linguistics, cognitive science, and fields related to knowledge engineering and information technology, like AI-driven medical diagnosis) have highlighted specific logico-mathematical representation-regimes, building up a paradigm of logicality (as a philosophical quality, something one senses in analytic methods) and propositionality (as a corresponding analyzand). The various layers of this construction address different aspects of logic, or "logicality" as such, such as predication (that which can be qualified as true or false in the first place), quantification (establishing a scope for empirical truthness, so logic does not not decay into tautology — that *one* thing or *some* members of set have a property where others don't, modeling contingency and *a posteriority*), modality (capturing the further contingency that most facts could have been otherwise), mereology and individuation, quantification scope, supervenience, and other logical themes that seem intrinsic to any intellectual territory where predication and true-falseness pertains. Codification of these facets of logic not only fine-tunes philosophical analysis; it also provides a semantics for Natural Language insofar as we accept that meaning is centered on locutionary truth-conditions (from which phenomena like illocutionary force and polarity — our feelings and pragmatic intentions vis-à-vis states of affairs at the predicate substrate of language — can be reached in supplemental analysis) and a philosophical basis for the formal/computational representation of facts and knowledge (such as, in database design). So insofar as a philosophical-computational-linguistic consensus emerged on the broad outlines of what logic entails, this paradigm spread into multiple disciplines, scientific as well as humanistic, and applied as well as purely speculative. Insofar as Naturalizing Phenomenology involves dialog with Analytic Philosophy, it intersections with these different faces of logicality and the mathematical systems which prior generations believed best captured them.

But this does not mean phenomenology needs to endorse the full stack of paradigms layered in Analytic Philosophy's excavation of logic; that we need to approach logical-mathematical eidetics via quantifier-predicate logic, for example, or to prefer the mathematical frameworks through which quantification and predication are usually modeled. Mathematics itself pulls in different directions: quantification, precication, and set-membership have different theories in different contexts, e.g. mereotopology compared to algebraic topology compared to Category theory. These lines of development are largely tangential to Analytic Philosophy partly because the philosophical (and, say, cognitive-scientific) push toward formalized logic is not really a push toward *mathematics*, but rather a vision of bringing rigor to what is still essentially *informal* logic. That is, pursuing for instance a formal treatment of quantification to undergird natural language semantics does not mean building up to a rigorous, maybe Categorial theory of quantification in terms of (say) dependent coproducts, because what "logicality" does in language does not depend on that degree of technical detail. But such means in effect that operationalizing the "logicalness" of language is not so much a problem in *formal* (mathematical) logic but a formalized *informal* logic, logico-linguistic or logico-mental (as in "folk theory of other minds") more than logico-mathematical. Fair enough; but this then places other analytic conveniences (like referents as 4-dimensional manifolds) on shakier ground, because we're no longer in an all-encompassing logico-*mathematical* paradigm. Topology and Category Theory, in effect, reveals the difference between formal-mathematical and formalized-informal logic. Trying to negotiate with mathematics as source of methodological rigor, mathematics proves to be an elusive partner.

5.2 *Phenomenology and the Limits of Logic-Compositionality*

The trajectory through Algebraic Topology and Category Theory has been one vector of post-1950 mathematical progress. Another has been computer proofs, proof-assistants, and computer-inspired approaches to mathematical foundations, like Homotopy Type Theory. Regarding *types* rather than *sets* as the primordial elements of logic and mathematics positions mathematics and computer science as two different worlds evolving from a common type-theoretic universe. In this environment, mathematics as abstract thought gets mixed with mathematics as a technological discipline; specialists for example debate the merits of mathematical systems formalized with a priority to automated proof-checking vs. presentations more aligned with mathematical precedents. The proper place for technology and automation becomes debated. Computer theorem-provers after all are not oracles; they need their own quality-checking, their own design theory. Do we trust the theorem-prover (itself a human artifact) more than the conventional deliberations validating a proof in the eyes of mathematicians (and if so, why)? Are design principles of proof-assistant software and languages topics for mathematics or computer science? Does a test suite to demonstrate a proof assistant's trustworthiness bear witness to mathematics becoming suddenly an empirical rather than eidetic science? Does the empirical contingency of the correctness of software used to prove the 4-color theorem make the theorem something other than "synthtic *a priori*"?

There are analogs to these questions in the realm of Analytic-Philosophical logic. For example, the idea that cognitive or linguistic meanings can be reduced to first-order predicate formulae can be investigated by considering computer technology which does in turn model digital content, in effect, as predicate assertions together with rules of inference (that can in principle be modeled via first-order logic): the Prolog programming language, for instance; certain database query systems; the Semantic Web and "formal Ontologies". These technologies operationalize logistic paradigms, but they also put an empirical face on a logico-mathematical background that for Russell, Frege, and Wittgenstein would have been abstract speculation, akin to how proof assistants put an emprical tie on abstract mathematics. Similarly, formal linguistic approaches (like Categorial Combinatory Grammar) base themselves on abstract logico-mathematical paradigms (like Hindley-Milner type sysetms), but by 2019 we have a panoply of linguistic schools whose models are realized in computational linguistic technologies, digital platforms that represent and/or automatically identify semantic and grammatic patterns according to a specific thory of language. In this context, type theory informs linguistic research at a theoretical level as part of its logico-mathematical underpinnings, but it also belongs to the technological infrastructure wherein linguistic technology is implemented. These two roles can be complimentary: insofar as Classical Hindley-Milner type theory has been supplanted by competing paradigms in software which proves technologically advantageous for modeling natural language, we can explore whether more modern type theory is superior for linguistic analysis at a purely theoretical level too.

Insofar as Analytic Philosophy converged in the last century upon, it seems, a fairly consistent nucleus of logical paradigms — covering the various intrinsic facets of quantifier-predicate logic — the heritage of that philosophy is similarly rebased by 21st-century technology. The persistence of first-order logic as a reified example and medium of logic as such was driven by the abstract reality that almost any logical system can be translated first- or secod-order logic in principle (at least if we can tolerate whatever metaphysical posits may be needed to ground the resulting logic expressions, like Possible Worlds). As long as logic belongs just to pure thought, the formal/theortical isomorphism between superficially different theoretical architectures can be treated as a challenge to overcome: converging on first-order predicate-quantifier logic as a common ground beneath various shallower logics may seem (and perhaps did seem to early Analytic Philosophers) to be explanatory progress, a theoretical repositioning which really does evince a situation where philosophical disputation actually can progress toward greater clarity. However, now that different logics are indeed manifest in a concrete sense in different digital technologis, their contrasts no longer seem so shallow. It could be argued that the illusion of a "deep" logic underlying superficial variation (like the illusion of a "deep grammar" stabilizing the morphosyntactic surface, perhaps) is itself the superficial presumption, failing to duly appreciate surface contrasts which are only manifest in the register of applied technology, rather than abstract thought.

For example, one can make a strong semi-theoretical and semi-implementational case that Graph Theory or Process Calculii are a better foundation for projects like programming-language compilers and database query systems than conventional predicate logic — notwithstanding that propositions in graph or process algebras can potentially be reformulated in first-order logic (and vice-versa). The issue with such in-principle reductions is that they are of dubious explanatory merit; the pro-forma restatement of graph structures in predicate logic, for instance, has no particular importance unless we are prior committed to predicate logic being somehow fundamental, in which case the reducibility of graph theory (since this reducibility can be inverted — we can provide graph models of attribute predication, boolean operators, etc.) can't justify the commitment, on pain of circularity. What *can* be observed, however, is that graph-database queries cannot be optimized in their first-order translations (which is why graph databases are a different technology than relational databases), which in turn suggests that the structural differences btween graphs and propositions are philosophically non-trivial, and consequential.

Similarly, concrete technologies can point us to an intuition of sentence-comprehension as a calculus of interlocking cognitive processes, not the mechanical unzipping of a predicate compact, seeing that there are substantial implementational differences between process calculii and predicate logic as paradigms for programming languages. In short, technology reveals how formal systems may be substantially divergent from predicate logic even if the logical structures governing their operation have isomorphs in predicate logic: technology reveals that such "in principle" isomorphs are less important, less indicative of philosophical depth, than we may have believed a century ago. But this is revealed not within philosophy alone, but in an interdisciplinary spirit where insights are mined from fields like compiler design and database engineering; and from practical experience as well as speculation. We can appreciate the substantiveness of "surface-level" logico-structural variation when we actually *write* compilers or database query engines.

The phenomenological de-centering of metaphysics does not mean a complete abdication of metaphysical priorities, of the need for a measure to assess the reach and limits of thought, or science or intellectual explanation; to place the norms of philosophical exposition and conversation on a disputable, theorizable conceptual bedrock. Bracketing metaphysics does not mean suspending what metaphysics is supposed to do to philosophical performance. But phenomenology can seek to bracket metaphsyics as something received, habitual, or institutioanlized; something that influences scholarship more than it is studied. Phenomenology brackets metaphysics in the hope that it can be recreated and return, but more transparent and self-aware than before, like a professional athlete who returns from a league suspension chastened and technically sounder. Metaphysics is suspended but not expelled. There is an analogous dialectic in open-source progrommaing; institutional norms for software quality are both suspended and resinstated in a more transparent, technical incarnation. The decentering of *institutional* controls does not foreclose a re-centering of scientific convergence in a shared technical understanding of the project. Similarly, the decentering of *institutional* metaphysics — not just the ideas, but the academic workflows and publishing conventions that support them — does not foreclose a recovery of metaphysics in the philosopher's relation to her own consciousness, in writings as an existential trace more than a social production.

All of this then produces the question: what should metaphysics be if it is not the paradigms we have received? Where does a phenomenological analysis take us that we were not before it started? As with any writing, we have to start with the question: now that the writing has finished, what has changed? Aniticpating the writings of the future: what do we want to have changed?

We have to communicate this to Analytic Philosophers (and practitioners of many other branches of scholarship, like cognitive science and linguistics): what changes when a phenomenological study is complete? What changed when there was a *Thing and Space* or a *Phenomenology of Perception* compared to before there was? Failure to understand what a writing wants to change can easily yield to failure to understand the writing.

I have often felt that Analytic and phenomenological practitioners were talking past each other precisely in this sense: a specialist in the philosophy of mind or of science might approach a reading or conversation thinking the phenomenologists is working to one kind of telos, while the other is going somewhere else. In apparently the most common iteration, the Philosopher of Mind thinks the phenomenologist is aiming toward a kind of skeptically inflected science of perception, a theory of the deep structures behind perceptual experience that potentially takes us further toward an unbiased and even scientific theory by bracketing presupposions about how consciousness and cognition are supposed to work. The Philosopher of Mind might then think that phenomenology should, let's say, uncover the synthesizing and interpretive acts that constitute my raw sensate awareness as the grasping and judging that Hugo is sleeping on the sofa, or that it is half-past four and the sun is setting outside, or that the car double-parked outside is red. By attending in a hopefully presupposionless way to the immediacy of consciousness, we can see the underlying stitching and unifying that normally passes beneath the threshold of awareness, as if we were observing our own consciousness like a shaman on ayahuasca.

Yet, I have never in a philosophy classroom felt that my role was to issue oracular pronouncements as if from a drug-induced trance. Consciousness is not usually extravagant and cosmic; my awareness of Hugo sleeping on the couch is, really, not much more than just Hugo sleeping on the couch. Notice the structural analogue to logistic philosophies of language: just as adding logical symbols to "Hugo is sleeping on the sofa" does not guarantee we are uncovering some deeper structure in the language, some precious scientific insight, nor does superimposing talk of a Passive Synthesis of Perception or Hyletic Immediacy on the mundane episode wherein I see Hugo sleeping on the sofa make that perception suddenly scientifically tractable, as if we can solve the mind-body problem just by concentrating hard enough. It is what it is. The things themselves are the things themsevles; if we're going to them we can't assume we're en route to some revelation or science, as if the laws of consciousness are present in the room alongside Hugo, the sofa, and the lamp.

But a reframing of the sentence "Hugo is sleeping on the sofa" *can* take us at least modestly further toward a good theory of language, something beyond the disquotational verity that a sentence means what it means, just as "it is what it is"; "Snow is white" means that snow is white. Similarly, I believe reframing perceptual episodes can shed light on the formal — and perhaps even scientific — structures of cognition, but we have to clarify ahead of time what magnitude of clarity we are hoping for; what precision of understanding landmarks a successful analysis. If a scientist reads phenomenology hoping for an exposé of consciosuness that is both first-person accurate and naturalistically revelatory — something experientially faithful like a physchological novel but clinically analyzble like a Brain Simulation — then what is actually on offer will fall short. Both attending to consciousness as it is experienced and honoring professional and scientific standards of intellectual rigor are guiding principles of phenomenological research, but these are principles, not minimal standards like a one-drink minimum at a night club: a very good phenomenological writing will *not* truly be either stream-of-consciousness realistic like a novel nor scientifically complete like a Neural Network platform presented at a computer science conference. The point is via phenomenology to move a little closer to both experiential honesty (to accept consciousness as it is experienced, not as something we hypothetically transform to fit cognitive and physical explanations) and scientific rigor (both the science of neurophysical explanations and the science of cognitive or intelligence simulations), but while doing so acknowledging the incompleteness of both projects and the tensions between them.

In the case of perceptual synthesis, we have good reseon to believe that biophysiology and experimental psychology gives us a well-informed acccount of perceptual phenoema, in their episodic unity, at the neurological and sensori-motor levels; presumably I have some brain function that unifies white-sensations and gray/brown-sensations and distributes the color regions to different concepts (sofa, Hugo). Since I'm not aware of these levels they are not phenomenological subjects per se (which doesn't mean we should reject them entirely, since I have reasonably firm beliefs about the scientific basis of perception, beliefs which I don't deliberately question any more than I deliberately apply them to mundane perceptions). Perhaps our scientific training causes our actual perceptual content, at last sometimes, to be subtly different in our experience of it. I am reminded of the rainbow color of a thin slick of spilled oil: knowing to some approximation how we think that phenomenon occurs makes me explicitly associate the rainbow with the oil, and therefore to almost unconsciously direct my gaze to the border lines where the colors are brownish and less pronounced. Somone who did not impose a mental explanation on what they're seeing, even if unintentionally, would perhaps attend more intently to the color and experience it more vigorously. So scientific beliefs are relevant in the limited sense that their trace can sometimes be detected in actual experience. With this qualification, however, any scientific story about how percption *works* lies outside phenomenology proper.

Over-analysis, *excess* clarity, *too much* resolution distorts experience even if it aims to explain it. So phenomenology does not neatly fit within a scientific paradigm where magnification often leads to elucidation and discovery: we cannot take a microscope to consciousness and find new candidates for scientific treatment, the way we can advance science by making more powerful telescopes. For a scientist or someone with scientific intiutions it can seem hard to know how to go forward: you don't study cancer by staring at tumors; so how can you study consciousness without some analysis, some distortion and defamiliarization? Otherwise we seem fated to endless circularity: "it is what it is". The things themselves are what they are.

This point, relative to perceptual synthesis, has similar forms in other aspects of cognitivity activity: judging that the animal on the sofa is a cat, indeed Hugo, that he's sleeping, that it's daytime becauuse it is light outside, that the men in uniform skating on an ice rink on television are hockey players, and so forth. Phenomenology cannot ignore that many of the perceptual and conceptual judgments that we are aware of take the form in consciousness of settled fact; we can't do first-person analysis of chains of reasoning that we don't actually experience ourselves performing. So while presumably there is a detailed story to be told about how optical and inferential thought-processes lead us to the conclusions that it's daytime and that Hugo is sleeping, the perceptual record shows that none of this labor was special enough to warrant conscious attention. It's not like I first speculated that some unfamiliar creature was on the sofa, and subsequently concluded that it's just Hugo; or that I had to stand and ponder who the cat is until I could assemble enough visual detail to reach that conclusion. I honestly don't know what I was unconsciously thinking to presume passively that it's Hugo — honestly, I usually don't know what I'm unconsciously thinking. I cannot, accordingly, use unconscious or too-mundane-to-experience judgments as part of phenomenology at least during argumentational stretches where I'm sticking to phenomenological reports.

Insofar as this is characeristic of phenomenology in general, we should not expect that phenomenology will advance us further to some sort of rigorous philosophy or experientially faithful science by revealing things about experience that we have not yet noticed due to lack of attention: we cannot magnify consciousness the way a microscope enlarges small things and a telescope reveals distant ones; metacognition and first-person reflection don't enlarge or polish the things in consciousness so that we can describe them more thoroughly or scientifically. Phenomenology does not take us to some new place by making us aware of pieces of experiential synthesis that we don't experience directly otherwise, as we don't experience the molecules in water; or minutiae of conceptual reasoning that we would otherwise take for granted, like how we figure out when an animal is a cat.

Of course, however, often we *are* aware of perceptual synthesis and conceptual judgment. If after seeing Hugo I walk toward him, with my perspecive gradually changing, I consciously register a change in how Hugo appears to me which produces an explicated synthsis, a self-conscious accumulation of visual evidence telling me about Hugo's current state, at least if I am looking at him with express interest him as opposed to looking in his directly and passively noticing him while attending to something else, like the television. Likewise I may passively observe that he is sleeping if I previously thought he was sleeping and just happened to glance at him again, but there's an alternative scenario where I don't specifically assume he is sleeping, but upon looking at him rather attentively, with his lack of movement and his relaxed posture, I reach the conclusion self-consciously. Walking outside I may see a familiar stray cat and put no thought into recognizing her, but I may also spot a movement in the distance and look purposefully before identifying the animal as a cat. In short, perceptual synthesis and conceptual judgments are neither *intrinsically* conscious or pre-conscious, active or passive; many cognitive episodes that we are explicitly aware of in their unfolding could, in slightly different circumstances, remain below the threshold of conscious awareness. Conversely, many judgements we make without much conscious attention could alternately be experienced with more deliberation and attention. Indeed, sometimes we revise our passive judgments when something goes awry in our passive estimation of what's going on around us — we assume we hear the dog barking in the back yard, but then we see her eating veal chops in the kitchen, so now we have to account for the mysterious barking outside. We all have the faculty to quickly adopt the mode of conscious investigation, trying to gather specific information, when the passive judgments we have just assumed to be true turn out to have some incongruity, some gap in their logical order.

Now we are moving toward some insight, since although we can't give a phenomenological account of preconscious judgment, we can at least confirm that *some* judgments are "active" and part of explicit awareness, while others are passive and not (in any inner details) noticed; we can also say that at least some passive jugments seem similar in form and outcome to active ones. This raises several avenues for further, maybe scientific continuation: why do we have both active and passive judgment? What benefits accrue to us biologically, as animals who depend on precise judgments to survive, that we make many instinctive judgments and some additional deliberated ones? Why are active and passive judgments often similar? What triggers a decision to actively attend to specific components of experience so that associated judgments in that one area will, at least in the immediate aftermath, be more active than passive? What is actually neurophysically different in the two cases so that, in a pure subjective and first-person sense, I know when a judgment is active and passive?

Furthermore, since many judgments *do* rise to a level of consciousness — and not just the minimal awareness of believing such-and-such but some explicit experience of how the judgment is formed, of their inner pieces and intemediate stages — these conceptual and perceptual episodes *are* candidates for phenomenological analysis. We are certainly aware of perceptual episodes in their unfolding; how perception scans over a room, or any other surrounding, like the pan of a camera; while, also, different episodes piece together, with shifts in attention (and, often, kinaesthetic actions) — like looking up from a book — juncturing disparate perceptual phases. It seems self-evident that perception unfolds according to multiple time scales, where episodes measured in seconds join to become the perceptual background as we engage in activities over the course of minutes, within errands that stretch toward hours and engagements over the course of a day (we cook, go to the store, ride a subway, watch a show), and of course we plan for a future and remember a past over monrhs and years. Cognitive acts and perceptual interludes can be slotted into different time scales, affecting how we experience them and should analyze (or even name) them: a perceptual episode, brief enough to appear in consciousness as a single event, needs a different theoretical registration than experiences implying lengthier segments. Practical actions, also, bridging perception, conceptualization, and planning, sort into different time-spans: opening a bottle vs. preparing a meal; petting the dog vs. walking the dog.

We have, as such, I would argue, a collection of observations and distinctions we can make about consciousness and conscious experience, that emananate from consciousness itself and not from prior scientific or metaphysical commitments. These observations seem presuppositionless, or at least common-sensical. We should not take that too far: the "suspension of belief" should not commmit us to a virgin brilliance exorcising millenia of thought, posturing us as priests of intellectual purity that can be defrocked by the smallest trace of naturalistic thinking — gotcha, a presupposition! Philosophy as volumes forging profound insight from pure thought alone seems silly in our time, more art created from ideas than rational exposition. But we can make a good-faith effort to present patterns in consciousness based on rather casual and common-sense reflections not explicitly aligned with scientific thories, or with schools of philsophy, and I claim at least some of the intellectual structure we can get to via that route takes the form of observations I have highlighted: passive vs. active judgment; the various scales of perceptual and enactive temporality; the individuality, aggregation, and junctioning between perceptual episodes.

Insofar as these observations and distinctions form the rudimentary constructs in a theory of consciousness, the explanatory value of that theory will depend on how it can be consistently extended. Remaining within phenomenology, we cannnot analyze deeper into consciousness — capturing more fine-grained layers of perception, uncovering more details of passive synthesis — because we cannot impose scientific-empirical data or philosophical speculation on subjective experience. So if we can only articulate a handful of organized but commonsensical comments about experience, we need to find away to make the analysis meaningful: for it to make a difference.

One way to do this, I believe, is to make the commonsensical observations more than just observations; not in the sense of importing interpretive claims that don't unfold from them organically, but in the sense of trying to express their as a formal structure, something which can be then set in relation to other structures and other accounts of mental processes. There are many formal systems that have been proposed to cover various features of cognition and intelligence; but only a few of these, I suspect, are formal views on experientially vivid acts of mind; on judgments or perceptual syntheses that we can experience in their unfolding and reflect upon first-personally.

There is a considerable body of cognitive-scientific literature that aspires to formalize (and sometime simulate) mental activity via structures that have some blend of logical, mathematical, and computational specification. There is also a considerable body of literature that remains true only to the first-person perspective, not explicitly trying to align with scientific explanations and world-view. But where these bodies overlap I believe lays the potential for overlapping theories, like a Naturalized Phenomenology.

Part II

While the first half of this paper was built around a review of semantic theories, this part will attend equally to grammar. As I argued at the end of Section 3, we can find logical form in language — even subtle, visual, "narrative" language — but *how* language often evokes its logical form reveals the limitations and the reductionist effect of semantic theories that reify logical form over against the full cognitive spectrum of linguistic processes. Insofar as our semantic theory is shaped by a vision of cognitive-linguistic processes, tied together to create aggregate comprehension (of sentences, for example), a natural *syntax* paradigm to ground such a "procedural" or "interface" semantics would be Link or Dependency grammar: syntax as a graph of associations between language elements rather than a compositional hierarchy of words and phrases. This is the conception of the syntax/semantics interface that I will examine in following several sections.

6 Cognitive and Computational Process

Any attempt to bridge Computational Linguistics and Cognitive Grammar or Phenomenology must solicit one or several "founding analogies", linking phenomena on the formal/computational side with those on the cognitive/computational side. Here, I will start from the analogy of *cognitive* and *computational process*, or generically "process" (of either variety). Processes, per se, I will leave undefined, although a "computational" process can be considered roughly analogous to a single procedure implemented in a computer programming language. Th story I want to tell goes something like this: understanding language involves many cognitive processes, many of which are subtly determined by each exact language artifact and the context where it is created. Properly understanding a piece of language depends on correctly weaving together the various processes involved in understanding its component parts, and the structure of the multi-process intergration is suggested by the grammar of the artifact. Grammar, in a nutshell, uses relationships between words to evoke relationships between cognitive processes.

My formal elaboration of this model will be inspired at an elementary level by process *algebra* in the computational setting, but more technically by applied *type theory*. Inter-process relations are the core topic of Process Algebra, including sequentiality (one process followed by another) and concurrency (one process executing alongside another). In practice, detailed research around Process Algebra seems to focus especially on concurrency, perhaps because this is the more complex area of application (designing computer systems which can run multiple threads in parallel). It is likewise tempting to imagine that cognitive-linguistic processes exhibit some degree of parallelism, so that the various pieces of understanding "fall into place" together as we grasp the meaning of a sentence (henceforth using *sentence* as a representative example of a mid-size lanuag artifact in general). Nevertheless, I will focus more on *sequential* relations between processes, suggesting a language model (even if rather idealized) where cognitive processes unfold in a temporal order.

On both the cognitive and computational side, temporality is relative rather than quantified: the significant detail is not "before" and "after" in the sense of measuring time but rather how one process logically precedes another in effects and prerequisites. No theoretical importance is attached to *how long* it takes before processes finish, or how much time elapses between antecedent and subsequent processes (in contrast to subjects like optimization theory, where such details are often significant). We can set aside notions of a temporal continuum where subsequent processes occupy disjoint, extended time-regions; instead, one process follows another if anything affected by the first process reflects this effect at the onset of the second process. Time, in this sense, only exists as manifest in the variations of any state revelant to processes — in the computational context, in the overall state of the computer (and potentially other computers on a network) where a computation is carried out. Two times are different only insofar as the overall state at one time differs from the state at the second time. Time is *discrete* because the relevant states are discrete, and because beneath a certain scale of time delta there is no possibility of state change.

Analogously, in language, I suggest that we set aside notions of an unfolding process reflecting the temporality of expression. Of course, the fact that parts of a sentence are heard first biases understanding somewhat; and speakers often exploit temporality for rhetorical effect, elonging the pronunciation of words for emphasis, or pausing before words to signal an especially calculated word choice, for example. These data are not irrelvant, but, for core semantic and syntactic analysis, I will nonetheless treat a sentence as an integrated temporal unit, with no value atributed to temporal ordering amongst words except insofar as temporal order establishes word order and word order has grammatical significance in the relevant natural language/dialect.

While antecedent/subsequent inter-process relations are among those formally recognized in Process Algebra, this specific genre of relation is implicit to other models important to computer science, such as Type Theory and Lambda Calculus. If $\mathfrak{t}$ is a type, then any computational process which produces a value of type $\mathfrak{t}$ has a corresponding ("functional") type (for sake of discussion, assume a "value" is anything that can be encoded in a finite sequence of numbers and that "types" are classifications for values that introduce distinctions between functions — e.g., the function to add two integers is different than the function to add two decimals; more rigorous definitions of primordial notions like "type" and "value" are possible but not needed for this paper). Similarly a process which takes as *input* a value of $\mathfrak{t}$ is its own type. If two processes have these two types respectively — one outputs $\mathfrak{t}$ and the other inputs $\mathfrak{t}$ — then the two can be put in sequence, where the output from the antecedent becomes the input to the subsequent. In this manner inter-process sequential relations become subsumed into "type systems" can can be studied using type-theoretic machinery rather than Process Algebras or Process Calculii as such.

There also exists a robust type-theoretic tradition in (Natural Language) semantics, which is disjoint from but not entirely irrelevant to the type systems of formal and programming languages. Semantic types are recognized at several different levels of classification, but some of the most interesting type-theoretic effects involve medium-grained semantic criteria that are more general than lexical entries but more specific than Parts of Speech. For example, the template *I believed X* generally requires that X be a noun (?*I believed run*), but more narrowly a certain *type* of noun, something that can be interpreted as an idea or proposition of some kind (?*I believed flower*). Asher and Pustejovsky point out the anomaly in a sentenc like "Bob's idea weighs five pounds" [7, example 2, p. 5], which possesses a flavor of unacceptability that feels akin to Part of Speech errors but are not in fact syntactic errors. The object of *weigh* is "five pounds" and its subject is "Bob's idea", which is admissible *syntactically* but fails to honor our semantic convention that the verb "to weigh" should be applied to things with physical mass (at least if the direct object denotes a quantity; contrast with *Let's all weigh Bob's idea*, where the *idea* is object rather than subject). These conventions are analogous to Part of Speech rules but more fine-grained: there is a meaning of *weigh* which has (like any transitive verb) to be paired with a subject and object noun, but beyond just being nouns the subject must be a physical body (in effect a sub-type of nouns) and the object a quantitative expression (another sub-type of nouns). Potentially, type restrictions on a coarse scale (e.g. that the subject of a verb must be a noun) and those on a finer scale (as in this sense of *to weigh*) can be unified into an overarching theory, which spans both grammar and semantics — for instance, both Part of Speech rules and usage conventions of the kind often subtly or cleverly subverted in metaphor and idioms (see *flowers want sunshine*, *my computer died*, *neutrinos are sneaky*, as rather elegantly compactified by assigning sentient states to inert things). This is one way of reading the type-theoretic semantic project.

Along with Process Algebra, my take on linguistic understanding is informed by type theory (in both computational and linguistic contexts), but particularly by the merged notion of *typed* processes. So if we say that something has the *type* of a physical-body noun — that "Physical Body" is a type in the overall semantics of language — then I propose a corresponding type of cognitive (perceptual and conceptual) processes characteristic of perceiving and reasoning about physical things. A particular designatum — a bag of rice, say — is subsumed under the semantic type insofar as our perceptual encounters with that thing — and/or our concepual exercises pertaining to its properties and proclivities (like being difficult to carry) — are roughly prototyped by a certain generic kind of cognitive process. This assumes that there is a similitude among processes of perceiving and thinking about physical bodies (at least the mid-sized, quotidian physical things that tend to enter nonspecialist language) sufficient to subsume them under a common prototype, which I then argue forms the cognitive substratum for the semantic type "Physical Object". Moreover, I contend a similar cognitive substratum can be found for other mid-scale semantic types that underlie analyses of semantic acceptability and metaphoricality, like "Living Thing", "Sentient Living Thing" ("flowers want sunshine" is metaphorical because it ascribes propositional attitudes to something whose type does not literally support them), and "Social Institutions" ("The newspaper you're reading fired its editor" exhibits a "type coercion" where *newspaper* is read first as an object and then as a company). One feature of semantic types is the lexical superposition of different types to produce what (in a slightly different context) Gilles Fauconnier calls a "blend": in "Liverpool, which is near the ocean, built new docks", the city is treated as both a geographic region and a body politic.

"Weighs", too, as a verb, can be given a typed-process interpretation. In its least metaphoric sense, "to weigh" connotes a practical action of measuring some object's weight by using something like a scale; as *cognitive* process the verb embodies are ability to plan, reflect upon, or contemplate this practice. So an "idea weighing 5 pounds" is anomalous because it is hard to play out in our minds a form of this practical act where the thing being weighed is mental. Howevere, there are plenty of more figurative uses related to "weighing ideas", "heavy ideas", and so forth, so we are able to isolate the dimension of "judging" and "measuring" which is explicit in literal "weighing", and abstracting from the physical details use "weigh" to mean "measure" or "assess" in general. The phrase "weigh an idea" therefore connotes its own cognitive process — imagining someone thinking about the idea in an evaluative way — but this figurative "script" is closed off by "5 pounds" which forces us to conceive the weighing literally with a scale, not figuratively as a kind of mental assessment. Once again, the type anomaly can be seen as a failure to map the linguistic senses evident in a sentence to an internally consistent set of cognitive procedures for dilating the semantic content seeded within each word.

Notice that I am treating cognitive processes, in themselves, as semantic more than grammatical phenomena. Literally, weighing something is a multi-stp act (lifting it on the sale, reading the measurement), and even in our mental replay of hypothetical weighing-acts it seems impossible not to imagine distinct phases (just as it is impossible not to picture left and right sides of an imaginary cow). Howevere, I assume that the cognitive script is figured by the lexeme "weighs" as a connotative unit: whatever internal structure our mental script of "weighing something" has, this structure is not a *linguistic* structure that must be encoded grammatically. Similarly, the concept *buttered toast* suggests a confluence of perceptual, physical-operational, and conceptual aspects — we are incljied to regard toast as *buttered* if it looks a certain way and also if we have seen someone apply butter to it (or have done so ourselves) and also if we are in a context where we expect to find toast that may be buttered (we are not disposed to call a piece of bread in a grocery store "buttered toast" even if it has that appearence). So the adjective *buttered* introduces multiple cross-modal parameters in addition to the underlying concept *toast*; but I feel that the lexeme aggregates these parameters into a single *linguistic* unit. In Langacker's terms, the various elements of "buttered" do not suggest *constructive effort*, as if deliberate *linguistic* processing were needed to unpack the linguistic entity to its constituent parts. Instead, "buttered" functions *semantically* as a unit (and likewise syntactically as the unit entering relations with other words — e.g. buttered-toast is an adjective/noun pair, not the noun *butter* at the root of the adjective) — even if its cognitive process is multi-faceted. Indeed, this is precisely the signifying economy of language: it captures complex cognitive procedures by iconic, repeatable lexical units.

On that theory, tieing specific word-senses to stereotyped cognitive processes is a matter of semantics, not grammar per se. Grammar, I contend, comes into play when multiple processes need to be integrated. The concept "buttered toast", for example, seems to start from a more generic concept (toast) and then add extra detail (the buttering, with all that implies conceptually, pragmatically, and sensorially). This is suggested by the substitutability of just *toast* for *buttered toast*:

- (106) I snacked on toast and coffee.
- (107) I snacked on buttered toast and iced coffee.

Because the first sentence is perfectly clear, it seems that the ideas expressed (at least in this context) by *toast* and *coffee* are reasonably complete in themselves, so the adjectives have the effect of starting with a complete idea and adding on extra detail. Procedurally, then, it seems like we have some process which takes us to "toast" and "coffee" and then, subsequent to that (logically if not temporally) we add the wrinkle of re-conceiving the toast as buttered and the coffee as iced. In short, the adjective-noun pairing is compelling us to run a pair of cognitive processes in sequence, one establishing the noun-concept as a baseline and one adding descriptive detail by an "adjectival", a specificational process.

Counter to that analysis, someone might judge that phrases like "buttered toast" and "iced coffee" are conventional enough that we don't interpret them through two meaningfully disjoint processes. This is entirely possible, given how erstwhile aggregate expressions bcome established units — what Langacker calls *entrenchment*. Different phrases ehibit different levels of entrenchment:

- (108) I snacked on toast and instant coffee.
- (109) I snacked on toast and Eritrean coffee.

Arguably "instant coffee" is a de facto lexical unit, partly because reading it in terms of constituent parts is rather nonsensical (there's no non-oblique way to understand "coffee" being qualified as "instant"). Surely, however, *Eritrean coffee* is heard as a compound phrase (at least in 2019 — it is unlikely, but not impossible, that future Eritrean coffee growers will be so successful that we hear the phrase as a brand name or culinary term of art, like "Hershey's kisses" or "French toast"). The status of *iced coffee* is probably somewhere between these two. But to the degree that a language element (whether word or phrase) is entrenched and generally processed linguistically as a unit, I maintain, it tends to be governed by an integrally complete cognitive process — not necessarily one without inner structure, but where the elements of this structure piece togther perceptually and situationally, rather than seeming to be *linguistically* disjoint conceptualizations that are brought together by the shape of linguistic phrases. Conversely, where a cognitive process has this integral character, discursive pressures nudge the language toward entrenching some descriptive phrase as a quasi-lexeme; what starts being heard as a compound designation evolves to the point where language users don't attend to constituent parts.

Obviously, this theory presupposes that there is an available distinction to be drawn between a "procedural" synthsis of disparate cognitive processes and a perceptual and/or conceptual synthesis constitutive of individual cognitive episodes. Phenomonology seems to back this up — there are some conceptual compounds that come across as more episodically fused than others. Buttered toast may evoke a temporally not-quite-instantaneous conceptualization — at the core of the concept is a practical activity that takes a few seconds to complete — but we also can imagine the buttering-act apprehended in one sole episode. On the other hand, "Eritrean coffee" ties together concepts of much more scattered provenance; the perceptual unity of *coffee* (in the sense of a specific liquid in a specific container) along with the geopolitical "background knowledge" implicit in the adjective *Eritrean.* As a cognitive synthesis *Eritrean coffee* is conceptual rather than perceptual. Provisionally we can treat this in the context of *buttered toast* being a partially-entrenched phraseology while *Eritrean coffee* is undeniably a phrasal compound, something whose constructive form must be parsed linguistically rather than figuratively.

This analysis, though, needs many caveats. After all, many bonafide *phrases* (not "quasi-lexemes") nevertheless exhibit significant phenomenological unity — i.e., they evoke integral perceptual complexes: *big dog*; *hot coffee*; *speeding car*; *red foliage.* Linguistically these seem like an underlying concept acquiring perceptual specificity via adjectival modification: "hot" was how the coffee came to my exprience because I experienced it as hot (it wasn't like I experienced the coffee and then had to contemplate whether it is hot or cold). Coffee can't *not* be experienced as hot, cold, or lukewarm; it cannot be experienced without temperature (assuming I am coming into contact with it and not just looking at it). Similarly a car must be seen as at rest, moving slowly, or speeding along; foliage must be seen as having some color(s).

I have argued, however, that unless entrenched as idiomatic phrases adjective-noun pairs like *hot coffee* or *buttered toast* should be read as grammatical complexes and accordingly (in my theory) as junctures between distinct cognitive processes. On the other hand, I argued that "instant coffee" was effectively entrenched *because* there is no simplistic concepual unity between *instant* and *coffee*, which makes it harder to hear the phrase as descriptive. Instead, the semantics of that particular adjective-noun connection are circuitous and a little hyperbolic: "instant" coffee is coffee as a substance (not a drink, in that state) from which coffee the drink can be quickly (but not instantaneously) prepared. There is a lot going on the semingly simple "instant coffee": the shift from coffee-as-substance to coffee-as-drink; the "instant" exaggeration. In this case, the adjectival modification has *so many* moving parts that, I'm inclined to argue, it is hard to cover the whole scenario with a dscriptive phrase; which in turn creates selective pressures for some pseudo-lexical unit to emerge (which turned out to be *instant coffee*) as a mnemonic for the whole conceptual multiplex. Indeed conceptually intricate wholes tend to quickly acquire pithy conventional nominalizations simply for rhetorical convenience ("Brexit"; "Quantum Gravity"; "International Transfer Window"; "#metoo").

Notwithstanding these variations, I still find a certain logic in the relation between phenomenological unity and semantic entrenchment. Perceptually integrated wholes may correlate with linguistically aggregate constructions insofar as there is a transparent logical destructuring in the perceptual unity: in the case of substance-attribute pairs (like *hot coffee*) — deferring in the phenomenological context to Husserl's account of dependent moments — there is a basically unsubtle distinction between an underlying concept (like coffee) and the qualities which are its mode of appearance as well as conceptual predicates (like hot, cold, black, or light, describing sensory properties innate to the experience of a coffee-token as well as state-reports that can be propositionally attributed to it). Although the minimal sensate intention of the coffee and the predicative disposition toward ascriptions like *black* and *hot* are consciously intertwined, surely I am aware of a logicality in experience that gives the sensate and predicative dimensions different epistemic status. I don't think of my experience of the coffee's being hot as just a hot sensation qua medium of my sensorily apprehending the coffee, but rather as the sensate mechanism by which I observe the apparent fact that the coffee is hot, as a state of affairs and not just as subjective impression. We are constantly extrapolating our perceptual encounters to propositional content along these lines.

As such, I contend such an (in some sense) innate perception-to-predication instinct grounds the procedural slicing of linguistic processes: *hot coffee* retraces in a linguistic construction the logical order of a coffee perception which on one level is a raw perceptual encounter but is simultaneously a predicative attribution. "Hot coffee" denotes a substance that can be experienced in the mode of a base concept (coffee) which is given predicative qualification (the coffee *is* hot). The fact that there may be no noticed temporal gap in *experience* between the sensate perception and the epistemic posture does not preclude a certain logical antecedent-subsequent ordering: the concept *coffee* is the predicative base for my propositional attitude that what I am dealing with here is hot coffee, not hot-sensations-disclosing-coffee or coffee-I-experience-as-hot (but who knows, maybe I'm hallucinating) or any other artificial skeptifying of my actual experience, which is of raw perception pregnant with propositional content.

So I wish to justify claims that (non-entrenched) phrase complexes like "hot coffee" are unions of disjoint cognitive processes by noting that while such phrases evoke a certain perceptual unity, they evoke a *kind* of unity which we habitually regard *conceptually* as divided into sensate givenness founding epistemic attitudes. Cognitive processes are not exclusively perceptual; they are some mixture of perceptual and conceptual (and enactive/kinaesthetic/operational). A perceptual unity can cover two conceptual aspects, like a sheet covering two mattresses. So the perceptual unity of hot coffee can become the conceptual two-step of coffee as substance and hot as attribute; committing this unity to cognition as an overarching lifelong faculty involves registering a thought-process of coffee as a substance which can, in acts of logical predication, be believed to be hot or cold, black or light, etc. The apprehension of the substance is a different cognitive process than the predication of the attribute, in terms of how these mental acts fit within our epistemic models, even if these two processes are experientially fused. Typically we see the coffee before we touch or taste it, so already the coffee has a logical status apart from the heat we predicate in it.

Likewise, even if the black color is inxtricable from our perceiving (apart from odd situations where we drink the coffee without looking at it), we know the color will change if we add milk (even if just in principle because, preferring black coffee, I don't actually do so); so we know the coffee has a logical substrate apart from its color too. All of this ideation is latent in the coffee-perceptions notwithstanding whatever perceptual unities we experience that cloak logical forms like substance/attribute under the inexorable togetherness of disclosure (the phenomenological impossibility of spatial expanse without color, say). In short, disjoint cognitive processes can be required to reconstruct a perceptually unified situation or episode, insofar as we are not just living through the episode but prototyping, logically reconstructing, signifying it — the perceptual unity in the moment does not propagate to procedural atomicity in absorbing the episode into rational exercises.

Experience, then, presents *both* perceptual unities and cognitive-propositional multiplicity; language can inherit both holism on the perceptual side and compositionality on the rational side, even in a single enactive/perceptual episode. Depending on how we via language want to figure and express experience, we can bring either unity or compositionality to the fore. Our linguistic choices will evoke perceptual unity if they select entrenched word-senses or quasi-lexical forms; they will evoke compositionality if they gravitate toward compound phrases and complex, relatively rare lexicalizations and modes of expression. To the degree that we are interested in a cognitive-phenomenological *semantics*, we can attend to the first part of this equation, to how the understood atomicity of a word sense or a conventionalized phrase often suggests an object or phenomenon consciously apprehended as an integral whole; we can trace phenomenologically the apperceptive unity that seems to drive the linguistic community's accepting lexical atoms in this sense. Conversely, to the degree that we are interested in a cognitive-phenomenological *grammar*, we can attend to how logically composite predication emerges even within perceptual unity, because our encounter with phenomena is not (save for exotic artistic or meditative pursuits) the "*dasein*" of irreflective sensory beings immersed in a world of pure experience but the deliberate action of epistemic beings carrying (modifiable but not random) propositional attitudes to perceptual encounters.

Modeling grammar as a coordination between cognitive processes may be an idealization, precisely because the compositive and integrative faces of consciousness are two sides of the same coin: it's not as if we work through a thought of *coffee* or *toast*, abstract and without sensory specificity, noticeably prelude to conceived/perceived attributes like *hot*, *cold*, or *buttered*. But we can still ascribe to linguistic-understanding processes an idealized, "as if" temporality, treating the elucidating of a sentence as a sequence of procedures leading from bare concepts to well-rendered logical tableau, suffused with some level of descriptive and situational particularity. So we go from *coffee* to *iced coffee* to *butterred toast and iced coffee* to *snacking on butterred toast and iced coffee*; each link in the chain stepping up toward propositional totality.

My point is not that the logical form of the sentence is composed from logically primitive and abstract parts, which is fairly trite; my point is that such logical composition is only apparent after a pattern of cognitive integration that is more subtle and exceptional. Extramentally, buttered toast is just toast with butter on it, a fairly simplistic logical conjunction. Read as a baton passed between two acts of mind, however — conciving toast and then conciving it buttered — the conjunction is more elaborate; the cognitive resources of *buttered* are not just "something with butter on it" but the implication of a sensory summation (the flavor, color, scent) and operational narrative (we have seen or performed the deliberate act of applying the butter). Similarly a person dressed up is not just someone whose torso is encircled by articles of clothing; a barking dog is not just an animal making random noises; a stray cat is different from a lost cat. In their interpenetration, cognitive processes develop (in the photographer's sense) narrative and causative threads that are latent in worldly situations but reduced out of logical glosses; that is why it seems incomplete, lacking nuance, or beside the point to explicate semantic meanings in logical terms, like "bachelor" as "unmarried man" (we can certainly imagine a sentence like *My best friend has been married for years but he's still a bachlor*, to imply he still has the habits and attitudes of his single days).

A theory of sentences building from conceptual underspecification to logical concreteness does not preclude there being different scales of specificity. *I snacked on toast and coffee* is just as acceptable as *I snacked on buttered toast and iced coffee*. The communication conveys as much situational detail as warranted in the conversational, pragmatic context. Language always has the *capability* to push further and further into specificty; how exhaustively the language user avails of this capability is a matter of choice. As theorists of language we must then analyze how language possesses the *latent* capacity to draw ever finer pictures; the adjectival *buttered* toast and *iced* coffee takes the granularity of signifying at one level (the level of the *I snacked on toast and coffee* sentence) and layers on (or really layers *within*) a yet more specific level. The architecture of how this happens is well addressed by type-theoretic methods (both coarse and mid-grained).

The remainder of this section, and indeed of the second part of this paper, will try to expand on this type-theoretic intuition. My central thesis is that language understanding involves integrating diverse "cognitive procedures", each associated with specific words, word morphologies (plural forms, verb tense, etc) and sometimes phrases. The form of type theory appropriate in this context is therefore one closely associated with procedural typing and resolution: that is, assigning types to procedures, and differentiating procedures based on the types of their "arguments" or "parameters" (input and output data).

6.1 *Interpretive Processes and Triggers*

The type-theory/procedural perspective I will mostly work from here contrasts with and adds nuance to a more "logical" or "truth-theoretic" paradigm which tends to interpret semantic phenomena via formal logic — for example, singular/plural in Natural Language as a basically straightforward translation of the individual/set distinction in formal logic. Such formal intuitions are limited in the sense that (to continue this example) the conceptual mapping from single to plural can reflect a wide range of residual details beyond just quantity and multitudes. Compare *I sampled some chocolates* (where the count-plural suggests *pieces* of chocolate) and *I sampled some coffees* (where the count-plural implies distinguishing coffees by virtue of grind, roast, and other differences in preparation) (note that both are contrasted to mass-plural forms like *I sampled some coffee* where plural agreement points toward material continuity; there is no discrete unit of coffee qua liquid). Or compare *People love rescued dogs* with *People fed the rescued dogs* — the second, but not the first, points toward an interpretation that certain *specific* people fed the dogs (and they did so *before* the dogs were rescued).

The assumption that logical modeling can capture all the pertinent facets of Natural-Language meaning can lead us to miss the amount of situational reasoning requisite for commonplace understanding. In *People fed the rescued dogs* there is an exception to the usual pattern of how tense and adjectival modification interact: in *He has dated several divorced millionaires* it is implied that the ladies or gentlemen in question were divorced and millionaires *when* he dated them: that the events which gave them these properties occurred *before* the time frame implied (by tense) as the time of reference for the states of affairs discussed in the sentence (jokes or rhetorical flourishes can toy with these expectations, but that's why they *are*, say, jokes). But we read "people fed" in *People fed the rescued dogs* as occurring before the rescue; because we assume that *after* being rescued the dogs would be fed by veterinarians and other professionals (who would probably not be designated with the generic "people"), and also we assume the feeding helped the dogs survive. We also hear the verb as describing a recurring event; compare with *I fed the dog a cheeseburger*.

To be sure, there are patterns and templates governing scope/quantity/tense interactions that help us build logical models of situations described in language. Thus *I fed the dogs a cheeseburger* can be read such that there are multiple cheeseburgers — each dog gets one — notwithstanding the singular form on *a cheeseburger*: the plural *dogs* creates a scope that can elevate the singular *cheeseburger* to an implied plural; the discourse creates multiple reference frames each with one cheeseburger. Likewise the morphosyntax is quite correct in: *All the rescued dogs are taken to an experienced vet; in fact, they all came from the same veterinary college* — the singular on *vet* is properly alligned with the plural *they* because of the scope-binding (from a syntactic perspective) and space-building (from a semantic perspective) effects of the "dogs" plural. Or, in the case of *I fed the dog a cheeseburger every day* there is an implicit plural because "every day" builds multiple spaces: we can refer via the spaces collectively using a plural (*I fed the dog a cheeseburger every day — I made them at home with vegan cheese*) or refer within one space more narrowly, switching to the singular (*Except Tuesday, when it was a turkey burger*).

Layers of scope, tense, and adjectives interact in complex ways that leave room for common ambiguities: *All the rescued dogs are [/were] taken to an experienced [/specialist] vet* is consistent with a reading wherein there is exactly one vet, and she has or had treated every dog. It is *also* consistent with a reading where there are multiple vets and each dog is or was treated by one or another. Resolving such ambiguities tends to call for situational reasoning and a "feel" for situations, rather than brute-force logic. If a large dog shelter describes their operational procedures over many years, we might assume there are multiple vets they work or worked with. If instead the conversation centers on one specific rescue we would be inclined to imagine just one veterinarian. Lexical and tense variation also guides these impressions: the past-tense form (*...the rescued dogs were taken...*) nudges us toward assuming the discourse references one rescue (though it could also be a past-tense retrospective of general operations). Qualifying the vet as *specialist* rather than the vaguer *experienced* also nudges us toward a singular interpretation.

What I am calling a "nudge", however, is based on situational models and arguably flows from a conceptual stratum outside of both semantics and grammar proper; maybe it is even prelinguistic. Consider

- (110) People fed the rescued dogs.
- (111) Vets examined the rescued dogs.

There appears to be no explicit principle either in the semantics of the lexeme *to feed*, or in the relevant tense agreements, stipulating that the feeding in (110) was prior to the rescue — or conversely that (111) describes events *after* the rescue. Instead, we interpret the discourse through a narrative framework that fills in details not provided by the language artifacts explicitly (that abandoned dogs are likely to be hungry; that veterinarians treat dogs in clinics, which dogs have to be physically brought to). For a similar case-study, consider the sentences:

- (112) Every singer performed two songs.
- (113) Everyone performed two songs.
- (114) Everyone sang along to two songs.
- (115) Everyone in the audience sang along to two songs.

The last of these examples strongly suggests that of potentially many songs in a concert, exactly two of them were popular and singable for the audience. The first sentence, contrariwise, fairly strongly implies that there were multiple pairs of songs, each pair performed by a different singer. The middle two sentences imply either the first or last reading, respectively (depending on how we interpret "everyone"). Technically, the first two sentences imply a multi-space reading and the latter two a single-space reading. But the driving force behind these implications are the pragmatics of *perform* versus *sing along*: the latter verb is bound more tightly to its subject, so we hear it less likely that *many* singers are performing *one* song pair, or conversely that every audience member *sings along* to one song pair, but each chooses a *different* song pair.

The competing interpretations for *perform* compared to *sing along*, and *feed* compared to *treat*, are grounded in lexical differences between the verbs, but I contend the contrasts are not laid out in lexical specifications for any of the words, at least so that the implied readings follow just mechanically, or on logical considerations alone. After all, in more exotic but not implausible scenarios the readings would be reversed:

(116) The rescued dogs had been treated by vets in the past (but were subsequently abandoned by their owners).

(117) Every singer performed (the last) two songs (for the grand finale).

(118) Everyone in the audience sang along to two songs (they were randomnly handed lyrics to different songs when they came in, and we asked them to join in when the song being performed onstage matched the lyrics they had in hand).

In short, it's not as if dictionary entries would specify that *to feed* applies to rescued dogs before they are rescued, and so forth; these interpretations are driven by narrative construals narrowly specific to given expressions. The appraisals would be very different for other uses of the verbs in (lexically) similar (but situationally different) cases: to "treat" a wound or a sickness, to "perform" a gesture or a play. We construct an interpretive scaffolding for resolving issues like scope-binding and space-building based on fine-tuned narrative construals that can vary alot even across small word-sense variance: As we follow along with these sentences, we have to build a narrative and situational picture which matches the speaker's intent, sufficiently well.

And that requires prelinguistic background knowledge which is leveraged and activated (but not mechanically or logically constructed) by lexical, semantic, or grammatical rules and forms: *rescued dogs* all alone constructs a fairly detailed mental picture where we can fill in many details by default, unless something in the discourse tells otherwise (we can assume such dogs are in need of food, medical care, shelter, etc., or they would not be describd as "rescued"). Likewise *sing along* carries a rich mental picture of a performer and an audience and how they interact, one which we understand based on having attended concerts rather than by any rule governing *along* as a modifier to "sing" — compare the effects of *along* in *walk along*, *ride along*, *play along*, *go along*. Merely by understanding how *along* modifies *walk*, say (which is basically straightforward; to "walk along" is basically to "walk alongside") we would not automatically generalize to more idiomatic and metaphorical uses like "sing along" or "play along" (as in *I was skeptical but I played along (so as not to start an argument)*).

We have access to a robust collection of "mental scripts" which represent hypothetical scenarios and social milieus where language plays out. Language can activate various such "scripts" (and semantic as well as grammatical formations try to ensure that the "right" scripts are selected). Nonetheless, we can argue that the conceptual and cognitive substance of the scripts comes not from language per se but from our overall social and cultural lives. We are disposed to make linguistic inferences — like the timeframes implied by *fed the rescued dogs* or the scopes implied by *sang along to two songs* — because of our enculturated familiarity with events like dog rescues (and dog rescue organizations) and concerts (plus places like concert halls). These concepts are not produced by the English language, or even by any dialect thereof (a fluent English speaker from a different cultural background would not necessarily make the same inferences — and even if we restrict attention to, say, American speakers, the commonality of disposition reflects a commonality of the relevant cultural anchors — like dog rescues, and concerts — rather than any homogenizing effects of an "American" dialect). For these reasons, I believe that trying to account for situational particulars via formal language models alone is a dead end. This does not mean that formal language models are unimportant, only that we need to picture them resting on a fairly detailed prelinguistic world-disclosure.

There are interesting parallels in this thesis to the role of phenomenological analysis, and the direct thematization of issues like attention and intentionality: analyses which are truly "to the things themselves" should take for granted the extensive subconscious reasoning that undergirds what we consciously thematize and would be aware of, in terms of what we deliberately focus on and are conscious of believing (or not knowing), for a first-personal exposé. Phenomenological analysis should not consider itself as thematizing every small quale, every little patch of color or haptic/kinasthetic sensation which by some subconscious process feeds into the logical picture of our surroundings that props up our conscious perception. Analogously, linguistic analysis should not thematize every conceptual and inferential judgment that guides us when forming the mental, situational pictures we then consult to set the groundwork for linguistic understanding proper.

These comments apply to both conceptual "background knowledge" and to situational particulars of which we are cognizant in reference to our immediate surroundings and actions. This is the perceptual and operational surrounding that gets linguistically embodied in deictic reference and other contextual "groundings". Our situational awareness therefore has both a conceptual aspect — while attending a concert, or dining at a restaurant, say, we exercise cultural background knowledge to interpret and participate in social events — and also our phenomenological construal of our locales, our immediate spatial and physical surroundings. Phenomenological philosophers have explored in detail how these two facets of situationality interconnect (David Woodruff Smith and Ronald McIntyre in *Husserl and Intentionality: A Study of Mind, Meaning, and Language*, for instance). Cognitive Linguistics covers similar territory; the "cognitive" in Cognitive Semantics and Cognitive Grammar generally tends to thematize the conception/perception interface and how both aspects are merged in situational understanding and situationally grounded linguistic activity (certainly more than anything involving Artifcial Intelligence or Computational Models of Mind as are connoted by terms like "Cognitive Computing"). Phenomenological and Cognitive Linguistic analyses of situationality and perceptual/conceptual cognition (cognition as the mental synthesis of preception an conceptualization) can certainly enhance and reinforce each other.

But in addition, both point to a cognitive and situational substratum underpinning both first-person awareness and linguistic formalization proper — in other words, they point to the thematic limits of phenomenology and Cognitive Grammar and the analytic boundary where they give way to an overarching Cognitive Science. In the case of phenomenology, there are cognitive structures that suffuse consciousness without being directly objects of attention or intention(ality), just as sensate hyletic experience is part our consciousness but not, as explicit content, something we in the general case are conscious *of*. Analogously, conceptual and situational models permeate our interpretations of linguistic forms, but are not presented explicitly *through* these forms: instead, they are solicited obliquely and particularly.

What phenomenology *should* explicate is not background situational cognition but how attention, sensate awareness, and intentionality structure our orientation *vis-à-vis* this background: how variations in focus and affective intensity play strategic roles in our engaged interactions with the world around us. Awareness is a scale, and the more conscious we are of a sense-quality, an attentional focus, or an epistemic attitude, reflects our estimation of the importance of that explicit content compared to a muted experiential background. Hence when we describe consciousness as a stream of *intentional* relations we mean not that the intended noemata (whether perceived objects or abstract thoughts) are sole objects of consciousness (even in the moment) but are that within conscious totality which we are most aware of, and our choice to direct attention here and there reflcts our intelligent, proactive interacting with the lifeworld. Situational cognition forms the background, and phenomenology addresses the structure of intentional and attentional modulations constituting the conscious foreground.

Analogously, the proper role for linguistic analysis is to represent how multiple layers or strands of prelinguistic understanding, or "scripts", or "mental spaces", are woven together by the compositional structures of language. For instance, *The rescued dogs were treated by an exprienced vet* integrates two significantly different narrative frames (and space-constructions, and so forth): the frame implied by "rescued dogs" is distinct from that implied by "treated by a veterinarian". Note that both spaces are available for follow-up conversation:

(119) The rescued dogs were treated by an experienced vet. One needed surgery and one got a blood transfusion. We went there yesterday and both looked much better.

▾ (120) The rescued dogs were treated by an experienced vet. One had been struck by a car and needed surgery on his leg. We went there yesterday and saw debris from another car crash — it's a dangerous stretch of highway.

In the first sentence "there" designates the veterinary clinic, while in the second it designates the rescue site. Both of these locales are involved in the original sentence (as locations and also "spaces" with their own environments and configurations: consider these final three examples).

▾ (121) The rescued dogs were treated by an experienced vet. We saw a lot of other dogs getting medical attention.

▾ (122) The rescued dogs were treated by an experienced vet. It looked very modern, like a human hospital.

▾ (123) The rescued dogs were treated by an experienced vet. We looked around and realized how dangerous that road is — for humans as well as dogs.

What these double space-constructions reveal is that accurate language understanding does not only require the proper activated "scripts" accompanying words and phrases, like "rescued dogs" and "treated by a vet". It also requires the correct integration of each script, or each mental space, tieing them togther in accord with speaker intent. So in the current example we should read that the dogs *could* be taken to the vet *because* they were rescued, and *needed* to be taken to the vet *because* they needed to be rescued. Language structures guide us toward how we should tie the mental spaces, and the language segments where they are constructed, together: the phrase "*rescued* dogs" becomes the subject of the passive-voice *were treated by a vet* causing the two narrative strands of the sentence to encounter one another, creating a hybrid space (or perhaps more accurately a patterning between two spaces with a particular temporal and causal sequencing; a hybrid narration bridging the spaces). It is of course this hybrid space, this narrative recount, which the speaker intends via the sentence. This idea is what the sentence is crafted to convey — not just that the dogs were rescued, or that they were taken to a vet, but that a causal and narrative thread links the two events.

I maintain, therefore, that the analyses which are proper to linguistics — highlighting what linguistic reasoning contributes above and beyond background knowledge and situational cognition — should focus on the *integration* of multiple mental "scripts", each triggered by different parts and properties of the linguistic artifact. The *triggers* themselves can be individual words, but also morphological details (like plurals or tense marking) and morphological agreement. On this theory, analysis has two distinct areas of concerns: identification of grammatical, lexical, and morphosyntactic features which trigger (assumedly prelinguistic) interpretive scripts, and reconstructing how these scripts interoprate (and how language structure determines such integration).

In the case of isolating triggers, a wide range of linguistic features can trigger interpretive reasoning — including base lexical choice; word-senses carry prototypical narrativ and situational templates that guide interpretation of how the word is used in any given context. *Rescued*, for example, brings on board a network of likely externalitis: that there are rescuers, typically understood to be benevolent and intending to protect the rescuees from harm; that the rescuees are in danger prior to the rescue but safe afterward; that they need the rescuers and could not have reachd safety themselves. Anyone using the word "rescue" anticipates that their addressees will reason through some such interprtive frame, so the speaker's role is to fill in the details descriptively or deictically: who are the rescuees and why they are in danger; who are the rescuers and why they are benevolent and able to protect the rescuees. The claim that the word *rescue*, by virtue of its lexical properties, triggers an interprtive "script", is a proposal to the effect that when trying to faithfully reconstruct speaker intentions we will try to match the interpretive frame to the current situation.

The "script" triggered by word-choice is not just an interpretive frame in the abstract, but the interpretive *process* that matches the frame to the situation. This process can be exploited for metaphorical and figurative effect, broadening the semantic scope of the underlying lexeme. In the case of "rescue" we have less literal and more humorous or idiomatic examples like:

▾ (124) I'm going to rescue her from that boring conversation.

▾ (125) The trade rescued a star athlete from a losing team.

▾ (126) Your invitation rescued me from studying all night.

▾ (127) New mathematical models rescued her original research from obscurity.

▾ (128) Discovery of nearby earth-like planets rescued that star from its reputation as ordinary and boring and revealed that its solar system may actually be extraordinary.

- (129) His latest comments rescued him from the perception that he never says anything controversial.
- (130) The Soviets rescued thousands of people from a basically-defeated Germany and sent them to Siberia.

Each of these cases subverts the conventional "rescue" script by varying some of the prototypical frame details: maybe the "danger" faced by the rescuee is actually trivial (as in the first three), or the rescuee is not a living thing whose state we'd normally qualify in trms of "danger" or "safety", or by overturning the benevolence we typically attribute to rescue events. In the penultimate sentence someone is described as rescuing *themselves*, but the effect is ironic: he actually caused trouble for himself, or so the speaker clearly believes. And in the final sentence the speaker clearly believes the "rescue" was not needed, that it was not benevolent, and that the "rescuees" ended up worse off: so the choice of word "rescue" is clearly both ironic/sarcastic and implies a mockery of attempts to portray the rescuers as benevolent.

But in these uses subverting the familiar script does not weaken the lexical merit of the word choice; instead, the interpretive act of matching the conventional "rescue" script to the matter at hand reveals details and opinions that the speaker wishes to convey. The first sentence, for instance, uses "rescue" to connote that being stuck in a boring conversation (and being too polite to drift away with no excuse) is an unpleasant (even if not life-threatening) circumstance. So one part of the frame (that the rescuee needs outside intervention) holds while the other (that the rescue is in danger) comes across as excessive but (by this very hyperbole) communicating speaker sentiment. By both invoking the "rescue" script and exploiting mismactches between its template case and the current context, the speaker conveys both situational facts and personal opinions quite economically. Similarly, *rescue a paper from obscurity* is an economical way of saying that research work has been rediscovered in light of new science; *rescued from a bad team* is an economical way of connoting how an athletic career is less fulfilling on a poor team, and so forth.

All of these interpretive effects — both conventional and unconventional usages — stem from the interpretive scripts bound to words (and triggered by word-choice) at the underlying lexical level — we can assess these by reference to lexical details alone, setting aside syntactic and morphological qualities. Of course, then, a host of further effects are bound to morphological details when they *are* considered. Case in point are plurals: for each plural usage we have a conceptual transformation of an underlying singular to a collective, but how that collective is pictured varies in context. One dimension of this variation lies with mass/count: the mass-plural *coffee* (as in "some coffee") figures the plurality of coffee (as liquid, or maybe coffee grounds/beans) in spatial and/or physical/dynamic terms. So we have:

- (131) There's some coffee on your shirt.
- (132) There's coffee all over the table.
- (133) She poured coffee from an ornate beaker.
- (134) There's too much coffee in the grinder.
- (135) There's a lot of coffee left in the pot.
- (136) There's a lot of coffee left in the pot — should I pour it out?

These sentences use phrases associated with plurality (*all over*, *a lot*, *too much*) but with referents that on perceptual and operational grounds can be treated as singular — as in the appropriate pairing of *a lot* and *it* in the last sentence. With count-plurals the collective is figured more as an aggregate of discrete individuals:

- (137) There are coffees all over the far wall at the expresso bar.
- (138) She poured coffees from an ornate beaker.
- (139) There are a lot of coffees left on the table — shall I pour them out?

So mass versus count — the choice of which plural form to use — triggers an interpretation shaping how the plurality is pictured and conceived (which is itself trigggered by the use of a plural to begin with). But if we restrict attention to just, say, count-plurals, there ar still different schemata for intending collections:

- (140) New Yorkers live in one of five boroughs.
- (141) New Yorkers reliably vote for Democratic presidential candidates.
- (142) New Yorkers constantly complain about how long it takes to commute to New York City.

The first sentence is consistnt with a reading applied to *all* New Yorkers — the five boroughs encompass the whole extent of New York City. The second sentence is only reasonable when applied exclusively to the city's registered voters — not all residents — and moreover there is no implication that the claim applies to all such voters, only a proportion north of one-half. And the final sentence, while perfectly reasonable, uses "New Yorkers" to name a population completely distinct from the first sentence — only residents from the metro area, but not the city itself, commute *to* the city.

These examples demonstrate a point I made earlier, that mapping singular to plural is not a simple logical operation. We need to invoke narrative frames, interpretive scripts, and prelinguistic background knowledge to understand what *sort* of plurality the speaker intends. To be sure, the more subtle plurals can still be read in logical terms, and we can imagine sentences that hew more crisply to a logical articulation:

- (143) All New York City residents live in one of five boroughs.
- (144) The majority of New York voters support Democratic presidential candidates.
- (145) Many New York metro area residents complain about how long it takes to commute to New York City.

According to truth-theoretic semantics, sentences compel addressees to believe (or at least consider) logically structured propositions *by virtue of* linguistic shape replicating the architecture of the intended propositional complexes, as these would be represented in first-order logic. This view on linguistic meaning is consistent with the last three sentences, which are designed to map readily to logical notations (signaled by quasimathematical phrases like *the majority of*). But most sentences do not betray their logical form so readily: these latter sentences actually sound less fluent, more artificial, than their prior equivalents.

It is also true that the more "logical" versions are more, we might say, dialectically generalized because they do not assume the same level of background knowledge. Someone who knew little about New York geography could probably make sense of the latter sentences but might misinterpret, or at least have to consciously think over, the former ones. So we may grant that exceptionally logically-constructed sentences can be clearer for a broad audience, less subject to potential confusion, and indeed such logically cautious language is a normal stylistic feature of technical, legal, and journalistic discourse. But for this reason such discourse comes across as self-consciously removed from day-to-day language. As I argued from multiple angles earlier, in the typical case — i.e., stylistically neutral, day-to-day language — syntactic composition does not neatly recapitulate logical form.

My prior analysis demonstrated warrants for this idea by highlighting narrative and imagistic aspects of language used to convey ideas, like "come out against" providing the verb-phrases in reports of people criticizing something. Here, examples like (142)-(142) point to a similar conclusion, but from a more lexico-semantic orientation: words like *borough* and *commute* carry a space of logical details that tend to force logical interpretations one way or another (e.g., the detail that the territory of a city is fully partitioned by boroughs, *so*, it is *all* citizens who live in a borough). This part of the logic is however not reflected in sentence-structure; it is, rather, latent in lexical norms and assumed part of understanding relevant sentences only because linguistic competence is understood to include familiarity with the logical implications of the lexicalized concepts: e.g. that the quantification in "New Yorkers live in one of five boroughs" is *all*, but the quantification in "New Yorkers vote democratic" is *most*.

Here I'll also add the following: the current examples show how if addressees *have* the requisite background knowledge, linguistic structure does not have to replicate logical structure very closely to be understood. The content which addressees undrstand may have a logical form, and language evokes this form — guides addressees toward considering specific propositional content — but this does not happen because linguistic structure in any precise way mimics, replicates, reconstructs, or is otherwise organized propositionally. Instead, the relation of language to predicate structures is evidently oblique and indirect: language triggers interpretive processes which guide us toward propositional content, but the structure of language is shaped around fine-tuning the activation of this background cognitive dynamics more than around any need to model predicate organization architecturally. In the case of plurals, the appearance of plural forms like *New Yorkers* or *coffees* compels us to find a reasonable cognitive model for the signified multitude, and this model will have a logical form — but the linguistic structures themselves do not in general model this form for us, except to the limited degree needed to activate prelinguistic interpretive thought-processes.

I make this point in terms of plural *forms*, and earlier made similar claims in terms of lexical details. A third group of triggers I outlined involved morphosyntactic *agreement*, which establishes inter-word connections which themselves trigger interpretive processing. Continuing the topic of plurals, how words agree with other words in singular or plural forms evokes schema which guide situational interpretations. So for instance:

- (146) My favorite band gave a free concert last night. They played some new songs.
- (147) There was some pizza earlier, but it's all gone.
- (148) There were some slices of pizza earlier, but it's all gone.
- (149) There were some slices of toast earlier, but there's none left.
- (150) There was some toast earlier, but they're all gone.
- (151) That franchise had a core of talented young players, but it got eroded by trades and free agency.
- (152) That franchise had a cohort of talented players, but they drifted away due to trades and free agency.
- (153) Many star players were drafted by that franchise, but it has not won a title in decades.
- (154) Many star players were drafted by that franchise, but they failed to surround them with enough depth.
- (155) Many star players were drafted by that franchise, but they were not surrounded with enough depth.
- (156) Many star players were drafted by that franchise, but they did not have enough depth (around them).

Plurality here is introduced not only by isolated morphology (like *slices*, *players*, *songs*), but via agreements marked by word-forms in syntactically significant pairings: was/were, it/they, there is/there are. Framing all of these cases is how we can usually schematize collections both plurally and singularly: the same set can be cognized as a collection of discrete individuals one moment and as an integral whole the next. This allows language some flexibility when designating plurals (as extensively analyzed by Ronald Langacker: see his discussion of examples like *Three times, students asked an interesting question*). A sentence discussing *slices of pizza* can schematically shift to treating the pizza as a mass aggregate in *it's all gone*. Here the antecedent of *it* is *slices* (of pizza). In the opposite direction, the mass-plural "toast" can be refigured as a set of individual pieces in *they're all gone*. The single *band* becomes the group of musicians in the band. In short, how agreements are executed invites the addressee to reconstruct the speaker's conceptualization of different referents discussed by a sentence, at different parts of the sentence: linking *it* to *slices* or *cohort*, or *they* to *the band* or *the toast*, evokes a conceptual interpretation shaped in part by how morphosyntactic agreement overlaps with "semantic" agreement. Matching *they* to *the band* presents agreement in terms of how we conceive the aggregate (as a collection of musicians); using "it" would also present an agreement, but one schematizing other aspect of the band conecpt.

In the last five above cases, *it* similarly binds (being singular) to *the franchise* seen as a single unit — here basic grammar and conceptual schema coincide — but *it* also binds to the *core of young players*. The players on a team can be figured as a unit or a multiple. The franchise itself can be treated as a multiple (the various team executives and decision-makers), as in *they failed to surround the stars with enough depth*. The last sentence is ambiguous between both readings: "they" could designate either the players or the franchise. Which reading we hear alters the sense of "have": asserting that the star *players* lack enough depth implies that they cannot execute plays during the game as effectively as with better supporting players; asserting that the *franchise* lacks depth makes the subtly different point that there is not enough talent over all. The variant which would include "around them" nudges toward the second reading; but it is still permissible to, according to speaker intent, parse the last *they* as designating the *franchise* and the last *them* as the *players* — i.e., that final *they*/*them* pair having different antecedents.

The unifying theme across these cases is that when forming sentences we often have a choice of how we figure plurality, and moreover these choices can be expressed not only in individual word-forms but in patterns of agreement. Choosing to pronominalize *slices of pizza* or *cohort of players* as *it*, or alternatively *they*, draws attention to either the more singular or more multitudinal aspects of the aggregate in question. But this effect is not localized to the individual *it*/*they* choice; it depends on tracing the pronoun to its antecedent and construing how the antecedent referent has both individuating and multiplicity-like aspects. Thus both individuation and plurality are latent in phrases like *slices of* or *cohort* *of*, and this singular/plural co-conceiving is antecedently figured by how subsequent morphosyntax agrees with the singular or, alternatively, the plural.

Moreover, these patterns of agreement invoke new layers of interpretation to identify the proper conceptual scope of plurals. In *The band planned a tour, where they debuted new songs* we hear the scope of "they" as narrower than its antecedent "the band", because only the band's *musicians* (not stage crew, managers, etc.) typically actually perform:

- (157) The band planned a tour, where they debuted new songs.
- (158) The team flew to New York and they played the Yankees.
- (159) The city's largest theater company will perform "The Flies".

Likewise in (), only the athletes are referenced via *they played*; but presumably many other people (trainers, coaches, staff) are encompassd by "the team flew". And in () we do not imply that the Board of Directors will actually take the stage (the President as Zeus, say). Even in the course of one sentence, plurals are reinterpreted and redirected:

- (160) The city's largest theater company performed "The Flies" in French, but everyone's accent sounded Quebecois.
- (161) The city's largest theater company performed "The Flies"; then they invited a professor to discuss Sartre's philosophy when the play was over.

In the first sentence, the "space" built by the sentence is wider initially but narrows to encompass only the actual actors on stage. In the second, the "space" narrows in a different direction, since we hear a programming decision like pairing a performance with a lecture as made by a theater's administrators rather than its actors. I discussed similar modulation in conceptual schemas related to plurality and pluralization earlier; what is distinct in these last examples is how the interpretive processes for cognizing plurality are shaped by agreement-patterns (like *it* or *they* to a composite antecedent) as much as by lexical choice, or morphology, in isolation.

I have accordingly outlined a theory where lexical, morphological, and morphosyntactic layers all introduce "triggers" for cognitive processes, and it is these procsses which (via substantially prelinguistic perception and conceptualization) ultimately deliver linguistic meaning. What is *linguistic* about these phenomena is how specifically linguistic formations — word choice, word forms, inter-word agreements in form — trigger these (in no small measure pre- or extra-linguistic) interpretations. But as I suggested this account is only preliminary to analysis of how multiple interpretive processes are *integrated*. Linguistic *structure* contributes the arrangements through which the crossing and intersecting between interpretive "scripts" are orchestrated. Hence at the higher linguistic scales and levels of complexity, the substance of linguistic research, on this view, should gravitate toward structural intgration of interpretive processes, even more than individual interpretive triggers themslves.

This higher scale is my focus in the next section — seen from the perspective of formal and computational models as well as everyday language use.

7 Procedures and Integration

So far I have criticized paradigms which try to account for linguistic meaning via concordance between linguistic and proppositional structure. The logical dimension to language is real, but it is not neatly ordered in the syntax/semantics interface. My slogan is that *syntactic comppsition does not recapitulate logical form.*

I believe that a lot of linguistics and philosophies of language obscure this point by virtue of commitments to two reasonable theses: *one*, that logical form is an important (and often the central) dimension of meaning, and *two* that language is compositional. But while language expresses propositional content — i.e., in many cases language "means" the way that propositions "mean" — language is not *compositional*, in general, the way that propositions are compositional. So compositionality and logicality have to be disentangled, and I contend linguistics and philosophies of language have failed to do so. Moreover, as I argued in Section 4, I think this can be explained by the historical roots of philosophy of language — and by extension linguistics — in Analytic Philosophy, which in turn has a specific history and collaboration with formal logic.

This critique has two dimensions: first, although a predicate structure, a predicative specificity, does indeed permeate states of affairs insofar as we engage them rationally, such logical order is not modeled by language itself so much as by cognitive pictures we develop via interpretive processes — processes *triggered* by language details but, I believe, to some not insubstantial degree pre- or extra-linguistic. Moreover, second, insofar as we *can* develop formal models of language, these are not going to be models of predicate structure in any conventional sense.

Cognitive-interpretive processes may have formal structure — structure which may even show a lot of overlap with propositional forms — but these are not *linguistic* structures. Insofar as language triggers but does not constitute interpretive "scripts", the scripts themselves (i.e., conceptual prototypes and perceptual schema we keep intellectually at hand, to interpret and act constructively in all situations, linguistic and otherwise) are not linguistic as such — and neither is any propositional order they may simulate. Language *does*, however, structure the *integration* of *multiple* interpretive scripts, so the structure of this integration *is* linguistic structure *per se* — and formally modeling such integration can be an interesting tactic for formally modeling linguistic phenomena. However, we should not assume that such a formal model will resemble or be reducible to formal logic in any useful way — formalization does not automatically entail some kind of *de facto* isomorphism to a system of logic (if not first-order then second-order, modal, etc.).

Instead, I want to focus in on branches of computer science and mathematics (such as process algebra, which I have already referenced) as part of our scientific background insofar as the *structural integration* of diverse "processes" (computational processes in a formal sense, but perhaps analogously cognitive processes in a linguistic sense) can be technically represented.

In "truth-theoretic" semantics, artifacts of language are intuitively pictured in terms of propositional structure. The guiding intuition compares word meanings to logical predicates; e.g. *John is married* is typically said when the speaker believes that, in fact, the predicate *married* applies to the speaker *John*. Switching to a more "procedural" perspective involves intuiting word-meaning more in terms of interpretive procedures than logical predicates. The change in perspective may not yield substantially different analyses in all cases, but I believe it does affect many cases.

Even a simple predicate like "married" reveals a spectrum of not-entirely-logical cases in ordinary language:

- (162) John is married to a woman from his home country, but he had to get the marriage legally recognized here.
- (163) John married his boyfriend in Canada, but they live in a state that does not recognize same-sex marriages.
- (164) John has been married for five years, but in many ways he's still a bachelor.
- (165) Every married man needs a bachelor pad somewhere, and wherever yours is, you need a mini-fridge.

We can make sense of these sentences because we do not conceptually define lexemes like *married* or *bachelor* via exhaustive logical rules, like *a bachelor is an unmarried man*. Instead we have some combination of prototypical images — familiar characteristics of bachelors, say, which even married men can instantiate — and a conceptual framework recognizing (and if needed distinguishing) the various legal, societal, and dispositional aspects of being married.

Intuitionwise, then, we should look beyond potential logical glosses on meanings — even when these are often accurate — and theorizee semantics as the mapping of lexical (as well as morphosyntactic phenomena) to interpretive scripts and conceptual or perceptual/enactive schema — which we can collectively designate, for sake of discussion, as "cognitive procedures".

The truth-theoretic mapping of words to predicates (and so phrasal and sentence units to propositional structures) provides an obvious way to formalize linguistic structure by borrowing the analogous structuration from predicate complexes. Substituting a procedural semantic model allows a comparable formalization of linguistic structure through theories exploring procedural integration, for instance the interactions between computational procedures. Analysis of *computational* produres can yield interesting ideas for linguistic theories of *cognitive* procedures — without endorsing a reductive metaphysics of cognitive procedures as "nothing but" computational procedures implemented in some sort of mental software.

I earlier used computing procedures roughly sketched — like code which may open a file (61) — as loose metaphors for cognitive processes; my point before was that both cognitive and computational processes can be hard to gloss logically because they are often dealing with incomplete logical information. More seriously — because *incomplete* logical information is not necessarily outside of logic; there are logical systems which can model information partiality in systematic ways — processes which occur in the midst of logically incomplete spaces (in the context of message-passing, function-routing, etc.) do not nessarily *operate* logically. That is, local rules for message-passing or function-routing systems do not seem to be (in their "native" semantics) logical rules. In the current context, I want to consider in greater detail the interoperation *between* computational procedures, to consider how procedures form "networks" and whether this is a useful analogy for cognitive/linguistic processes.

7.1 Procedural Networks as a Cognitive/Linguistic Metaphor

The notion of computational procedures is certainly not foreign to symbolic logic or to analyses often associated with logistical models (in linguistics and philosophy, say), like Typed Lambda Calculus. In those paradigms we certainly have, say, an idea of applying formulae to input values (where formulae can be seen as referring to or as compact notations for computational procedures). Comparing the results of two formulae yields predicates (e.g., equalities or greater/less-than relations of quantity) that undergirds predicate systems. Furthermore, combining formulae — plugging results of one formula into a free variable in another — yields new formulae that can in turn be reduced to different forms or to single values, either for all inputs or for particular inputs. In short, a large class of computational procedures can be modeled in predicate and equational or formula-reduction terms. I point this out because shifting to a "procedural" intuitive model does not *by itself* take us outside of logistic and truth-thoretic paradigms.

And yet, in computer science, theories of procedural networks begin to branch out from formal logic or lambda calculii when we move past the "mathematical" picture of procedures — as computations that accept a collection of inputs and return a collection of outputs — and theorize procedures more as computational modules that input, output, and modify values from multiple sources, in different ways. In practical technology, this includes developments like Object-Oriented computer languages and programming techniques such as Exceptions and mutable references. Likewise, real-world code can pull information from many sources — like databases, files, and networks (including the internet) — in addition to values input as parameters to a function. Conversely, functions have many ways to modify values — many ways to manifest side-effects — beyond just returning values as outputs. Collectively these various channels of communication — wherein different procedures can exchange values in different ways — are often described as "inpure", by contrast to "pure" functions which use only a single input channel for (non-modifiable) input parameters and a single output channel.

The design and implementation of computer programming languages — sometimes called "Software Language Engineering" — is partly a theoretical discipline (because programming languages are based on formal systems that can be studied mathematically, like Lambda Calculus), but also very pragmatic. Computer languages are judged by practical considerations, like how efficiently they allow programmers to create quality software. The impetus for new programming techniques often comes from the practical side: mainstream languages began to incoporate features like Object-Orientation and Exceptions (which are a mechanism to interrupt normal program flow when coding assumptions are violated) because these features proved useful to programmers. At the same time, various "inpure" features can still be modeled at the theoretical level — there are extensions to Lambda Calculus with Exceptions and/or Objects, as well as "effect systems" that systematically model functional side-effects via Type Theory. In this case, though, the thoretical models are partly isolated or even lag behind the evolution of practical coding techniques.

It is also true that "inpure" code can always be refactored into a code base that uses only "pure" functional-programming techniques. That is, at least if we exclude the "cyberphysical" layer — the body of code that directly measures or alteres physical data, like writing text to a computer screen or reading the position of a mouse — any self-contained collection of "inpure" functions can always be re-implemented as a system of pure "mathematical" functions, using only one-dimensional, immutable input and output channels (this is not necessarily true of single functions, but abstractly true of complete code *bodies* encompassing many functions, i.e., many implemented procedures). Analogously, any computing environment based on a type system that incorporates impure function-types can be recreated on top of a different type system that recognizes only pure functions. For sake of discussion, define a *procedure space* as a self-contained network of computational procedures, where each procedure has the ability to invoke other procedures in the network. We can then say that any procedure space developed with the benefit of "impure" coding styles (like Objects, Exceptions, and side-effects) is *computationally isomorphic* to a procdure space implemented exclusively in a pure-functional paradigm.

This principle might suggest that the pure/impure distinction is superficial, and so that any computing environment is actually manifesting a purely logical framework, because it is (in one sense) isomorphic to a structur which *can* be thoroughly modeled via formal logic. However, this reductionism actually reveals the limits of "computational" isomorphism in the abstract. Impure procedure-spaces are not *equivalent* to their pure isomorphs. The whole rationale for "impure" coding techniques — Object-Orientation, functions with side-effects, etc. — is that the resulting code better models empirical phenomena and/or how programmers themselvs reason about software design. Any notion of computational isomorphism which is *itself* prejudiced toward formal logic will fail to model how systems which are isomorphic *on these* (already logical) *terms* will nevertheless vary in how organically they model empirical and mental phenomena. If engineers discover that Object-Oriented paradigms produce more effective software for managing biomedical data — that is, biomedical concepts are usefully modeled in terms of semiautonomous computational "objects" whose properties and functionality are enginereed via many discrete, partially isolated software components — this suggests how Object-Oriented structures may be a more natural systematization of the underlying biomedical reality. Object-Oriented software can *in principle* be redesigned without Objects, but the resulting code base would then be a weaker semantic "fit", a less faithful computational encoding, of the external information spaces that the software needs to model and simulate.

I contend that this duality between Object-Oriented and pure-functional programming is analogous to the paradigmatic contrast between cognitive and truth-theoretic semantics. On this analogy, pure-functional programming can be associated with truth-theoretic semantics in that both are founded on formal systems that more or less straightforwardly operationalize first-order logic — a logic with quantification and with sets or types modeling collections, but whose foundational units are boolean predicates and elementary formulae rather than proceures with multiple "channels of communication" and potentially many intermediate states. Reducing impure (e.g., Object-Oriented) code to pure-functional procedure spaces is analogous to providing truth-theoretic reconstructions of linguistic meanings, as in (revisiting examples from prior sections):

- (166) People had fed the rescued dogs (i.e.: before they were rescued).
- (167) New Yorkers vote democratic (i.e.: the majority of registered voters in New York do so).
- (168) There is milk in that coffee (i.e.: almond milk).
- (169) I handed him a bottle opener (i.e.: a butterfly corskscrew).
- (170) That wine is Fabernet Franc (i.e.: "W is CF").

Propositional reconstructions of sentences like these can capture a logical substrate that contributes to their meaning, but completely *reducing* their semantics to such logical substrata jettisons, I have argued, interpretive and contextual schemata which are equally essential to their meaning. Analogously — considered in relation to data that it must curate and model (so that pople may manage and aggregate data; for instance, collect biomedical data to ensure proper diagnoses and implement tratments) — software does not only represent the logical substrata undrlying information systems. It needs to capture conceptual and operational/logistical phenomena as well.

Along these lines, note that Object-Oriented techniques originally emerged from scientific-computing environments, to model complex systems, with multiple levels of organization, emergent structure, and so forth (in the 1990s these techniques were then applied to more enterprise-style applications, for User Interface design, business operations workflows, etc.). The effectiveness of Object-Oriented models suggests that as a form of computing environment, and a framework for coding procedure-spaces, Object-Orientation captures structural properties of complex systems more richly than paradigms that reduce procedural implementations to a purely logical substratum. This observation can then generalize to the whole range of modern-day programming techniques and all the various domains where software is used to monitor, simulate, and manage information about natural and human phenomena.

Technically, the multi-dimensional structure of computational procedures implemented with modern coding techniques — multi-dimensional in the sense of multiple forms of channels of communication and functional side-effects — demands new conceptualizations of the formal architecture of computing environments as such. Rather than seeing computer software, for example, as a complex system built architecturally from predicate logic, we need to undrstand software as a procedure-space or procedural network receptive to external information. On this account, a software application internally possesses a set of capabilities, and achieves this functionality by invoking different procedures which are implemented in the software; the application as a whole is the aggregate of its procedural building-blocks. Which procedures get invoked depends on user actions — we use a mouse, keyboard, and other input devices to trigger responses from the software. Applications are therefore built around an "event loop": the software can enter a passive state, performing no operations apart from monitoring physical devices to detect user actions. Once an action does occur — we press a letter on a keyboard, say, or press a mouse button — the application responds by invoking a specific procedure, which in turn may trigger a complex cascade of other procedures, to complete whatever operation we requested via our action (saving a file, selecting one record to visualize from a database, etc.). Via such networks of procedures and functionality, software models and simulates empirical phenomena — at least enough so that we can maintain databases, remotely operate machines, and in other ways track and manipulate physical states.

Consequently, computer models of empirical phenomena can take the form of *procedural networks*, and we can designate the design and theory of such models as *procedural modeling*. I have argued that procedural networks are not reducible to logical predicate systems even though procedure-spaces in general are (in a certain sense) isomorphic to procedure-spaces which are more purely logical, or employ pure-functional type systems. The "isomorphism" relevant here, I am arguing, eliminates semantic and simulative structures that make procedural models effective constructions conveying the organization and behavior patterns of complex, real-world phenomena. On this theory, procedural modeling is a more effective tool for representing real-world systems than are computing environments built more mechanistically from predicate logic.

Interestingly, however, the predominant contemporary paradigms for modeling real-world information systems — particularly what has come to be called the "Semantic Web" — is built on a framework of description logic and "knowledge graphs" rather than (at least except very indirectly) anything that could be called "procedural data modeling" [96], [8], [88]. There is, of course, a robust ecosystem of network-based code-sharing that provides a viable infrastructure for a more procedural data-sharing paradigm. To illustrate the contrast, consider the problem of biomedical data integration: of merging the information known to two different mdical entrprises, as when a patient moves between two different hospital systems. We can assume that each hospital uses a different set of software tools to store patient records and manage data from their various secondary or constituent sources (diagnostic labs, specialized departments, outside clinics, etc.). Such multi-faceted data then needs to be translated from formats native to the prior hospital's software to formats needed by the new hospital.

Such data-intgration problems tend to be conceptualized in one of two ways. One approach is to seek a common representation, or an overarching unified model, which can reconcile structural differences between the two systems. If both hospitals use the same biomedical "Ontologies", for example, then those Ontologies serve as a logical paradigm through which the distinct systems can be bridged. In effect, structural differences between the systems are treated as superficial variations on a common or unified logical "deep structure" — analogous to translating between natural languages by mapping sentences to a propositional core. Indeed, the field of "Ontology Engineering" can be seen as a way of marshaling abstract logic into a form that is practically useful for information storage and extraction, in open-ended environments where data may be aggregated from many heterogeneous sources. The term "Ontology" in this context is not wholly unrelated to its philosophical meaning, bcause "knowledge engineers" assuming that the primordial structuring paradigms of such "universal" logical systems are relations and distinctions investigatd by the philosophical ontological tradition — substance and attribute, part and whole, time-point vs. time-span, spatial region vs. spatial boundary, subtype and supertype, and so forth. Abstract Ontological systems are then formalized into logical rules that provide an axiomatic core — sometims called "Upper" Ontologies — which are then extended via empirical models or "domain-specific" rules to create Domain-Specific Ontologies used to integrate data in concrete enterprise/scientific fields (medical information, government records, and so forth).

The overarching paradigm of such Ontology-based integration is the idea of a logical model that recognizes superficial differencs between incompatible (or at least not fully compatible) data sources. An alternative approach to data integration problems is to treat these as issues of procedural capability. In order to import data from one hospital into a second hospital system, for example, assuming their respective software and databases are at least somewhat incompatible, you need to perform certain procedures that translate data from the first format to the second. Insofar as this is possible, the two software systems have a certain procedural synergy: the capabilities of the first system include exporting data in a format the second can use, and the capabilities of the second system include integrating data presented in formats that the first can export. This synergy does not need to be theorized in terms of an overarching logical ur-space which both systems indirectly manifest; instead, it reflcts how some subset of the overall procedural network germane to each respctive software system includes — either by deliberate cooperative enginering or because the two systems are guided by similar standards and technical orientations — procedures on the two ends that can be aligned in terms of the kind of data and data-formats they produce and/or consume. In short, targeted (and potentially cooperatively-engineered) procedural alignments — rather than overarching logical commonalities — form the bedrock of data integration.

These contrasting paradigms are not only theoretical. Computer scientists hafve actually tried to promote data sharing and data integration to improve governance, health care, urban infrastructure (via "smart cities"), sustainable development, and so on. Insofar as we see data integration in terms of Ontology Engineering, these practical goals can be met with the curation and publication of formal Ontologies that can guide software and database development. Data sharing is then driven by Ontological alignment — the Semantic Web, for example, designed as an open repository of raw data annotatd and structured in accord with publishd Ontologies, data which can be reused and integrated into different projects more readily because it adopts these published models. On the other hand, insofar as we see data sharing in terms of *procedural alignment*, we prioritize the curation and publication of procedure implementations, in the form of software libraries, open-source code repositories, and other building-blocks of modular software design. Consider again the case of data integration between two hospitals: to integrate data between the two, programmers may need to implement special "bridge functions" that reconcile their respective formats. This implementation is simplified insofar as the respective software systems are well-organized and transparent — so that programmers can examine import and export functions in the two code bases and write new procedures, extending their respective capabilities, so that import functionality on one end can be aligned to export functionality on the other. These new procedures can then be shared so that similar data integration problems — for instance the first hospital sharing data with a third — can be solved more readily, reusing some of the code thereby developed. This approach to data integration emphasizes transparency, modularity, and code-sharing.

Rather than seeing the Semantic Web as a network of raw data conforming to published Ontologies, the more procedural perspective would see endeavors like a Semantic Web as driven by code sharing: open repsoitories of procdural implementations that can be used to reconcile data incompatibilities, pull data from different sources, document data structure and representation formats, etc. Decentralized networks like the Semantic Web would then be characterized by the free exchange of procedural implementations, so that enginers can pull procdures providing different capabilities togther, to assemble fully-featured software platforms. Code libraries would play a homogenizing role in this paradigm analogous to Ontologies in the Semantic Web. And, indeed, there exists a mature and sophisticated technical infrastructure for publishing software componenrs and maintaining code repositories, forming the productive underbelly of the Open-Source ecosystem ("git" version control, the GNU Compiler Collection, Linux distributions, etc.). However, the Semantic Web and Open Source development communities are largely separate, apart from the practical given that many Semantic Web technologies are distributed as Open-Source software. Despite the *practi-*

cal adoption of Open-Source norms, the Semantic Web community has arguably not engaged the Open-Source community at a deeper theoretical level, in terms of how the curation of public, collaborative code libraries can promote data integration analogous in effect to (but arguably semantically more accurate than) Semantic Web Ontologies — in light of critiques that the logical intuitions behind the Semantic Web create a distorted and oversimplified theory of what semantics is all about (in the words of Peter Gärdenfors, "The Semantic Web is not very Semantic").

7.2 *Phenomnology and the Semantic Web*

These questions bear directly on phenomenology, because philosophers in the phenomenological tradition have directly influenced the evolution of the Semantic Web — notably Barry Smith, who has both published sophisticated theoretical work on Ontologies in the Semantic Web sense and also spearheaded practical initiatives like the OBO (Open Biological and Biomedical Ontology) Foundry. The OBO Foundry emerged in the mid-2000s, on the heels of a renewed interest in phenomenology as a philosophical basis for Cognitive Science and other practical/technical disciplines, like knowledge engineering. It is not hard to see practical artifacts like the OBO system as concrete realizations of theoretical goals articulated in volumes such as 1999's *Naturalizing Phenomnology*. This association is not only at the level of scholarship — the academic papers describing OBO, for example — but also the design and organization of Semantic Web tools like the OBO Foundry, as technologies and platforms.

Seen in those terms — and if we restrict attention to work done by scientists like Barry Smith and his colleagues who are actively enagaged in both the phenomenological and computer-science communities — Semantic Web technology suggests a paradigm wherein "Naturalizing" Phenomenology involves isolating logical structures which are at once essential to modeling empirical data and also emerge organically from phenomenological accounts of perception and cognition — that is, capturing the logical order of our experiencing the world as well as of the facts experienced. A case in point is formalizing systems of "mereotopology" — combining the mereological account of part vs. whole with "topological" models of spatial continuity, locality, and boundary — which reflect both perceptual schema and information gestalts. So one the one hand the fusion of mereological and topological relations gives us a vocabulary for describing how we experientially apprehend spatial forms — the continuity, regionality, intersections, and disjunctions between visual (and sometimes tactile) elements that gives logical articulation to visual/tactile sense data (never experienced only as "raw" sensation since we fundamentally experience space and visual continuity in these structured forms). Meanwhile, on the other hand, Mereotopology provides a semantic matrix for representing facts and relations in biological, geographical, and other scientific data, so it serves a practical information-management role. In short, isolating logical gestalts and then codifying them in practically useful forms serves to "Naturalize" phenomenology by anchoring phenomenological reflection in applied science.

The general implication of this "Naturalizing" strategy is that phenomenology becomes naturalized, or reconciled with the physical sciences, insofar as structures of consciousness can be aligned with logical systems. This strategy seems to extend beyond just the Semantic Web projects I have highlighted; it is likewise evident for example in Kit Fine's logical mereology in Barry Smith and David Woodruff Smith *Cambirdge Companion to Husserl* [30]. Indeed Husserl himself invites us to consider the logical formalization of phenomenological systems in works like the *Formal and Transcendental Logic*, which appears to suggest that human conceptual systems are an even more refined manifestation of logical systems than are "formal" logics which get entangled in model-thoretic problems like the Löwenheim-Skolem thorem. In other words, systems of formal logic are codifications of a mental order and therefore natural cadidates for a technical representation of the mental realm in its structure and specificity.

However, we can also observe that Husserl was writing at a time when abstract logic was still the preeminent phenotype for systematic exposition of formal structures in general — this was before computer programming and even before mathematical developments like Category Theory. In the first half of the last century, someone hoping to create a formal and systematic representation of cognitive processes would gravitate toward symbolic logic simply because mathematicians and philosophers at the time followed the general intuition that *any* formal structure was essentially characterized by its logical/axiomatic foundations. A century later, formal logic has been displaced from the germinal origins it was once assigned. For mathematicians, logic itself is revealed to be a kind of emergent system that depends on Categorial definitions like limits and colimits, and can vary across Categories — there are different logics for different kinds of Categories. As such it is not logic itself but the properties and contrasts between Categories which is the truly primordial foundation of logico-mathematical thought. A contemporary logico-mathematical formulation of phenomenology may therefore try to establish a Category-Theoretic grounding rather than a logical one as ordinarily understood. A case in point would be how Jean Petitot situates phenomnological analysis in certain soecific genres of Categories, like sheaves and presheaves, in his "Morphological Eidetics" chapter in *Naturalizing Phenomenology* [66] and elsewhere.

Petitot's and Barry Smith's formalizing projects were parallel and collaborative to some extent. Maxwell James Ramstead in a 2015 master's thesis reviews the history elegantly:

> Now, the "science of salience" proposed by Petitot and Smith (1997) illustrates the kind of formalized analysis made possible through the direct mathematization of phenomenological descriptions. Its aim is to account for the invariant descriptive structures of lived experience (what Husserl called "essences") through formalization, providing a descriptive geometry of macroscopic phenomena, a "morphological eidetics" of the disclosure of objects in conscious experience (in Husserl's words, the "constitution" of objects). Petitot employs differential geometry and morphodynamics to model phenomenal experience, and Smith uses formal structures from mereotopology (the theory of parts, wholes, and their boundaries) to a similar effect.

Except, there are interesting contrasts between the Cognitive-Phenomenological adoption of mereotopology (by Barry Smith and also Roberto Casati, Achille C. Varzi, Kit Fine, Maureen Donnelly, etc.) — which stays within a more classical logical paradigm — and Petitot's Morphological Eidetics, which is more Category-Theoretic.

Meanwhile, contemporary formalizations of phenomenological analyses can also gravitate toward a more concrete and computational framework — simulating cognitive processes via software or comparing artificial constructions of perceptual objects (via Virtual Reality, 3D graphics, 3D printing, robotics, etc.) to lived exprience [72]. In particular, graphics engineers have a rich theory about how to create realistic (albeit not truly life-like) 3D models and scenes. The mathematical and computational elements in this theory — triangular, quadrilateral, and polygonal meshes; shader algorithms; "NURBS" (Non-Uniform Rational Basis Spline) surfaces; textures and *uv*-mapping; camera matrices; diffusion and stochastic processes — create a formal model of perceptual phenomena insofar as these can simulated *to a close approximation*: visual phnomena artificially built with these techniques can be *almost* realistic.

The gaps between such "virtual" scenes and real life may suggest that there are additional facets suffusing "real life" perception, or even that despite their realism the mathematical building-blocks of CGI-like scenes are fundamentally different from the formal structures governing nurophenomenological perception. But nevertheless the almost lifelike realism that *can* be achieved via Computer Graphics is a data-point that phenomenology should acknowledge: that a perceptual world built out of certain rigorously mathematical constituents can feel almost lifelike when apprehended as if it were a real visual-perceptual surrounding. In particular, Computer-Generated Imagery can evoke the same embodied engagement and intentional patterns as non-artificial, ambient perception so long as we accept a certain "suspension of disbelief", or mentally adjust to the phenomenological limitations of seeing visual tableau on a two-dimensional screen — analogous to watching movies or television. Despite the phenomenological chiasma of directing visual attention to a 2D screen — it feels "not quite right" — we can still become engaged and largely immersed in the visual scenes before us; which means that full phenomenological realism is not prerequisite for our intentional comportment toward visual (and auditory) phenomena.

We can then observe that constructed scenes built entirely from mathematical structures carry comparable potential for intentional engagement. Moreover, Panoramic Photography and Immersive Visual Reality present another genre of phenomenological immersion that transcends the limitations of the 2D screen — though still without full realism, because however lifelike the visual content we may perceive with, say, 3D goggles, we still are not engaging tactilely and kinaesthetically with the world in the usual ways.

In short, one route toward a formal framework for elucidating perceptual-phenomenological content is to examine realistic simulations of visual contents as computational artifacts — not in terms of abstract formulations (logical or otherwise) but in terms of concrete computer code and software. With reference to Mereotopology, for example, we can contrast the logical groundwork set out by Barry Smith (for example) with the differential-geometric and category-theoretic landscape considered by Jean Petitot *and also* a more "experimental", software-driven intuition associated with, for example, Virtual Reality research. Looking at mereotopology in particular, this more computational approach can examine how part-whole relations are created within CGI and Computer Aided Design by mesh alignment or texture mapping, or how texture and diffusion algorthms create effects of material continuity and locality. In this case mereotopological notions are not embedded in logical systems — or even, from a computational perspective, in formal Ontologies — but rather latent in graphics code.

For scholars pursuing a "Naturalized" phenomenology, then, we (in the 2010s and 2020s) have several avenues to choose from, including logical formalism (including as practically leveraged in the Semantic Web) but also mathematical formalization (as with Category Theory and Differential Geomtry) and, also, computationally. Computer Aided Design and Computer Generatd Design point to a theory of formal structures producing life-like (if not perfectly realistic) perceptual content. Analogously, computational models of linguistic structure can help represent the organizing principles of our reasoning toward language understanding — even if these formal models are not proposed as direct simulations of natural linguistic cognition.

Simultaneously, real-world applied projects — like the Semantic Web, Virtual Reality, or CGI/CAD technology — can be seen as practical test-beds for the realism and analytic potential of formal-phenomenological frameworks. In some cases, like the OBO Foundary, the link between applied technology and phenomnology is explicit (at least at the level of institutional and intellectual history); in others, as with VR and CGI, this link is more implicit and thematic (but still addressed by interdisciplinary research grounded in phenomenology and Husserl scholarship). But in any case technological experience retroactively seems to shape the direction of phenomenological research, while at the same time phenomenology has, for some researchers, provided a metatheortic and metaphysical guideline.

Here the Semantic Web presents an interesting case-study, because the manifestation of phenomenological themes (e.g., Mereotopology) in a practically useful resource like Biomedical Ontologies suggests an *ex-post-facto* vindication of *logical* formalization as a "Naturalizing phenomenology" project. On the other hand, critiques of the Semantic Web — which have emerged, among elsewhere, from Cognitive Linguistics — can accordingly be studied as potential indications of how classical logical formalism is limited in the phenomenological context. Peter Gärdenfors, for example, has critiqued the Semantic Web on theoretical grounds while also developing a model of Natural Language semantics (via Conceptual Space Theory) that we may find more phenomenologically realistic than the Semantic Web's (as Gärdenfors puts it) "syllogistic" paradigms. Here, I propose a critique from a more "procedural" angle. From my perspective, the foundational characteristic of "information systems" is the existence of *procedures* (say, cognitive and/or computational procedures) which "act on" (aggregate, interpret, reshape) the data at hand. I believe it is a fair critique to say that Semantic Web technology has unduly discounted the procedural dimension of information management — not only in a thoretical sense, but also quite practically. For example, the OBO Foundary does not include a mechanism for code sharing with the goal of curating software libraries that implement datatypes conformant to the various published Ontologies. In the Semantic Web paradigm, defining logical formalizations of standardized concept-systems is considered orthogonal to implementing software components where these formal criteria are realized in practic. In short, *logical specification* is trated as distinct from *implementation*. This is not a universal approach: many technological standards are published at least in part via "reference implementations" which demonstrate standardized concepts and guide other implementations, helping to enforce compatibility between different software components. Moreover, code sharing and code reuse can promote interoperability no less effectively than alignment relative to logically defined standards. So there *are* technological trends that emphasize "procedural alignment" and code-sharing as important contributors to data integration. However, these branches of technology do not appear to have exerted a strong intuitive influence on the Semantic Web.

I argued above that technology has a retroactive influence on phenomenology, or at least on the threads of research that follow the "Naturalizing" project and the reconciliation of phenomenology with Analytic Philosophy. Even if this effect is rather modest, it still bears on the topic that is my primary emphasis at this point, namely the integration of phenomenology with Cognitive Grammar. One of the most prominent practical domains that has influenced phenomenology has been the Semantic Web, insofar as Semantic Web technology (via Ontologies) show some evidence that formal models influenced by phenomenology can be practically useful, which is one criteria to suggest that the models have philosophical or epistemological merit. On the other hand, Cognitive Linguists have tended (if anything) to be critical of the Semantic Web (in contrast to other linguistics branches, which are generally sympathetic to Semantic Web paradigms and incorporate Ontologies into Computational Linguistics software). So a potentially fertile ground for collaboration between phenomenology and Cognitive Linguists has arguably been overlooked insofar as the respective communities have taken competing lessons from the successes and limitations of the Semantic Web, particularly how the Semantic Web leverages classical logical formalisms (particularly Description Logics) rather than "procedural" and/or Category-Theortic foundations.

This problem is not intrinsic to the Semantic Web as a data-sharing platform, however, only to the paradigms through which the current Semantic Web has been conceptualized and implemented. There are competing intellectual frameworks that embrace parallel goals but present alternative technical foundations, and phenomenology would benefit from thematizing these frameworks in a role analogous to the Semantic Web, both a practical application and a retroactive intuition-guide.

A case in point would be the OpenCog project, that presents a Hypergraph-based modeling paradigm related to but technically distinct from Semantic Web labeled graphs (one which is also consistent with procedural-network models) and which also embraces a specific linguistic model (based on Link Grammar). Philosophically, OpenCog appears to celebrate a vision of Artificial General Intelligence which I have already flagged as problemmatic; underestimating the context-sensitivity and empathic intersubjectivity intrinsic to human cognition and intelligence (and difficult to simulate with machines). Nevertheless, formal models designed to *replicate* intelligent behavior can still be useful as structural *models* of cognitive phenomena, even if we believe in a metaphysical gap between the model and the reality. Implementing software on the basis of explanatorarily useful cognitive models does not guarantee that the software will realistically approximate human cognition, but articulating and fine-tuning the models themselves can notwithstanding be a valuable exercise.

In the case of OpenCog, the impetus toward "Artificial General Intelligence" has motivated that project to explore cognitive models that coalesced around several key structures, including Directed Hypergraphs, Link Grammar, and (in my terms) Procedural Networks (as underlying models for Information Spaces). This aggregate of theories can be juxtaposed to Description Logic, Directed Labeled Graphs, and formal Ontologies as the groundwork for the Semantic Web. I'd also argue that the OpenCog model can potentially be a technological improvement over the existing Semantic Web, in the sense that semantic networks built around OpenCog-like structures can be more effective vis-à-vis several important practical concerns, like application design, data integration, and Human-Computer Interaction. These comments do not necesarily apply to the actual OpenCog software — the major OpenCog component, "AtomSpace", is in a practical sense harder to compile and use than most Semantic Web components — but instead to a potential standardization of the core OpenCog data structures as modeling paradigms that can be adopted by heterogeneous information sources and data-sharing initiatives. In this eventuality, the OpenCog model can provide a test-bed for applied phenomenology that stands on a different formal foundation — one less inured to symbolic logic.

Along these lines, then, I contend that a circle of data models analogous to the OpenCog architcture can provide a formal structuration for phenomenological accounts of linguistic processing and information spaces comparable in analytic roles to 3D modeling primitives in a phenomenology of Perception. On one side, mathematical elements like mesh geomtry, NURBS surfaces, and texture mapping/generation point toward formal theories of perceptual *cognition* by allowing for the construction of perceptually realistic *scenes*. These mathematical elements are building-blocks for an (artificial) perceptual *content* rather than (as far as we know) actual neurocognitive subvenants of perceptual *experience*, but their formal specificity still gives us material to work with when trying to consolidate a "scientific" phenomenological research programme. Analogously, I suggest that OpenCog-like structures such as Directed Hypergraphs, Procedural Network models, and Link Grammar are potential building-blocks for formal models of Cognitive Linguistics and "information management" — for our procssing of both linguistic content and the contxts and situations wherein language artifacts are grounded. In other words, these procedural/hypergraph/link-grammar structures can model linguistic "deep structure" and linguistic environments by analogy to how mesh geometry, texture mapping, and so forth model 3D spatial primitives and visual-perceptual environments.

This idea is still somewhat hypothetical because the "procedural/hypergraph/link-grammar" nexus has not been consolidated into a general to the same degree as a common vocabulary of 3D modeling primitives has been incoporated into disparate software and research projects. Having said that, Link Grammar itself does have standing as a distinct and institutionally circumscribed body of research, so it is a reasonable starting point for integration with phenomenological and cognitive-linguistic approaches, an integration which can then be extended to related structures like Procedural Networks and Directed Hypergraphs.

7.3 Phenomenology as Experiment

Phenomenology has not usually attended to formal analysis of cognitive models, or models of mental phenomena overall. This is entirely understandable, since exploration of formal systems surely does not belong to phenomenological analysis itself, at least outside the exotic sense of studying what it is like to learn or think about mathematics, say, from a first-person perspective. Nevertheless, even a writer committed to phenomenology does not solely do phenomenological analysis, any more than a Structuralist poeticist devotes all paragraphs to close-readings. Equally intrinsic to the philosophical process is how intra-methodological analyses ("readings" of consciousness or literary works, say, respectively) are placed in a larger context, which can have multiple dimensions: relations to other scools of philosophy, but also other academic disciples and other regimes of knowledge and practice. Pursuit of formal models can help ground and orient phenomenological investigations, and vice-versa.

As a case in point, consider how phenomeneology was among the inspirations for what computer scientists call the Semantic Web and Formal Ontologies — protocols for sharing information and aggregating "knowledge" across computer networks, paricularly the World Wide Web. Although the distinction is not sufficiently discussed, I believe, the Semantic Web idea really has two dimesnions: we can call them *static* and *dynamic*. The *dynamic* aspect of the Semantic Web (and any data-sharing platform) reflects how the technology needs to enable, and verify, correct and useful behaviors. In particular, the Semantic Web needs to treat *information* as an asset that appreciates in value as it is shared and duplicated. Semantic Web technology needs to identify situations where it would be valuable for some aggregate of data present at locality $L1$ to be shared with locality $L2$; and should provide the technological capabilities to ensure that $L1$ and $L2$ can interoperate properly to effectuate this sharing.

These goals and requirements are *dynamic*: they model and implement scenarios where some piece of software concludes that some remote information would be valuable, and initiates a process of acquiring that data, by interoperating with other software which takes steps to respond cooperatively (within the limits of proper data sharing protocols). I will discuss this *dynamic* aspect of the Semantic Web below.

By contrast, the *static* dimension of the Semantic Web reflects the goals of data representation itself: the essential information and structure manifest in data needs to be preserved arocss locations as data is routed and shared. Accordingly, one goal of Semantic Web technology is to design data representations that retain a static meaning across contexts and locations. These representations have to be sufficiently precise and unambiguous that heterogeneous software platforms can interoperate, by sharing the data represented, without distorting or misinterpreted the information encoded in the relevant shared data.

Such information is not only abstract mathematical or technical data: our world is founded on communicating structured knowledge from many human and scintific domains, like medicine and government. We cannot in this context construe data as just bytes and numbers, but rather encodings of human concepts and judgments. Trying to map essentially informal human concepts, like *illness*, to a precise scientific formulation, is of course a foundational concern in philosophy; but computer networks and technology-enhanced knowledge sharing reveal practical applications of these perhaps once purely abstract problems. Scientists use Formal Ontologies to codify conceptual systems underlying human knowledge and beliefs. This, moreover, spans both fairly narrow and concrete propositions (e.g., that the pericardium surrounds the heart) and deeper, more abstract, more cognitively primeval concepts (like what it means for one thing to surround another thing).

In short, part of the requiements of building knowledge "engineering" or "sharing" systems was to give a technical specification for apparently innate concepts or gestalts like *part of*, *inside of*, *surrounding*, and so on. At least one method for approaching this problem was via phenomenology, meaning that phenomenology serves as one tributary among others that can be followed into the technical context of data modeling and data sharing protocols. At the same time, the Semantic Web community has converged on several preferred models and formats — bearing acronyms like OWL and RDF — which in turn have proved controversial. Some researchers, notably Gärdenfors, have critiqued the Semantic Web for a conceptual simplification that does not really capture the semantics of technical domains (like science and medicine), still less of Natural Language. Others from a more implementation-minded perspective can highlight technical limitations of Semantic Web models, such as how data sharing *between* computing environments can best integrate with data managment *within* particular databases and applications. The Semantic Web — whose underlying representations are based on labeled, directed graphs — has been critiqued by advocates for modestly different graph-like structurres, like Conceptual Graph Semantics and Directed Hypergraphs. These alternative models are arguably more conceptually accurate and/or more practically efficacious, from an engineering perspective, than the paradigms for representing Formal Ontologies and Informations Spaces or "linked data" which emerged as predominant in the community of Semantic Web developers and researchers.

These unfolding perspectives are relevant to phenomenology partly because competing representational paradigms can seem more or less phenomenologically faithful; can intersect with phenomenological accounts in different ways. For example, suppose we judge that an alternative representational model, like the Hypergraph framework associated with the OpenCog project — itself oriented to Artificial General Intelligence — is a more realistic model of conceptual sructures insofar as these intrinsically emerge from and regulate cognitive/perceptual processes as articulated in phenomenology. That is just a claim, of course, but assuming for sake of argument it is plausible, then we have a case of two competing formal models — both reflecting some measure of at least informal influence frpm phenomenological ideas, as far as seeking philosophically well-grounded accounts of ontology and intelligence. These models can be contrasted on philosophical grounds, but also technologically. Neither OpenCog nor the overall Semantic Web are academic theories per se, but technology projects with their own software ecosystems and engineering norms, alongside academic literature and philosophical attitudes or intuitions that can be evaluated theoretically.

Even though phenomenology is *philosophy*, I believe, that doesn't mean considerations from other disciplines as they bear on — to take this one specific case — OpenCog vs. the canonical Semantic Web are not potentially relevant and interesting to the phenomenological project. The relevant contrast here presents two competing computational frameworks, and the ecosystems can be scrutinized side-by-side with an eye to the merits of their technology, to how they are used, extended, and integrated into practical software and respond to technical requirements. These engineering comparisons can co-exist with more philosophical ones: if one paradigm seems superior *both* practicallly and philosophically, this deserves consideration — do the two horns reinforce each other? Conversely, if the more phenomenologically faithful theory proves less implementationally useful, does this shed light on philosophically interesting issues — the weakness of "mind as compuer" analogies, for instance? We may not be able to specify *a priori* what kind of significance to attach to comparisons between formal models on phenomenological vs. engineering grounds. But we should recognize that technical comparsions are at the least nontrivial data points that should at the least be acknowledged in the background while investigating formalizations that incoporate, and insofar as they incorporate, phenomenological intuitions.

If this is plausible, then the disciplinary frontier of phenomenology significantly expands. Phenomenologists can in any cases engage with the *academic* face of, say, OpenCog and Semantic Web projects — texts by Ben Goertzle or Gärdenfors, for instance — read as at least tangentially philosophical ouevres. But any discipline which finds relevance in these *writings* should also find relevance in the technology they are writing *about*, in their concrete form as technical artifacts and (products of) engineering processes. We can therefore approach technologies like AtomSpace (a database associate with OpenCog) and Fact++ (a Semantic Web engine) from an engineering as well as theoretical perspective — how they are implemented, compiled, and interoperate with other applications. Or, as this one example illustrates, we can incorporate within the phenomenological discipline an interest in technical comparison between formal systems which also manifest phenomenological intuitions, so the phenomenological and engineering dimensions of their juxtaposition can be juxtaposed in turn. This represents a new avenue for engagement with formalizations following the example of, let's say, Husserl's *Formal and Transcendental Logic*, which approached from a phenomenological perspective then-contemporary issues in logic and mathematics. But a key difference is that the formalizations Husserl entertained were fully abstract, while the formal systems that can be approached phenomenologically in our century are more concrete and enmeshed in social-scientific practice (health care, environmental policy, etc.). Engaging with these "concretized" formal systems is not a matter of proving theorems, or understanding proofs of prior theorems; it more involves compiling computer code, or writing new code, and understanding the technical structure of programming languages and data representations.

In effect, computer code — software and formal languages (including markup and database query as well as general-purpose programming languages) — has in many contexts supplanted abstract logic as formal foundations of well-structured thought. This even applies to mathematics, where type-theoretic and proof-assistant methods take the place of set theory and predicate logic as foundations. This new reality should be confronted by philosophers as well — what is the philosophical analog of the Univalent Foundations project in mathematics? How should Analytic Philosophers — or indeed phenomenologists — re-evaluate the last century with computers replacing logic as the instuitional mechanization of thought? How should Philosophy be reconsidered if some founding books were reimagined as, let's say, the *Formal and Transcendental Computer Science* or the *Tractatus Computational-Philosophical*? To speak more precisely, what are the consequences propagating across Philosophy if quantification is foundationally conceived as over type-instances rather than sets? What changes when the domain of a quantification has to have a conceptual unity at least to the level of what can be modeled via a formal type theory rather than being open-ended sets? What changes when our reigning paradigm of perfect reasoning is not proofs as a mental exercise, but the engineering of computer systems and then the engineering of (formal representations of) theories and then of apparent theorems so as feed theories and theorems into the aforementioned computer systems for verification? What changes when even mathematics becomes a rather empirical domain that can be experimented with on a computer? What kind of Philosophy can be done by experimenting on a computer?

I will pick up this thread of discussion in a later section, but beforehand will make explicit the potential theoretical integration between linguistics and *procedural networks*, which I have assumed but not directly analyzed to this point.

8 Procedural Networks and Link Grammar

My goal in this section is to incorporate Link Grammar into a phenomenological and Cognitive Grammar perspective, more than to offer a neutral exposition of Link Grammar theory. Therefore I will accept some terminology and exposition not necessarily originating from the initial Link Grammar projects (though influenced by subsequent research, e.g. computational models developed by Matt Selway and Kenneth Holmqvist [79]; [39], [38]). I also want to wed Link Grammar to my own semantic intuitions, set forth earlier, that word-meanings and morphosyntactic interpretations should be grounded on pre- or para-linguistic cognitive "scripts" that are activated (but not structurally replicated, the way that according to truth-thoretic semantics linguistic form evokes-by-simulating propositional form) by linguistic phenomena.

Link Grammar is, depending on one's perspective, either related to or a variant of Dependency Grammar (DG), [23], [22], [24], [62], [37], [5], which in turn is contrasted with "phrase structure" grammars, such as Head-Driven Phrase Structure Grammar (HPSG) [48], [43], [78], [105] (for example). Link and Dependency Grammars define syntactic structures in terms of word-pairs; phrase structure may be implicit to inter-word relations but is not explicitly modeled by DG formalisms — there is typically no representation of "noun phrass" or "verb phrases", for example. Phrase structure is instead connoted via how relations fit together — in *rescued dogs were fed*, for instance, the adjectival *rescued-dogs* relation interacts with the *dogs-fed* (or *dogs-were* plus *were-fed*) predication, an interaction that in a phrase-structure paradigm is analyzed as the noun-phrase *rescued dogs* subsuming the noun *dogs*. Dependency analyses often seem more faithful to real-world semantics because, in practice, phrases do not *entirely* subsume their constituent parts. Linguistic structure is actually multi-layered, where semantic and morphosyntactic connections resonate between units within phrases separate and apart from how linguistic structure is organized into phrasal units themselves.

Except for phrases that coalesce into pseudo-lexemes or proper names (like "United Nations" or "Member pf Parliament"), or indeed become shortened to single words (like "waterfall"), we perceive phrases both as signifying units and as aggregate structures whose detailed combinative rationale needs contectualization and interpretation. In short, phrases are not "canned" semantic units but instead are context-sensitive performances that require interpretive understanding. This interpretive dimension is arguably better conveyed by DG-style models whose consituent units are word-relations, as opposed to phrase-structure grammars which (even if only by notational practice) give the impression that phrases conform to predetermined, conventionalized gestalts.

While Link and Dependency Grammars are both contrasted with phrase-structure grammars, Link Grammar is also distinguished from mainstream DG in terms of how inter-word relations are conceived. Standard DG recognizes an assymetry between the elements in word-relations — one element (typically but not exclusively a word) is treated as "dependent" on another. The most common case is where one word carries greater information than a second, which in turn adds nuance or detail — say, in *rescued dogs* the second word is more essential to the sentence's meaning. This potentially raises questions about how we can actually quantify the centrality of one word or another — in many cases, for instance, the conceptual significance of an adjective is just as trenchant as the noun which it modifies. In practice, however, the salient aspect of "head" vs "dependent" assymetry is that any inter-word pair is "directed", and one part of the relation defined as dependent on another, however this dependency is understood in a given case.

By contrast, Link Grammar dos not identify a head-dependent assymetry within inter-word relations. Instead, words (along with other lexically signifant units, like certain morphemes, or punctuation/prosodic units) are seen as forming pairs based on a kind of mutual incompleteness — each word supplying some structural or signifying aspect that the other lacks. Words, then, carry with them different varieties of "incompleteness" which primes them to link up with other modls. Semantic and grammatical models then revolve around tracing the *gaps* in information content, or syntactic acceptability, which "pull" words into relation with other words. This approach also integrates semantic and syntactic details — unlike frameworks such as Combinatory Categorical Grammar, which also treats certain words as "incomplete" but identifies word connctions only on surface-level grammatical terms — Link Grammar invites us to explore how semantic and syntactic "completion" intersects and overlaps.

Words can be incomplete for different reasons and in different ways. Both verbs and adjectives generally need to pair up with nouns to form a complete idea. On the other hand, nouns may be incomplete as lexical spotlights on the extra-linguistic situation: the important point is not that people feed dogs in general, but that *the rescued* dogs were fed prior to their rescue. So *dogs* "needs" *rescue* for conceptual specificity as much as *rescue* needs *dogs* for anchoring — while also *dogs* needs *the* for *cognitive* specificity, because the discourse is about some particular dogs (presumed known to the addressee), signaled by the definitive article. In other cases, incompleteness is measured in terms of syntactic propriety, as in:

- (171) We learned that people fed the rescued dogs.
- (172) No-one seriously entertained the belief that he would govern in a bipartisan manner.

In both cases the word *that* is needed because a verb, insofar as it forms a complete predicate with the proper subject and objects, cannot always be inserted into an enclosing sentence. *People fed the rescued dogs* is complete as a sentence unto itself, but it is not complete as a grammatical unit when the speaker wishes to reference the signified predicate as an epistemic object, something believed, told, disputed, etc. A connector like *that* transforms the word or words it is paired with syntactically, converting across part-of-speech boundaries — e.g. converting a proposition to a noun — so that the associated words can be included into a larger aggregate.

The interesting resonance between Link Grammar and Cognitive Grammar is that this perspective allows us to analyze how syntactic incompleteness mirrors semantic incompletenss, and vice-versa. "Incompleteness" can also often be characterized as *expectation*: an adjective "expects" a noun to produce a more tailored and situationally refined noun (or nominal "idea"); a verb expects a noun, to form a proposition. Analogously,when we have in discourse an adjctive or a verb we expect a corresponding noun — so via syntactic norms language creates certain expectations in us and then communicates larger ideas by how these expectations are met. Is a noun-expectation fulfilled by a single noun or a complex phrase? The notion of semantic and syntactic expectations also coordinates nicely with type-theoretic semantics; for example, the verb "believe" pairs with a semantic unit that can be interpreted in epistemic terms — not any noun but a noun of a kind that can be the subject of propositional attitudes (beliefs, opinions, assertions, arguments, etc.).

Kenneth Holmqvist, whom I discussed earlier as integrating Conceptual Space Theory with Cognitive Grammar, made a study of "expectation" in this or a similar sense a central feature of his doctoral dissertation [39]; I'll point out that there is an implicit resonance between *expectations* and link grammar; so Holmqvist's research actually potentially triangulates between Conceptual Space Theory, Cognitive Grammar, and Link Grammar.

Continuing analysis of *that* qua subordinator: the syntactic incompleteness of propositional phrases modified by *that* can therefore be traced to the semantic expectations raised by *believe*, and analogous verbs (opine, argue, claim, testify). The object of *testify*, say, is a statement of potential fact which we know not to take as necessarily true or honestly made (part of the nature of testimony is that it may be deliberately or accidentally fallacious). But to properly pair with *testify*, then, phrases must be semantically reinterpreted as nominalizations of propositions, rather than as mere linguistic exprssion of propositional content via complete sentences. The "epistemic" context transforms sentential contnt into nominal content available for further refinement:

- (173) The Trump campaign colluded with Russia.
- (174) Several witnesses testified that the Trump campaign colluded with Russia.
- (175) Reputable newspapers have reported that the Trump campaign colluded with Russia.
- (176) Most Democrats believe that the Trump campaign colluded with Russia.

The grammatical stipulation that a modifier like *that* is often necessary in such formulations correlates with the semantic detail that the "claimed", "testified", or "believed" content is not being directly asserted by the speaker as if in an unadorned declarative expression, as in (173).

Morphosyntactic transformation similarly models the correlation between semantic and syntactic expectation — as can be demonstrated by a variant of the "believe" forms, via the phrase "believe in":

- (177) I believed in Father Christmas.
- (178) I believed in Peace on Earth.
- (179) I believed in Obama.
- (180) I believed in lies.

Whereas *that* (after *believe*) "nominalizes" propositions, *in* reconceives (type-theoretically we would say "coerces") ordinary nouns into epistemic nouns (compatible with propositional attitudes). Obama is not an *idea*, but the connector *in* triggers an interprtation where we have to read "Obama" as something believed — effectively a type-theoretic tension resolved by understanding *Obama* in this context to designate either his platform or his ability to implement it. Interpretive *tension* is a natural correlary to a mismatch in expectations: *believe* expects something epistemic, but the discourse gives us a proper name. Analogously *budge* expects a brute physical entity in its simplest meaning, but in

(181) Obama wouldn't budge on reproductive rights.

we get a "sentient" noun, and have to read *budge* metaphorically. In short, *expectation*, *interpretive tension*, and *incompleteness* are interlocking facets of semiotic primitives that gestate into discursive maneuvers via which ideas are communicated economically and context-sensitively.

Link Grammar, proper, represents only the most immediate (mostly grammatical) facet of word links. For sake of discussion, I will discuss links in general as markers of *mutual dependency* between words, so a "link grammar" is essentially a "bi-directional" Dependency Grammar. Mutual dependencies manifest syntactic norms and contextual details that make individual words inadequate signifying vehicles for a particular communicating content. This overall principle becomes concrete in one form via grammatical relations, which is the layer modeled by Link Grammar proper. I have mentioned several ready examples — the syntactic dependency of verbs and adjectives on nouns for them to enter correctly into discourse (correlate with a semantic dependency in the other dirction, to shape noun-ideas to the proper context and signifying intent); also part-of-speech or "subtyping" dependencies reflecting mandates that (in my examples) propositional phrases are coerced to nouns or nouns coerced to "epistemic" nouns. Technical Link Grammars recognize a broad spectrum of "link relationship" — between 50 and 100 for different languages. Parsing a sentence is then a matter of identifying all of the mutual dependencies — at least those evident on a syntactic level — that appear as inter-word links in the sentence. Phrase structure may be implicit in some links in combination — for example verb-subject plus verb-object links generate propositional phrases — but the technical parse is a "graph" of inter-word links rather than a "tree" of phrases ordered heirarchically. The parse-graph itself is only a provisional reading of the sentence, and linguistic understanding exists only insofar as its skeletal outline is filled out with semantic and situational details. But the graph layer articulated by a Link Grammar still provides a useful intermediate representation, showing mutual dependencies in their syntactic manifestations that then point toward thir deeper semantic and situational origins.

For each *syntactic* bi-dependency, on this theory, there is a concordant semantic and signifying bi-dependency, partly conventionalized as a feature of the language and partly hewn to the current discourse context. To leverage Link Grammar in an overall Cognitive Linguistic environment, then, we need to examine the semantic relations that drive syntactic bi-dependency: how the grammatical structure of one word completing another is a codification of *semantic* mutual dependency. The *semantic* bi-dependencies operate on both abstract and concrete levels. Abstractly, it is obvious that an adjective or a verb depends on a linked noun to complete an idea. This abstract prototype of bi-dependency then takes concrete forms in each specific discourse, acquiring detail and specificity from situational contexts.

The crucial dimension in this theory is neither abstract nor concrete bi-dependency but the intersection of the two. The conventionalized lexical, syntactic, and morphosyntactic norms of a language present abstract prototypes of mutual word dependencies. The concrete instantiation of these forms — via word-pairs whose surface presentation indicates the presence of specific link relations (often with the aid of morphology, agreement, spoken inflection, and other morphosyntactic cues) — invites us to consider how an abstract bi-dependency becomes situationally concretized in the present, momentary context. In essence, abstract mutual dependencies are the raw materials from which situational appraisals are created. A pairing like "rescued dogs" uses a certain abstract-bidependent prototype — here the double-refinement of a noun and adjective grounding each other — to trigger the listener's awareness that the speaker's discourse is centered on one specific aspect of the dogs (that they were at some point rescued) with its conceptual corrolaries and unstated assumptions (that, being in need of rescue, they were abandoned, in danger, and so on). Similarly the further link to the definite article — "*the* dogs" — evokes the prototype of a definite article grounding a noun, which in turn communicates the speaker's beliefs about the current state of the discourse.

This last "bi-dependency" deserves further comments, because nouns more often than not reveal some dependency on an article: *some dog(s)*, *the dog(s)*, *a dog*, *many dogs*. These pairings paint a picture both through the choice of article and the presence or absence of a plural. This picture is partly situational — obviously whether the speaker is talking about one or multiple dogs is situationally important — but it is also meta-discursive: selecting the definite article indicates the speaker's belief that the listeners know which dogs are on topic. The lexeme "the" thereby signifies a meta-discursive stance as well as a cognitive framing — both that the collection has enough coherence to function as a conceptual unit in context, as *the* dogs (and not something less specific like "*some* dogs") *and also* that the speaker and listeners share compatible cognitive pictures as a result of the prior course of the discourse. This also introduces several avenues for future discursive evolution — the listeners can respond to the speaker on both cognitive and meta-discursive levels. A direct question like *which dogs?* signifies that the first speaker's meta-discursive presuppositions were flawed — the referent of "the dogs" has not been properly settled by the discourse to that point. Or questions for clarification — like *how many dogs are there?* — indicate the listeners' sense that all parties' respective construal of the situation needs to be more neatly aligned for the discourse to proceed optimally.

The point I particularly want to emphasize here, though, is that these discursive/cognitive effects inhere not only in the word "the" but in its pairing with other words, like *the dogs*. We tend to see the lexical substratum of a language as the ground level of its signifying potential, but we should perhaps recognize bidependent prototypes as equally originating. The communicative content of *the dogs* is ultimately traced not only to the lexical potentialities of *the* and *dogs* as word-senses, but to the abstract prototype of the definite-article bidependence, which becomes concretized in the *the dogs* pairing at the same time as the individual words do.

In order to bring this account full-circle, I would then add that lexical units mutually completed by an instantiated bidependence can also be seen as a tie-in between interpretive procedures. Lexical interpretive scripts — the cognitive processing solicited by *the* and *dogs* in isolation — are themselves open-ended and ungrounded or incompletely grounded.

We can speak metaphorically of "words" being incomplete, or carrying expectations, but it is really the cognitive scripts associated with words that are lacking in detail. The resolution of a merely schematic cognitive outline to a reasonably complete situational construal can be likened to a rough sketch filled out in color — but we have to imagine that a sketch can be completed by pairing it with a second sketch, and the content in each one, crossing over, allows a completed picture to coalesce.

So in the current running example, *the* in itself evokes an interpretive process that on its own logic cannot be completed, and likewise *dogs*; but each script supplies the content missing from the other. In this sense the bidependent form concretized by the pair is actualy evoking an interpretive phenomenon of mutual completion — the language structure here is guiding us toward an interpretive interpenetration where the two scripts tie each other's open ends. Whereas lexical items can be associated with single "scripts", prototypes of mutual dependency model patterns in how script-pairs can become mutually complete.

But unlike lexemes, which are notated directly by language, the instantiation of bidependent script-pairs occurs indirectly. Some paired-up words are of course adjacent, but adjacency between words does not have the same binding determinacy as sequencing among morphemes in *one* word. Instead, word adjaceny is only one signal among many others suggesting that some prototypical inter-word relation applies between two words (which might be widely separated in a sentence). Morphology and syntax also point towards the pairings operative in a sentence — they are to bidependency prototypes what word-choice is to the lexicon.

8.1 *Link Grammar as the Syntax of Procedural-Network Semantics*

Thus far I have made an admittedly *philosophical* and speculative case for "interpretive mutual dependence" as a constituent building block of linguistic understanding. This theory will remain troublingly incomplete if the more philosophical presentation cannot be wed to a more rigorous formal methodology. True, an essential core of this theory is that interpretive "scripts" are largely prelinguistic and so not covered by linguistic formalisms in themselves. However, I have also argued that formal linguistic structures *do* govern how we identify which links apply to which word-pairs, and the general outlines of how word-pairing coordinates cognitive processes associated with single words — the fully contextualized synthesis of lexically triggered cognitive procedures may involve extra-linguistic grounding, but abstract prototypes of bidependnet relations are also prototypes of a synthesis between cognitive/interpretive functions. It would accordingly be reassuring if notions like "bidependency" and "mutual completion" could be employed as foundations for a formal theory of grammar and/or semantics with a degree of rigor comparable to, say, Link Grammar in its computational form, or type-Thoretic Semantics in the sense of Zhaohui Luo or James Pustejovsky. Such a theory — and potentially concrete technologies associated with it — would also then have a reasonable ground of comparison to the Semantic Web and, in the context of phenomenology, to the formalizing influence which Semantic Web paradigms have exerted on projects to unite phenomenology with science and with Analytic Philosophy.

Given these considerations, I propose that formal grammars with the same underlying structure as Natural-Language Link Grammars can indeed be used as a foundation for type-theortic and programming-language-design methodology. The key step here is to generalize Link Grammar's notion of a "connector" — the aspect of a word or lexeme that allows (or requires) compltion via another word — to a gneric data structure where connections can be made between different parts of a system on the basis of double potentials that must be in some sense "compatible" for the connection to be valid. One way to visualize such a system is via graph theory: imagine a form of graphs where nodes are annotated with "potentials" or "half-edges"; a complete edge is then a union of two half-edges. Half edges are also classified into different families, and there are rules governing when a half-edge of one family may link with a half-edge of another. In the case of Link Grammar, these classifications are based on surface language structure — head/dependent and left-to-right relations — from which a suite of links and connection rules are defined (for instance, abstractly a head/right word must link to a dependent/left word, a rule that then becomes manifest in specific syntactic rules, like how a verb links to its subject). For a more generic model, however, we can stipulate only that there is *some* classification of connectors governed by *some* linkage rules, to be specified in different details for different modeling domains.

Such a graph model expands upon the notion of *labeled* graphs, where edges are annotated with labels that characterize the kind of relation modeled via the edge itself. A canonical example is Semantic Web graphs: the edges in any Semantic Web structure are labeled with "predicates", defined in different Ontologies, specifying what sort of relation exists between its adjacent nodes. That is, in the Semantic Web, nodes are not "abstractly" linked but rather exhibit concrete relations: a person is a citizen of a country, two persons are married, and so forth. These structures are then concrete instances of Labeled Graphs as abstract mathematical structures. Based on Link Grammar, we can then refine this model be splitting labels into two parts, and allowing edges to be incomplete: a fully formed edge is possible when the label-parts on one side are compatible with the label-parts on another. One valid class of graph transforms is then a mapping where a graph is altered by unifying two half-edges into a complete edge, subject to the relevant linkage rules.

Another way of modeling this kind of structure is via edge-annotations and a rule for unifying two edges into an edge-annotation pairing. For sake of discussion, I will express this in terms of Directed Hypergraphs: assume that edges are "hyperedges", connecting *sets* of nodes. In Hypergraph theory, the nodes incident to a hyperedge are divided into a "head set" and "tail set"; these sts can then aggregate as "hypernodes". We can then define a kind of unification where the "tail hypernode" of one hyperedges joins with the "head hypernode" of another, producing a new hypredge whose head comes from the first former hyperdge and whose tail comes from the second. The merged hypernodes, in turn, form a new hypernode which "annotates" the new hyperedge (this new hypernode is not connected to the graph via other nodes, but is indirectly "part" of the graph through the hyperedge it annotates). *Annotated* hyperedges therefore differ from "non-annotated" hyperdges in that the former are the result of a merger between two of the latter.

The rules governing when such merger is possible — and how to map a pair of hypernodes into a single "annotative" hypernode (which belongs to the graph through the aegis of its annotated hyperdge) are not internal to the graph theory, but presumed to be specified by the modeling environment where implemementations of such graphs are technologically applied. Annotated Directed Hypergraphs are then "complete" in a sense if every "un-annotated" hyperedge has been subsumed into an annotated hyperedge, via a fusional process we can call a "annotative-fusional transform".

Extending this model further, we can say that the tail of an *un-annotated* hyperedge is a "tail pre-annotation", since it is poised to be merged into an annotation. Analogously, the head of an un-annotated hyperedge is a "head pre-annotation", and "annotative fusion" is the synthesis of a head and a tail pre-annotation (triggering a synthesis of their incident hyperedges). Correlate to annotative *fusion* we can define a notion of annotative *partiality*, referring to the "incompleteness" of pre-annotations which leaves room for their fusion.

It turns out that annotative fusion and partiality in this sense is a non-trivial model for computation in general, and can be extended to a form of type theory and process calculus. The idea is that computational procedures can be modeled as hypergaphs (computer source code can certainly be modeled as hypergraphs which are productions of a certain class of parsing engines). Each "value" affected by a procedure — or more technically the source code symbols and memory addresses that "carry" a value — is then modeled as a hypernode that can link with other hypernodes in the scenario where one procedure calls a different one. Annotative fusion is then a phenomenon of values being transferred from one execution environment (associated with the caller procedure) to a second one (associated with the callee). The "annotations" themselves are then in this context the full set of type coercions, type checks, synchronization (e.g. resource locks or thread blocks depending on whether or not the caller waits for the callee to finish), and any other validations to ensure that the procedure call is appropriate. Annotative fusion also provides a formal basis for developing the intuition that "procedural networks" are rigorous representations of information spaces — annotative fusions capture the precise details of procedures linking (via caller/callee relations) with other procedures.

The constituent units of procedural networks are interprocedure calls — but procedural networks also reveal dimensions of connectivity and and clustering characteristic of large, complex networks (and the graphs that represent them) in general. What appears as one function-call in source code can actually represent many different inter-procedure connections, a phenomenon reflecting "overloading" and "genericity" in programming language theory. Functions are generic in the sense that any one of their arguments can take multiple types — either because the function is explicitly declared to take a "typeclass" or a single type for that argument, or because an instance of a given type may actually be at runtime an instance of some subtype. The engine which actually implements inter-procedure calls — i.e., the programming-language implementation — needs to factor this genericity into runtime decisions, so a single expression in one function body can branch to many different called procedures. This is the essential core of the "semantics" of programming languages: data structures manipulated by computer code do not *intrinsically* represent real-world, non-digital phenomena, though they ar enginered to model external data when used properly. However a code base does *internally* posess a space of implemented functions, and a symbol at one place in source code can match to some set of other functions so as to effect a procedure call. This "matching", and the rules governing how "overload resolution" occurs — "overload" meaning that a given notated procedure call can actually branch to multiple functions, so runtime information is needed to select the right one — are the essential formal principles governing the semantics of computer code.

From this basis, all the same, computer code can model a wide range of empirical phenomena. Generic code represents generic patterns of functional organization, allowing models to be built from varying layers of abstraction. From this perspective, to describe an empirical system it is neessary to identify important behaviors and functional patterns via which the system's observed behavior can be notated and/or simulated. To the degree that systems take on functional organizations that can be abstractly described, similar to the functional dynamics of other systems, their behavior can be represented and/or simulated via generic code. To the degree that there are particular details of a system's behavior that are more idiosyncratic to that system, and need to be modeled precisely, procedures can be crafted specifically for observing and emulating that exact behavior. More generic and more exact procedural implementations can coexist in a single code base, with generic functions calling granular functions narrowed to precise types, and vice-versa. The coexistence of generalization and specificty is an essential feature of code bases and, by extension, of procedural networks, ensuring the flexibility of these networks as tools to model information spaces.

Unfortunately, this kind of "procedural" modeling is hard to intgrate with the more static techniques represendt by the Semantic Web and the current "Big Data" fad. The latter paradigms tend to treat data as a static repository to be mined for patterns and insights, rather than a digital simulation or encoding of dynamic real-world systems. The Semantic Web, as a large, collaborative modeling project, evolved largely apart from the technological community concerned with computer simulations and the programming techniques which emerged from there, like Object-Orientation. This divergence is relevant for linguistics and cognitive science, because I would argue that the more "dynamic" paradigm is actually more "Semantic" in a Natural Language sense. In other words, our cognitive dispositions when interpreting empirical phenomena — and matching these interpretations to linguistic cues — are more like procedural networks capturing functional patterns and layers of genericity in observed phenomena, rather than an accretion of static data. The techniques of procedural data modeling may therefore be relevant for Cognitive Linguistics and Cognitive Phenomenology because they aspire to something which, arguably, the mind does instinctively: build cognitive or computational models of dynamic, functionally organized phenomena.

As a corrolary, the theoretical building-blocks of Procedural Data Modeling — how it leverages type theory, programming language semantics, and so forth — can provide at least analogs or case-studies for corresponding cognitive phenomena. Here I would argue that generalizing Link Grammar from Natural Language to formal languages, type systems, and lambda calculii yields added structures to type theory that are useful toward a more rigorous "theory" of Procedural Data Modeling — a theory of natural linguistics generalized to a theory of general data representation which, in turn, may offer insights onto the cognitive dynamics underlying (prelinguistic) situational/perceptual comportments and interpretation.

Type-theoretically, annotative partiality — which recall is my terminology for the abstract generalization of the mutual "incompleteness" in Link Grammar connctors, driving their link-fusion — extends conventional applied type theory (as in the Typed Lambda Calculus) in parallel to partial-labels extending labeled graph theory. It is paradigmatic in the theory of typed procedures and of "effect systems" that the type of a procedure is determined (up to certain equivalences that may discard overly granular type distinctions) by the types of all values affected by the procedure (including but not necessarily limited to the types of input and output parameters). We can then superimpose on this model an account of annotative partiality. Specifically, on the paradigm that procedure-calls are structurally represented as annotative fusions over Directed Hypergraphs, the values manipulated by a procedure are pre-annotations: they are not (in the *implementation* of a procedure, as a formal object) single values but rather typed spaces that can take on a spectrum of possible values depending on the inhabitants of their types. When a procedure is *called* these values become concretized, but as a formal system procedural networks model software in terms of its capabilities and expected behavior, rather than the state at any moment when the software is actually running. Partiality therefore models how precedures (as formal objects) deal with potentialities — we do not know what values will *actually* be present at runtime (e.g. what specific values passed to a procedure as arguments), so procedural analysis is essentially characterized by a partiality of information.

When one procedure calls another, the caller must build an *expression* — a gathering of values that provide all the information the callee requires — thereby creating a case of mutual-completion: the caller has values but not an algorithm to operate on them; the callee has an algorithm (that's what it implements) but needs concrete values so to produce concrete values. This dual partiality allows the caller to call the callee, via an *expression* which is part of the callee's implementation (represented as a hypergraph) which must in turn match the callee's signature — epigrammatically, we can say that "expressions are annotative-fusional duals of signatures". The point here is that whereas signatures are conventionally understood to be type-declarations assigning types to procedures, with annotative partially we can more precisely recognize signatures as stipulating *pre-annotative* types. The values carried within expressions also have pre-annotative types, but there is a distinction between types in the context of expressions and types in the context of signatures — and moreover this distinction is precisely the manifestation of the abstract head-pre-annotation and tail-pre-annotation contrast in the specific context of procedural networks. Just as signatures unify multiple types into one profile, we can analogously define "expression types" as the aggregate of all types from values affecting the expression — note that this is different from the type of the expression's calculated *result*, just as the type of a function is different from the type of its return value. Expression-types and signature-types are almost exact duals (the complication being default values for optional parameters, which are not directly represented in exprssions — obviously, since then they would not be missing). The "duality" involved here derives from partitioning a type system into "expression annotative partials" and "signature annotative partials", a projection of head/tail duality in an abstract theory of Annotated Directed Hypergraphs (and analogous to head/dependent and left/right partiality in Link Grammar).

9 Channel-Algebraic Grammar

This section will briefly introduce what I call "Channel Algebra" and how it can lead to a theory (and practice, in a sense) of formal and natural-language grammar. Channel Algebra is discussed in greater detail in [20]. It is fairly divergent from other formalizations in computer science, though loosely decended from Process Algebras and from the "sigma calculus", which is a formal model of Object-Oriented programming [1]; [87]; [75]. Channel Algebra may also be seen as distantly related to Santanu Paul's "Source Code Algebra" [64] and to a network of discussions — not necessarily coalesced into technical publications — about how to unify Object Oriented and Functional Programming. There are many interesting analyses presented by scientists like Bartosz Milewski, on web forums such as Milewski's blog (the address is his full name as a dot-com domain). In general, though, I am developing Channel Algebra in an "experimental" manner, using a concrete software implementation in lieu of a technical or mathematical axiomatic description.

In the present context I want to focus on Channel Algebra as a potential theory in linguistics — particularly Cognitive Grammar — but initially I'll describe the underlying theory in a more computational manner. A lot of the Channel Algebra formalization carries between formal and natural languages.

A key notion in Channel Algebra is *procedures*. As in Part 1, we can think of procedures as either cognitive processes or as functions implemented in a software system, although for exposition the latter interpretation is simpler. So, assume we have a computing environment where many functions are available to be called — in effect, a bundle of software libraries each exposing some collection of function-implementations. For reasons I'll cover momentarily, I'll call thse *ambient procedures*.

At one level, Channel Algebra is conceived as an alternative to data-sharing paradigms like the Semantic Web; so, one kind of analysis is concerned with cases where some body of information (which can be called a *data set*) needs to be transferred between two different computing environments. Channel Algebra takes the view that data does not have intrinsic semantics outside the computational environments where it is used. As I argued in the context of Searle's "Chinese Room", our identification that a software system represents facts — like someone's full name (the example I used over several paragraphs in the earlier discussion) — depends on the software possessing capabilities to display the information (usually visually). In other words, among the totality of all procedures that can be performed by the system, only a small set of procdures are involved in user-interactions where semantic intentions like "this piece of data represents someone's full name" are relevant.

As a consequence, when sharing data that includes information like *full-name*, we should not assume that the raw data, in its semantic interpretation, actually "means" *full-name*, or some kind of propositional assertion about full names. For example, a graph-edge in a Semantic Web resource intended to model the proposition "This person has full name Jane Doe" should not be seen as "meaning" anything about full names. Instead, it represents some computational artifact which *becomes* an asserion of that fact when a procedure is eventually called which converts the full name to a (usually visual) representation which a human user would recognize as a view on a full name (and hence on the proposition).

In sum, the Semantic Web (or any data sharing network) only *has* a semantics because software connected by the network has requisite procedures to make data-views that people can understand. Data does not have semantics (or at least not human-conceptual semantics); *views* do. This is consistent with an Interface Theory: most procedures manipulating Semantic Web data are part of an interface connecting networked data sources to the handful of procedures which create views for human users. Within the local structure of this interface, data does not have a "human" semantics; instead, it must be passed around between proceurs before eventually reaching human-interaction procedures where (what we would call) the "real" procedures come into play.

When data is shared btween localities, then, the procedures that will receive and manipulate this data are logicallly prior to the data itself and constrain when data-sharing is possible. Without the proper network of procedures, the data can never be transformed into the views where non-local semantics are relevant. This motivates my choosing the term "*ambient* procedures", because a certain collection of procedures must be in place on the receiver end of a data-sharing event. This also implies that one important role of data modeling is to indicate which procures a potential receiver needs to have available — i.e., needs to implement — to qualify as a capable recipient of data conforming to the model. Data models should describe what procedural capabilities must be afforded by software libraries in order for the human-level, conceptual semantics of the data can actually emerge from humans' interactions with the system.

Analogous to Ontologies as data model specifications for the Semantic Web, I'll use the term "Ambient-Procedural Ontologies" to express the paradigm that implememting data-sharing protocols involves crafting software libraries around procedural requirements. This has two implications for how we theorize software systems. First, we need to characterize procedures in a manner that expresses the proceural capabilities that a system offers, or must have to satisfy a data-sharing protocol. Second, we can assume that whenever data is sent, received, manipulated, or visualized, there is a collection of procedures available in the system which enact these computational processes.

On this basis, then, I will develop a Type Theory that operationalizes this intuition about "Ambient Procedural Ontologies". The main outlines of this type theory are first that procedures have types; and second that procedures are "ambient" or logically prior to (or at least equiprimordial with) the type system itself. This is not a mathematical type system where every underlying type (like Natural Numbers) and every operation (like arithmetic operators) have to be mathematically described in the theory. Instead, we can always take certain types and procedures as "primitive" or (at least in their inner workings) external to the type theory. For any type system $\mathbb{T}$, whose structure is regulated by a type theory we intend to present or assess, we can say that $\mathbb{T}$ is built around a *kernel* $\mathcal{K}$ of "primitive" types and functions.

In general, an assumption of Channel Algebra is that a significant portion of information, present in some structured system, can be extracted by identifying elements in the system with types in a suitably developd type system $\mathbb{T}$. In the case of Natural Language — specifically Cognitive Grammar — this means that many syntactic and semantic details for each word in a sentence can be provided by mapping words to types. As I have mentioned, linguists like Luo and Pustejovsky have given persuasive analyses of certain type systems for *semantics*, but I intend to apply type theory also to *syntax*. Later in this section I will demonstrate this in practice, but for now I will hust note that such analysis requires a sufficiently complex type system. For example, semantic notions like dot-typs and dependent-product typs, which have proven to be effective in shedding light on common lexico-semantic phenomena, may need to be expressible in a $\mathbb{T}$, *along with* link- or cognitive-grammatic notions like *connectors* and *expectations*.

Similar comments apply to modeling and sharing scientific data. Here, I have in mind projects like Conceptual Space Markup Language, and applications of Conceptual Spaces to study the nature and evolution of scientific theories, as reflected in research by (notably) Frank Zenker and Gregor Strle [32], [90]. Implicit in this research is the philosophy that scientific data models are not just electronic specifications for transmitting raw data, but embody scientific theories in terms of how data is structured and constrained. CSML, for example, defines criteria on data parameters such as ranges, dimensions (called "units" in CSML), and structural protocols (including CSML "scales") [3, p. 6]. As a concrete example, the biomedical concept "blood pressure" is usually understood as a pair of numbers whose dimnsions are each in kilopascals (kPa) and whose first number (systolic pressure) is necessarily greater than the second (diastolic) — technically, the pair is *monotone decreasing*. In conventional Biomedical Ontology, cf. SNOMED-CT or the Vital Signs Ontology, these conditions might be stipulated by defining a "blood pressure measurement" concept subject to the relevant dimensional and range criteria (e.g. diastolic pressure must be greater than zero but less than systolic pressure), and/or by classifying systolic and diastolic pressure as subconcepts of blood pressure (see [83] and [36]). In a kind of Ontology paradigm incoporating type theory, the same conceptual structure can be represented concisely by defining a type whose structure conforms to the semantic requirements on the *blood pressure* concept as it is scientifically understood: i.e., a monotone-decreasing integer pair whose dimensional units are labeled "kPa" or "kilopascals". Note also that the "monotone decreasing" criterion is an example of the structure of dependent-product types (in this case because the valid range for the second number depends on the value of the first), a construction which elsewhere is used for Natural Language semanticcs, e.g. [53, p. 40] and [54].

The point of this example is that many scientific concepts — the semantic norms embedded in how scientific terms are defined and understood and how the concepts ar used in scintific theories and research — can be rigorously specified with a suitably expressive type system. Therefore, a sophisticated system $\mathbb{T}$ is both a practical tool for scientific data sharing and scientific computing, but also an expository vehicle capturing theories' conceptual underpinnings. Developing scientifically useful type theories can then serve as a kind of formalized philosophy of science — type theory as metascientific analysis.

So in the past several paragraphs I have discussed the idea of using type attributions to represent semantic and syntactic details in natural language, and also metascientific concepts in scientific theories and data sharing. A suitably developed type-system can, in light of these possibilities, act as a kind of multi-purpose tool capturing semantic principles in a broad array of formal and informal cotexts. This is possible insofar as type theory is developed on a flexible basis so that type systems can expand in different directions for different intellectual environments — dependent sum and product types for Natural Language semantics; "connectors" for Link Grammar; CSML-style units, ranges, and scales for scientific data; etc. The overarching goal of Channel Algebra is to enable these flexible, multi-purpose type systems.

Another way of expressing this idea is that type systems should be *multi-paradigm*. Suppose we are using a collection of types to model the semantics of some linguistic or scientific model. We may realize that there are some crucial semantic formulations that need to be recognized within the type system itself, if this type-oriented modeling is to be comprehensive. For example, in a link-grammar context, we may recognize that, in addition to assigning semantic and/or Part-of-Speech types to individual words, we need to represent the "potentialities" latent in words allowing them to link up (each word has a *connectors* such that a pair of "compatible" connectors can produce a "link"). Or, in a metascientific context, we may rcognize that we need to annotate type-attributions with CSML notions like range, scale, and units. The multi-paradigm criteria means that there would be a mchanism in place to enrich a type system $\mathbb{T}$ so that such semantic details can be seen as structural parts of types modeled via $\mathbb{T}$.[3]

One virtue of organizing a type system $\mathbb{T}$ around *procedures* is that this "multi-paradigm" flexibility becomes easier to achieve when we can directly model requirements on procedures, and how procedures interact with types (for instance, each type needs one or more procedures to construct elements of that type). As I said earlier in this section, we can start from any "kernel" of types and procedures and build new types by describing procedures which create, and/or operate on, values of $\mathcal{K}$-types. However, there ar many different ways that procedures can act on values and call other procedures. This means there is a lot of room for extending type systems to represent different kinds of inter-procedural relations. For example, in Link Grammar a Part of Speech type is not just a "function" acting on other types — e.g., adjectives act on nouns; "red apple" modifies the image we have when we conceptualize "apple". The adjec-

[3] I refer to "semantic details" even in theories of Natural Language *syntax*, like Link Grammr, because many ideas about language *grammar* are relevant tobthe *semantics* of the linguistic *theory*, which is different than the Semantics of Natural Language which linguistic theories have as their subject matter.

tive/noun pair also needs the right potentials to create a connector. A type-thoretic model of this idea can involve stipulating that, in some cases, a function-type $\mathcal{F}_t$ is not only defined by the type of its argument(s), but by some added "connector" structure which must math between $\mathcal{F}_t$-instances and the instances of its argument types.

Channel Algebra, as I will now argue, givs us a way to encode "extra information" along these lins in type descriptions.

9.1 *Channels as Type-System Extensions*

In concvtional type theory, every type system has *some* notion of functional types, but these are often treated in a simple form based on Typed Lambda Calculus. Canonically, a function *inputs* one or more values, and *outputs* on or more values (in many concrete type systems, only on output value). We can (still rather informally) talk of these input and output collections as "channels". So, a procedure has an *input* channel — that's where it vgets its arguments from — and an *output* channel, where it provides a result. The term "channel" is usually used in the context of "process algebras" where procedures can run concurrently, and channels may be two-way means of communication between concurrent procedures. For this paper, I will only consider *sequential* procedurs — where two procedurs follow each other in time; no parallelism — and *one way* channels, which carry information from one procedure to another but have a fixed direction. Intuitively, if $\mathcal{P}_1$ sends a value to $\mathcal{P}_2$ via one channel, $\mathcal{P}_2$ cannot send a value back via the same channel (although it can *modify* the value in the channel).

While type theory may conceive functions as (in effect) a combination of input and ouput channels, actual programming practice reveals multiple distinct *kinds* of input and output channels. In Object-Oriented programming, Objects are passed to functions (i.e., "methods") using a different protocol than ordinary parameters. Also, many Object-Oriented languages support Exceptions, which are like non-standard return values that disrupt the normal program flow. This suggests two different *input* channels — I'll call them *lambda* and *sigma* for the calculii which can model their semantics — and two different *output* channeos, which I'll call *result* and *error*, for normal and exceptional return values, respectively.

Furthermore, many languages support "lambda" or "inline" functions which can be "closures", enabling a proceure to modify values in its "surrounding lexical scope". In other words, a *closure* is a procedure implemented inside the implementation of an enclosing procedure, and it has the ability to read and maybe modify data used by the enclosing procedure. We can consider this "handing down" of values from outer to inner procedures to be a kind of input channel, which I will call a "capture" channel. Some programming languages make this value-sharing explicit: in the case of modern-day C++ (since the 2011 standard) lambda functions have, as part of their definition, an explicit documentation of which symbols are "captured" from an enclosing lexical scope — these symbols are listed in square brackets, just as regular arguments are listed in parentheses, which helps reinforce the idea that inputs via symboo-capture are similar to inputs via argument-passing (which I say in Channel Alegebra as *lambda* and *capture* being both input channels).

Nested procedures can also be used to represent branching and control-flow, like *loop* and *if-then-else* formations. For instance, *if-then-else* can be represented as a structure which involves two nested procedures: if some condition (in the outer, enclosing procedure) is true, then the first nested procedure is calld; if not, the second is called. Similarly, a *loop* takes some nested procedure and calls it repeatedly. In the simplest case, the nested procedure is called again and again until the nested procedure returns in a manner that signals the loop should be brocken off (a common keyword for this condition, e.g. in C++, is "break").

To demonstrate with a trivial concrete example, we might have pseudo-code like this:

```
int x = 0;
loop {
    if (x > 10) break;
    ++x;
} // end the loop
```

If we want to analyze the inner code-block as a distinct (but nested) procedure, we would identify how the nested implementation "captures" the x value. We also have to identify how *break* causes the nested procedure to terminate — like *return* in an ordinary channel — but does so as a signal for *loop* (in the outer procedure) to break off.

In effect, a nested procedure used as a loop block has a spcial kind of output channel which can represent two possible states: *continue* the loop or *break* the loop. I will call this hypothetical channel a *control* channel after Chung-Chieh Shan [80] and Oleg Kiselyov [45] (although they work in a different underlying context). Most programming language runtimes don't actually support the more "exotic" channels I discuss here, and without runtime implementations they can remain as just theortical descriptions of programming phenomena implemented or analyzed via some theortical framework quite different from what I am calling "Channel Algebra". However, the data set accompanying this text demonstrates a runtine engine where the channel structures I describe here can be directly implemented.

I'll also mention the Link Grammar example, say an adjective as a function modifying a noun. In a formal model, an adjective is therefore a kind of "procedure" which inputs a noun and outputs a noun. In my terminology, a bread-and-butter input channel is called *lambda*, and a bread-and-butter output channel is called *return*. However, Link Grammar also recognizes various link kinds, each driven by connector-pairs. For example, consider a simple link-grammatic analysis of adjectives in the spirit of [81, p. 16]. Note that most nouns take adjectives, but some words we might want to classify as nouns don't seem to:

- (182) Today is Tuesday.
- (183) The big departmental meeting is Tuesday.
- (184) It is very windy.
- (185) The lousy weather is very windy.
- (186) They are forecasting snow.
- (187) The latest reports are forecasting snow.

We might want to consider *today*, *it*, and *they* as defacto nouns, but notice the adjectival constructions do not carry over: we can't say "big today", "lousy it", or "latest they".

In other words, some restriction on the "adjective" and "noun" types must be identified which blocks constructions like "big today" being parsed as valid examples of *big* as an adjective type-instance. One option might be to define the adjective and noun *types* more narrowly, which is more in the spirit of type-theoretic semantics. In that case, we don't take adjectives, say, as "functions" which input and output *any* noun, but rather model a suite of adjectival types operating on different noun types. For example, the adjectives *salaried* and *elected* in

- (188) She is a salaried employee.
- (189) He is an elected official.

can only be attributed to persons, so qua functions these adjectives only "input" persons, as a subtype of nouns in general. Via Link Grammmar, on the other hand, the basic theory involves adding extra conditions on the adjectives and nouns involved, which are required (along with the underlying type-compatibility) to permit the function (the adjective) to input the argument (the noun). Then *today*, *it*, and *they* cannot take adjectivs because they do not have the proper "connectors". Of course, both ideas can be combined, so we can define nouns and adjectives restricted to narrower subtypes (like person, living thing, physical object, etc.) and also marked with connectors, so adjective-noun pairings depend on compatibility both at the subtype level and the connector level.

The important point for the current context is that connectors essentially extend any type system compatible with Link Grammar, so we need to imagine an extra kind of input and output channel representing *connectors* as orthogonal to underlying Part of Speech or lexical types. In *big departmental meeting* we have to treat *departmental* as a kind of cognitive procedure modifying the concept *meeting*, and then *big* as a procedure modifying the "output" of the first procedure. Then we *also* have to represent a *connector* on *meeting* establishing that this conecpt/lexeme can be modified by an adjective, and similarly a related connector inheres to the *output* of the "departmental" procedure. So there is a kind of output-channel establishing which connectors are available on procedural outputs (connectors of the same varieties as would be available on individual words), and special input-channels which similarly model connectors which must be available on procedural inputs. I'll call these input-connector and output-connector channels. Type-thoretic semanticists like Luo and Pustejovsky might prefer to model connectors as aspects of types themselves, but we come closer to capturing the Link Grammar model if we represent the connector channels as distinct from the regular input and output channels, whose parameter-types are orthogonal to the language's connector-system.

I have, in any case, hereby presented eight different kinds of channels applicable to different programming- or natural-language constructions: *lambda*, *sigma*, *capture*, and *input-connector* on the input side; *return*, *error*, *control*, and *output-connector* on the output side (later I will introduce a few other channels). Notice that the range of different channels, each with distinct semantics and theoretical roles, extends far beyond the basic intuition that every procesure has some inputs and some outputs. Instead, type theories can evolve to capture theoretical structures in diverse domains, because many theoretical concepts can be systematically represented by describing special kinds of channels applicable to certain procedures. One way to capture data models and theoretical commitments is to envision scientific models as organized — implicitly or explicitly — around some sort of "procedures" and then analyze the various protocols by which information is mapped into and out of procedures, with the *semantics* of these protocols described by stating requirements on specialized "channels".

The notion of *channel* is therefore closely tied to the notion of *procedure*, and *types* are similarly specified via both procedures and channels. That is, most of the complex types in a type system are functional types, which in turn are characterized in part by the kind of channels used by instantiating procedures. In principle, function-types are differentiated by the *kinds* of channels they use as well as the *types* of their arguments. For example, in Object-Oriented programming, a *method* in a string class might take a string *object* (representing a string of textual characters) as the nethod "receiver", aside from *arguments*: e.g., a "substring" method would take a pair of intgers. This procedure would be considered to have a different type than an equivalent non-method function taking *three* arguments (one string and two integers) — even if both versions had the same number and types of input parameters. In C++, "pointer-to-member-function" types are never equated to function-pointer types.[4] The explanation for such distinctions in Channel Algebra is that a procedure which takes all inputs from a lambda channel has a different type than an (even if otherwise identical) procedure which takes one input from a *sigma* channel (equivalnt to the C++ *this* keyword).

[4]Note that C++ terminology is confusing in that pointer-to-member-functions can never point at *static* member functions (i.e., the fact that such functions are members has no bearing on their pointer-types), even though member functions themselves *can* be static.

In Object-Oriented environments, non-static member-functions (aka "methods") are distinguished from non-methods in part because there are different rules for resolving method-calls when a given function name refers to several different procedural implementations (such as a base-class function and a derived-class function which overrides it). This is one example of how "sigma" and "lambda" channels have different semantics: the types carried within sigma channels are more consequential for overload-resolution than those in lambda channels. Conversely, sometimes channels are not semantically significant enough to decisively differentiate types. In C++, a function which *does* throw an exception cannot be overloaded with a function which *does not* throw an exception (assuming the rest of the functions' signatures are identical). This means that — if we model type systems like that of C++ via Channel Algebra — procedurs with and without error channels can gbe the same type. But it is always possible *in principle* to differentiate function-types based on the kinds of channels their associated procedures use; just that somethimes this results in fine-grained distinctions not recognized by a particular type system.

The larger point is that function-types are specified via channels ("modulo" potential coarsening that equates types that could potentially be distinguished). Therefore, the fundamental fabric of the type system is dependent on modeling channels, because this determines how function-types themselves are miodeled; and, as I will now explicate, function-types ar ethe logical core of almost any practical type system

9.2 *Channels and Carriers*

Most type systems take it as self-evident that any type is associated with *values* of that type, and usually *sets* of values. That is, intuitively, for any type (say, 16-bit signed integers) there is a set of values which are the "inhabitants" of that type. One weakness of this picture is that many types vary in terms of *what* set of values is actually representable in a given computational context. The case of 16-bit signed integers carries no such ambiguity; this type always has an extension equivalent to the interval -32768 to 32767 in $\mathbb{Z}$. However, consider the type of *lists* of 16-bit signed integers; depending on a program's available memory, some relatively long lists which can be represented on one computer will exceed the capacity of a different computer. Since computer code in general is not tied to a specific environment, we have to accept that for many types we do not know *a priori* what set of values conformant to that type can actually be used.

In addition to this practical problem, it is also difficult to describe exatly what a value *is*. Any instance of any type (at least in the software ecosystem) does have a numeric manifestation in computer memory — essentially an encoding as a sequence of bytes, that is, 8-bit unsigned integers — but it is not obvious that such encodings (sometimes called a "bit pattern") actually are "values" of types. In reality, computer code almost never deals with "values" per se, but rather deals with types represented symbolically in function signatures: passing "values" around from procedure to procdure. One exception to this rule is that some values are written directly into computer code — the numeric literal "10" represents a specific value (usually in some intger type). However, even here some procedure is needed to interpret the character strings in source code to the actual typed value.

Given these considerations, while I will informally talk about "values" I try to minimize the use of "value" as a technical construct in Channel Algbra. With this foundation we can consider a kind of "value free" type theory by rough analogy to "point-free" topology (and therefore distantly to mereotopology). More central than the notion of *value* is the idea of a *carrier*. A carrier is a computational construct — symbolically represented by a source-code token — which represents an instance of a type. Each carrier is associated with one canonical type (though carriers may "hold values" associated with supertypes of its canonical type). When we talk about procedures calling other procedures, we really mean that the value of symbols in one body of code (whre the calling procedure is implemented) is sychronized with the value of symbols in another stretch of code (where the callee is implemented). In short, at any stage of program execution, we can form groups of source-code symbols across the code base unified by the guarantee that these symbols carry "the same" value. But rather than talking of values directly we can take this syncronization between symbols as the deeper notion: the notion *value* is itself defined as the correlation exhibited by synchronized "symbols". The notion of "carrier" is then a more rigorous extension of the notion of source-code symbols or tokens.

The difference between a *carrier* and a *type* is that carriers have aditional states. Some carriers are defind in function signatures, but others are introduced as lexical symbols in a procedure implementation. In many programming languags, lexical symbols can be *declared* before being *defined*. We can represent this scenario via a *carrier* which is in a particular *state* (I'll call it *preinitialized*). When a carrier is initialized, it takes on a state of holding a specific typed value — *values* are defined indirectly as characteristics of carriers in initialized states. At some point (consider a pointer to deleted memory) carriers no long hold meaningful values, and they enter a state I'll call *retired*. Introducing *preinitialized* and *retired* as carrier-states allows these to be separated from the type-system: we do not have to assume a "preinitialized" *value* which can be an *instance* of some types. In some cases, type systems *will* reognize values which play similar semantic roles to these carrier-states: for example, Haskell's "bottom" value is an instance of every type and represents a "null" or "missing" value. However, using semenatics of carrier-states rather than type-instancs means that we do not have to introduce extra structure to type systems which we may want to model via Channel Algebra.

Carriers which can be in preinitialized, retired, or initialized states I call *tropes* (there may be only one, or multiple, initialized states for tropes). A different class of carriers are called *emblems*, and represent abstract ("emblematic") specfications on carriers rather than carriers which hold concrete values: in effect, emblems are carriers present in function signatures. One or more carriers in an ordered list then form *channels* (though a channel can also be *empty*, with no carriers). I distinguish an *empty* channel, which exists but has no carriers, from a *vacant* channel which does not exist at all. For instance, a function that *can* throw exceptions but, at some point, has returned a normal value instead, has an *empty* error channel; a function which can *never* throw an exception (e.g. the C++ *nothrow* keyword) has a *vacant* error channel. Channels cannot include both tropes and emblems; those taking tropes are called *staged* channels, and those taking emblems are called *abstract* channels.

Carriers and channels interoperate according to several operators, which give Channel Algebra its "algebraic" character. To present these oprators I'll also intoduce the notion of *stages*. Briefly, any procedure is broken down into a sequence of stages, each of which involves constructing some aggregate of chanels. The basic outline is as follows:

Carrier Append Any staged channel can append a trope, and any abstract channel can append an emblem (represented as $\mathcal{C}\oplus\mathfrak{c}$).

Channel Product Any collection of abstract channels can combine to a "product", called a *channel complex*. Similarly, any collection of staged channels can become a channel *package*. A channel complex or package is generically called a channel *product*. A channel product is considered "complex" if any of its chanels are abstract. The basic channel-to-channel operator $\mathcal{C}_1\otimes\mathcal{C}_2$ represents a channel product formed by combining $\mathcal{C}_1$ and $\mathcal{C}_2$.

Carrier Handoff Given carriers $\mathfrak{c}_1$ and $\mathfrak{c}_2$, a *carrier handoff* $\mathfrak{c}_1 \looparrowright \mathfrak{c}_2$ means that the value carried by $\mathfrak{c}_1$ is (at last temporarily) carried to $\mathfrak{c}_2$. This means that there is some phase of program execution when $\mathfrak{c}_1$ and $\mathfrak{c}_2$ are synchronized, or "aligned"; exhibiting the same state (or sufficiently related) states. Alignment allows for imperfect handoffs, like coercing a floating-point number to an integer.

Digamma Reduction A channel *package* can be *allied with* a channel *complex* (written $\mathcal{C}_p\circledcirc\mathcal{C}_x$) if carriers in $\mathcal{C}_p$ and $\mathcal{C}_x$ are "alignable". The actual description of such alignment is non-trivial; in [20] I address this in terms of hypergraph models of computer code. But in general alignment means that handoffs are possible between tropes and emblems, and if there is enough alignment the chanel *package* $\mathcal{C}_p$ can be interpreted as a call to a *procedure*, whose *signature* is modeled by the channel *complex* $\mathcal{C}_x$. In this case we have a "Digamma Reduction" operator $\varsigma\Psi\mathcal{L}$, meaning that the package $\mathcal{C}_p$ is "evaluated" and then control passes to the stage labeled $\mathcal{L}$.[5]

Each of these operators represent a step in a computational process whereby channel packages are constructed and then evaluated, which over the course of several stages (in general) provides implementation of procedures. A single operator is associated with a *microstage*, for example, appending one carrier to one channel. A sequence of microstages is than an *intermediate representation* used to translate high-level source code to data structures that can be executed direcly (or more or less directly, by interfacing to "ambient procedures", e.g. via C++ reflection). This strategy is concretely put into practice in the sample code distributed with this paper. In effect, high-level source code is "compiled" into an intermediate representation, and this IR is a more or less direct translation of Channel Algebra oprations.

One of the technical challenges of using this strategy for practical software developments involves mapping sophisticated Channel semantics to ordinary type systems. Since a language like C++ does not support the full range of channels I have presented here, the more detailed channel-complees have to be mapped to function-call semantics which C++ will actually recognize. In practice, a lot of this work involves manipulating function pointers and casting carriers to generic binary representations, like arrays of void*-pointers. These techniques are not especially relevant to the philosophical issues I am focused on in this paper, so I'll leave them to the published data set (interested readers will find a relatively complete C++ development environment, intended to be used with the Qt platform, that operationalizes the theory I am developing in this section).

At this point however I *will* comment on the overall architecture of building and then evaluating channel packages. Supporting "Digamma Reduction" in a runtime encironment requires reasonably complex C++ libraries (assuming C++ is the language of the runtime itself); but most of the Intermediate Representation is concerned with asserting carrier properties and then adding carriers to channels. Channels themselves act as stack machines, in that they can be built up like machine stacks and then cleared in the passage from one stage to the next. This is an example of a point I made much earlier, in the introduction, that computing environments ultimately involve stack machines at their most primitive level.

We are, in any case, operating here on several different semantic levels. The Channel Algebra operators define one, intermediate level whose main theme is building channel packages. At a "lower" level each package must

[5]The motivation for the term "digamma" is first that the "sigma" in ς Calculus looksblike a smaller version of th Greek letter Digamma, and second that "gamma" is often used to represent graphs, and "digamma reduction" can be sen as a relationship between two different source-code graphs.

be evaluated at runtime, for instance by converting it to a C++ function-call, so the semantic issues there are identifying the proper C++ function (or function-pointer) and marshaling the channels to mimic the C++ ABI (Application Binary Interface). Conversely, at a higher level, source-code formations are interpreted in terms of the channel products they imply: so in code like $x = y- >f(z)$ the implicit channels are likely populated as follows: z goes into f's *lambda* channel, y into its *sigma*, and x becomes bound to its *return* (of course whether this is the actual meaning of the code depends on the high-level language's formal grammar). This implies that grammars can be organized around the channel structures indicated by conformant code. To the degree that grammar engines adopt this paradigm they can be called *Channel Algebraic Grammars*.

This paper's data set includes one example of an implmented Channel Algebraic Grammar insofar as code written in a special high-level language is translated to a Channel Algebraic Intermediate Representation (and then evaluated). The syntax and semantics of this spcial-purpose language is, of course, only distantly related to *natural* language; I won't address whether a comparable architecture could yield a workable Natural Language Processing engine. However, the design and role of this Channel Algebraic Grammar in the *Software Language Engineering* problem-space can perhaps serve as at least an analogy for how *natural* language orchstrates the "flow" of information, and the ordering of operations, across the cognitive proceures which underly linguistic understanding. I will return to this possibility at the end of the section.

9.3 *Channels and Constructors*

As I indicated, Channel Algebra downplays the notion of typed *values* except in a derivative sense (e.g. a "handoff" means an alignment between carriers which we can picture as a value being copied). However, carriers do become initialized, and even if this initialization results from a handoff originating with another carrier, that carrier in turn had to be initialized. At some point these chains of initialization have to be grounded on some underlying data. This data may come from outside the software itself: for example, a program emulating a calculator relies on human users to type numbers on a kyboard or by pushing buttons on a User Interface. Other times values are literally written in computer code, or obtained from files, databases, or over a network.

For sake of discussion, we can limit attention to values read literally from source code. Even external data tends to depend on some numeric or string literal: reading data from a file requires specifying a file name, and obtaining data from a network location requires a URL. So computer code itself provides the primordial values from which other values circulating through the software are derived.

In a typical type system, then, at least some types should have procdures which construct values directly from source code literals. I'll call these *literal-constructors*.[6] In addition to literal-constructors, there are some procedures to create type values from other values (or from no values at all); I will call these *co-constructors*.[7]

There is no strict rule separating constructors for a type $\mathfrak{t}$ from other procedures that may return values of $\mathfrak{t}$. Intuitively, they play different roles: constructors are about creating new values, while other functions analyze or modify existing valus. The canonical examples are so-called *trivial* constructors, which take no arguments — for instance, the constructor for a list of numbers returns an empty list. Such a function surely qualifies as a constructor. On the other hand, consider a function which takes a list of numbers and returns a new list with duplicate numbers removed — such a procedure acts more as a utility function and probably would not be classified as a constructor.

The constructor/non-constructor distinction is anyhow typically left open by the programming language environment, so coders have to signal their intention to treat a given function as a constructor by some extra syntax.[8] In Channel Algebra, one option is to define

[6] In C++, similar constructor-functions are called *literal operators*. This terminology only applies to "user-defined" constructors; the compiler itself handles initialization for built-in typs like integer and floats. However th overarching term "literal-constructors" is helpful for theory-focused languag-agnostic discussion about types and constructors.

[7] This terminology has the benefit of distinguishing the property of functions I call *co-constructors* from what existing programming languages call "constructors", which itself has different meanings for different languages. For example, in C++ one cannot take the address of a constructor function; however, co-constructors are implemented such that you *can* have co-constructor pointers, which is essential to the idea of "preconstructors" that I will address below.

[8] E.g. in C++ a constructor is given the same name as the type it con-

a special "*construct*" channel for values output from constructors.[9] Consider the case of appending values to a list of numbers: should a function which maps $\mathcal{L}{\ll}\mathcal{X}$ to $\mathcal{L}'$ — where $\mathcal{L}'$ is the same as $\mathcal{L}$ except it has x at the end — be considered a constructor? In most functional programming languages this is actually a classical case (along with trivial ones) of constructors, because they provide the basic mechanism wherein instances of list types are defined. In other words, this *append* function seems logically anterior to other functions which may create a list — for instance, by *removing* the last element from a (non-empty) list.

Such a notion of "anteriority" can sometimes be made rigorous. If we build up a list of numbers by appending values to smaller lists, we can eventually construct any list whatsoever. We can also run this process in reverse: for non-empty $\mathcal{L}'$ there is only one way to construct $\mathcal{L}'$ from a pair $\mathcal{L}{\ll}\mathcal{X}$. In other words, an *append* constructor is "reversible". Moreover, we can repeatedly reverse constructors like thse to get shorter and shorter (and eventually empty) lists. This means that algorithms can traverse a chain of constructors "backward" and will be guaranteed to terminate. For example, to determine if a list of numbers contains the number n, it is easy to check if it *ends* with n. If not, "reverse" the construction, and see if each smaller list ends with n. Eventually we would reach the empty list, meaning that the original list did *not* have n.

The possibility of "reversing" constructors is a familiar pattern in functional programming, where it is often called "pattern matching". It allows algorithms to be implemented in a functional style, with heavy use of recursive functions and sparing use of side-effects and mutable state. On the other hand, pattern matching relies on some simplifying assumptions that may not be consistent with all type systems. For example, C++ is laxer about how values are constructed; I can obtain a list of numbers by dereferencing a pointer to a list, with no information about the provenance of the referenced data. Data types in C++ do not usually carry around details about their "history", and it is not always easy to reconstruct that history the way we can "obviously" reverse the construction of a list.

In any case, these variations present some potentially informative characteristics about individual types. Given type $\mathfrak{t}$, we can ask questions like:

1. Which instances of $\mathfrak{t}$, if any, can be the result of a trivial constructor?
2. Does $\mathfrak{t}$ have a *default value* whish is the result of a trivial constructor?
3. Which instances of $\mathfrak{t}$ can be the result of a literal constructor?
4. Which instances of $\mathfrak{t}$, if any, can be the result of a reversible constructor?
5. If we have values which *are* the result of a reversible constructor, is there an efficient way to "un-construct" the value to support pattern matching?
6. Does $\mathfrak{t}$ have co-constructors (i.e., they are not literal) which also are neither trivial nor reversible?

Notice that a trivial constructor does not necessarily produce a default value. For example, a type meant to represent days of the week could default to whichever day is current when a constructor is called: if an application is run on Tuesday, the day-of-week trivial constructor would return the value for Tuesday. So a type may have *more than one* trivial-constructed values. But if a type has *exactly one* trivial-constructed value, this is *usually* a "default" value.

However, a type can have a default value without a trivial constructor. A defalt value plays the conceptusl role of a "fallback": 0 is a reasonable default for most numeric types. However, some numeric types don't have trivial constructors at all. Meanwhile, types representing calendar dates sometimes default to a standardized "day zero", like January 1, 1970. But a trivial constructor for such a type may instead return today's date (when the function is called). When a type has a default value, a (co-)constructor which returns that value can be called a *default* constructor.[10] As the Calendar Date example

structs for. One consequence is that two different constructors cannot be declared without overload-resolution: each constructor has to have a different signature than any other constructor of the same type. However, the rationale for this restriction seems to be syntactic more than semantic.

[9] It is useful to pair this channel with a semantically similar channel I'll call *placement* (after "placment new" in C++) for scenarios where the constructed result should be written to a buffer provided by the calling procedure rather than returned.

[10] For an example of a non-trivial default constructor, consider a literal constructor for a ratio type that returns 0/1 given a malformed character string.

shows, types can have default and trivial constructors that return different values.

Sometimes (co-)constructors are significant even if they are not actually used. To demonstrate how this may occur, consider the problem of enforcing dependent-type constraints without using dependent types explicitly. A canonical example is a function which must take a (maybe monotone) increasing or decreasing pair of numbes (I used the monotone-decreasing example for systolic and diastolic blood pressure). Suppose we implement a procedure to highlight a selection of characters in a screen display, whose inputs are the start and end character indices in some displayed text. We want to indicate that the second number (call it y) must be greater than the first (x). Via unrestricted dependent types, we could just define the type of y as "numbers greater than x"). The problem with this type-declaration is that we therefore do not know what type y has until the function is called (and x has a value). This could violate the principle that every argument to a function must have a type which is known in advance. Alternatively, we can say that y's type "provisionally" is, say, a 32-bit integer the same as x, but it's "real" type once x is known is a dependent type that depends on x's value. Not every type system however allows for this kind of distinction between "real" and "provisional" types.

One way to assert the dependent-type restriction while avoiding these problems is to note that x and y must form a monotone-increasing pair. That is, the procedure mandates the *possibility* to create the monotone-increasing pair xy from x and y, even though the procedure does not use this pair-value directly. As a construct in Channel Algebra, we can introduce the idea of a *rider* channel which asserts the *possibility* of creating certain values without actually creating them The simplest case is suggested by this number-pair example. Let's assume we have an implemented type modeling monotone-increasing pairs, with a co-constructor that creates such a pair from two numbers (verifying that the two numbers are indeed monotone-increasing). We can then form a pointer to this co-constructor function, or obtain some other unique identifier for it. I call a function-pointer or similar value a *preconstructor* if it references a co-constructor. In addition to being an indirect way of calling the co-constructor, a preconstructor serves as a *certification* that the co-constructor *could* be called. For example, one way to indicate that y has been checked and is indeed greater that x is to use the monotone-increasing pair preconstructor as a kind of signal value: test for $y > x$, but if so, instead of using boolean *true* for an affirmative, use the preconstructor.

The key point here is that many conceptual details or programming requirements that concern interrelationships between values can be modeled within a type system — even without full-fledged dependent types — via preconstructros used as signal values. For a given requirement, such as "is y greater than x?", we can identify a type that *could* be constructed if (and only if) the requirement is satisfied. For instance, y *is greater than* x is true iff we can form an instance of a monotone-increasing pair type out of x and y — and so, the preconstructor for this type becomes a convnient signaling value for the affirmation of $y > x$. Conceptual requirements can be defined by modeling types whose values necessarily exhibit some significant property, and then using preconstructors to those types as certificates that the property is true (in some context). A "*rider*" channel can then be populated with one (or possibly several) preconstructors affirming facts about the values carried in other channels. For instance, a *lambda* channel holding x and y can be paired with a *rider* channel holding a monotone-increasing-pair preconstructor, certifying that y has been checked to be greater than x.

The larger point of this whole subsection is that details about the nature and existence of types' constructors can provide useful conceptual information about types themselves. Often this information dovetails with the metadata pertinent to Conceptual Space Theory and CSML. Consider a simple but representative example of an object exhibiting core Conceptual Space "quality dimensions": a colored rectangle in a computer graphics environment. This object could have some 13 dimensions: colors for the shape's interior and border (including 3-dimensional color vectors plus transparency factors); the top-left position, width, and height of the rectangle; and the width of th border. A software engineer has numerous constructor options for this type of object: should there be one "pod-tuple" constructor that takes all 13 values in a flat list?[11] Should there be distinct data types for 3-vector colors or 4-vector colors (including transparency)?

[11] "POD" is a common coder's parlance for "plain old data", and it generally describes data structures conformant to *structs* in the C language, rather than C++ classes. A typical feature of *structs* is that they are initialized by listing all of their fields in one tuple.

Should the top-left point be merged into one 2-vector point type? The rectangle-constructor could potentially have its 13 fields folded into 5: two color 4-vectors; one top-left point; width; height; and border-width. Or border width and color can be merged into one "border" type. On top of that there is the question of default values: should pure black, or maybe pure white, be a default color for the interior? Should the border default to width-one black, or width-zero (i.e., no border), or something else? However the types are designed, there is a mutual dependency between simpler types like colors and points and the constructors for complex objects like rectangles: since complex objects are built from simpler ones, a type interface should be designed with consideration of how to assemble the whole from the parts, or retrieve the parts from the whole.

Some compound objects are conceptually analogous to basic pairs or tuples of values: 2D graphics points are 2-vectors, say, and solid colors are RGB 3-vectors. One way to signal that a compound type is like a tuple "product" of its component fields is to allow instancs of that type to be constructed just by listing each field separately. In C++, this is often implemented by defining a constructor which takes an "initializer list". Analogously, in Channel Algebra we can define a *pod-tuple* channel that serves as the *lambda* channel for pod-tuple co-constructors. A *pod-tuple* channel indicates that a given type behaves essentially like a tuple, with a sequence of values that, in most cases, vary independently of one another. These kinds of types hew closely to the Conceptual Space idea of multi-dimensional quality spacs. However, other kinds of types have more complex, interdependent internal structuration. I think Channel Algebra is a way to make Conceptual Space theory relevant for these more complex types also, using different Channel Semantics and the modeling roles of different forms of types' constructors; how these rooes reveal types' conceptual foundations.

Having argued for Channel Algebra as a formalization potentially relevant to Conceptual Space models, I want to conclude this section by considering how Channel Algebra msy be intuitively applicable to Cognitive Grammar.

9.4 Rider Channels and Deferred Coercions

Earlier in this section I described how Channel Algebra can represent dependent types and coercions, both of which are essential ingredients in type-theoretic semantics. I am not proposing Channel Algebra as a *literal* theory for natural language, particularly in its implemented form as a runtime and parsing environment for programming languages. However, some of its formal details for processing programming languages could be at last suggestive of procedural patterns factoring in to natural-language understanding.

Before going into detail, I think it's worth distinguishing different aspects of natural language where type theory may play a role. On one level, very general Part of Speech classifications can be approached type-theoretically. This helps reinforce the intuitive idea that syntactic categories like verbs, adjectives, and adverbs corresponds to conceptual, cognitive processes which effectuat changes in beliefs, conceptualizations, or situational records. A noun by itself is an abstract concept; during the course of a sentence, it is subject to concretization and preicatization, ending up in an idea that has some degree of concrete propositional content.

For example, we might go from *dog* to *dogs* to *those dogs* to the sentence *Those dogs are barking*. Logically we can see this as building up a propositional structure from sub-propositional parts. But cognitively the process is more like migrating from a cognitive register dealing in conceptual abstractions (like "dog") to a register for propositional attitudes and situational understanding. Logical constituents are more like stages in a concept-to-belief evolution than mereological units. That is, the relation between the signifying whole and its semantic or morphosyntactic parts is more the relationship between a process's ending to its intermediaries than a mereological hierarhy. If this picture seems compelling it can be conveyed by figuring the majority of Part of Spech types as function-like: the nature of verbs, for example, is to functionally transform (in our cognitive frames) nouns to propositions. Analogously, adjectives transform nouns to other nouns — in the sense that "red apples", say, can substitute as a noun-concept in most places that "apples" alone can; *red* being like a procedure that produces a modified *apples* concept which substitute for just *apples* in subsequent processes. Likewise, adverbs produce new verbs from other verbs; subordinators like *that* transform propositions back to nouns (as I argued in the last section), and so forth. So Parts of Speech can be usefully analyzed as "function-like" types (I will discuss specific language examples arguing for this prespective in the next section). These are, however, very general types, which would be the "uppermost" types in a natural language semantcs; I will call these *macrotypes*.

On the other hand, at a much finer level, individual lexical "cliques"[12] — the concept or extension or intensional property-set associatd with particular word-meanings — often seem to behave as *types* as well. In "Formal Concept Analysis", *concepts* are (statistically) defined as a combination of extensional and intensional criteria: neither extension nor attributes alone fully characterizes a concept, either cognitively or extra-mentally. In particular, practical fluency in a concept involves knowing canonical examples (like having seen many of the medium-size, traditionally architected dwellings that would be prototypical *houses*) and also the prototypical features that characterize the concept (houses are three-dimensional, enclosed, divided into rooms, function as a place of residence, etc.). A combination of exemplars and attribute-prototypes define the "core" or "center" of a concept: insofar as some example is "peripheral", an outlier which is somehow not representative of the concept (but still can be classified to it), it must have some *featural* difference from examplars; but we can also compare it as an individual to more exemplary individuals. That is, we understand outliers both intensionally — we can articulate the features which make both a log cabin and a gated mansion atypical as houses — and extensionally: we can mentally juxtapose cabins and mansions with ordinary houses.

If this gloss on the nature of concepts is accurate, it helps explain why the lexical entrenchment of concepts often has a type-theortic feel. In the more logical aspects of semantics, lexicalized concepts do present operationally as types:

- (190) A penguin is a flightless bird.
- (191) Rhinos in that park are threatened by poachers.
- (192) Baby elephants don't have tusks.

The point of these examples is that their signifying structures involve operations that can be explaind type-theoretically. In (190), a concept is charactrized via a subtype/supertype relation. In (191), a concept is being "extensionally filtered": we start with an expression that seems to designate the extension of some concept (*rhinos*) and then narrow it based on extensional criteria (*in that park*). This suggests a type/set interface similar to my analysis earlier of "students polled" (81). And (192) suggests an *intensional* filter, narrowing a type for contxtual purposes into a subtype that is conceptually meaningful but not entrenched: there is no common word (peer to "kitten" or "puppy") for *baby elephant*.

All of these operations — fine-tuning concepts to the specific ideas salient in a specific signifying act — have plausible representations based on a concepts-as-types analogy, and suggest another level where type theory could be an effective formalizing tool. But in this case, we are discussing the almost minimal groupings of a linguistic hierarchy, individual word-senses — I'll call these *microtypes*.

Meanwhile, in between coarse Part of Speech types and fine lexical "cliques" are the kinds of Ontologically-characterized categories or "lexical sorts" [58] associated with linguists working in a formal type-thoretic vein, like Zhaohui Luo and Bruno Mery. I will call types in this vein *mesotypes*, being intermediate in generality between individual lexemes and syntactic categoires (Parts of Speech and their refinements, like plural nouns). The broad philosophical implications of mesotypes is that they give some formal traction to what happens cognitive-procedurally when we negotiate between different word senses and/or use language in seemingly metaphoric (but not unrestricted) ways.

Consider these exmples:

- (193) My favorite Korean restaurant is adjacent to the bookstore.
- (194) My favorite Korean restaurant is closed today.
- (195) My favorite Korean restaurant is decorated with posters from the 2002 World Cup.
- (196) My favorite Korean restaurant started out in a food court.
- (197) My favorite Korean restaurant said I'm their most loyal customer.
- (198) She's constantly barking at her employees.
- (199) He's not playing well because his back is barking at him.

[12] Borrowing this term from [31] though I'm not using it exactly the same way

- (200) He's not playing well because his sore back is acting up.
- (201) The kitten barked at the dog.

The first three profile (using Langacker's term) a restaurant as a location, a building (with commercial and architectural properties), or an institution/organization. Note that we can distinguish the commercial/architectural sense from the institutional sense: to *close* can be temporary (as in 194), which we hear in conjunction with the former sense, or more permanent as in "cease operations", i.e., close "qua institution". The former sense seems to mix the institutional and location sense: while location is not explicit as in (193), an asserion that some *chain* restaurant is closed today would usually be heard as referring to one location, not the entire chain. In (198) through (201), a common idiom applies "bark" to things that are not dogs; but this is not just a matter of metaphor, blending different "spaces" with no conventionalizing pressues. The (198) and (199) senses are rather entrenched, using *bark* to suggest something a little obnoxious or mean. But (201) does not sound right, even though it is no more of a strecth to imagine a kitten's hissing as argry bark-like than a boss's orders. Perhaps the *literal* similarity between cats and dogs maks the figurative usage harder to accept as a purported abstraction from literal situations.

The conventional type-semantic picture is that language has a collection of (what I am calling) "mesotypes" and we modulate word-uses by switching between this medium-grain types, sometimes in unexpected ways. An effective way to develop such an analysis is to identify one or two senses as the most prototypical for some concept/lexeme, and read other senses as transforms involving other types. So the commercial/architectural mesotype may be canonical for *restaurant*, and then we branch out to a more geo-spatial sense (*where* the building is located), or institutional (the food-court incarnation may have been in a different place with diffrent staff and business classification). Hence a *commercial building* type is "cast" to a geosptial point or to a social institution. Thse "casts" are not really metaphors; they have conventions, limitations, and rules.

The mainstream theory is simplest when analyzing casts between mesotypes of similar gnerality, like plant-to-sentient in "flowers like water" or cerebral-to-physical in "heavy thoughts". But not all casts follow this recipe: (198) and (199) seems to cast from a *microtype* to a *mesotype*. The construction in (200) is a common "personifacation" of medical/anatomical concepts — a similarly scalar idiom is cases like *my arthritis is acting up*, or *flaring up* to render figure ailment as physical rather than personalistic — but here we care operating between typs of comparable Ontological granularity (anatomical part/medical ailment to person/physical thing) But semantically and syntactically (200) seems a lot like (198), even though the ploy in that case is to compare things to a lexical "clique" (dogs). And in (197) we infer that some *person* complimented the speaker, but this is more of a synecdoche than a cross-type cast like (196)-(196): the point is not that a restaurant has a personhood "aspect" that can be highlighted (the way it *does* have an architectural or geo-spatial aspect) but that reference to the restaurant can be proxy for people closely associated with it.

Another complication for type-cast theories is potential ambiguity between word-senses and coercing "usages", as in:

- (202) Tea-smoked duck is a Sichuan delicacy.
- (203) The baby's favorite toy is a rubber duck.
- (204) Wedding ducks are traditional Korean gifts.

If the prototypical duck sense is an animal, these cases disrupt the basic type hierarchy: Wedding ducks are made of wood; tea-smoked duck is a kind of food; rubber ducks are toys (is the phrase descriptive — ducks which happen to be rubber — or a distinct noun-concept, like *decoy duck*?). This translation from one branch of sub/supertype relations to another is what we would expect of type-cases, but we can also see these cases as distinct lexemes, or word-senses, or entrenched phrases with *de facto* lexical status. The overall picture which seems to emerge is that type-coercions remain relatively metaphorical or metonymic in cases like (198) or (197); become idiomatically entrenched in cases like (193) and (196) — especially where there is a similar scale of granularity btween mesotypes in a coercion — and can become *lexically* entrenched in cases like (203)-(204).

Let's assume in any case that we can give a thorough analysis of type-coercions as semantic devices. This is still working on the level of generalized lexical use-patterns; we are not studying the *cognitive* steps involved in actuallly making whatever imagistic, situational, or conceptual modifications are directed by a type-cast. In other words, there is a cognitive process of thinking of a restaurant (say) and then revising this framing to accommoate senses like spatial points or social institutions. We can weave different senses and coercions into one sentence:

- (205) This book, which costs $40, has some crazy ideas inside.
- (206) This book, which the library classifies as young adult nonfiction, has some dude's phone number scrawled inside.
- (207) My boss barks louder than his dog does.

In short, we can't assume that type-coercions simply replace an image forged according to one micro- or mesotype with one shaped by an alternative type. Instead, signifying elements seem to carry a package of type attributions around, and different types are "activated" to different extents, and in different ways, at different stages of linguistic processing.

Another complication is that types of different scales seem to coexist and yet in other respects macrotypes, mesotypes, and microtypes seem to be distinct hierarchies. A microtype like *dog* acts sometimes as a subtype for a mesotype like *animal*, but also mesotype concepts like *animal* and *person* are sometimes microtypes themselves: after all, these are lexical entries as well as Ontological categories. So on the one hand we may say that words have three different types — even excluding cross-mesotype or cross-microtype ("bosses barking" cases) casts — and that macro-, meso-, and microtypes are distinct thoretical posits with different analytic mthodology; but sometimes the boundaries between micro- and meso, and thir analyses, seem to blur. Analogous comments can apply to the meso/macro boundary as evinced by issues like classifying forms of pluarality, as in [57]'s analysis of noun plurals.

This metathoretic hemming and hawing may be acceptable — even desirable — at the philosophical level. But it causes problems if we want to see type theory as a formalizing (albeit simplifying) window onto cognitive-linguistic processes. In a computational context values have one canonical type; they can be cast to other types but do not maintain a kind of superposition "history" over multiple types. These kinds of phenomena can be technically modeld in various ways (e.g. Luo's "dot-product" types), but in that case we want a formalization that seems appropriate for how the corresponding cognitive procedures might unfold.

In the case of Channel Algebra, I mentioned the idea of "rider" channels which supplement the type information contained in other channels, adding more information without actually introducing new parameters into a proceure. So a rider asserting that y can be made into an xy pair is semantically analogous to giving y the type *integer greater than* x, but y itself is not presented as having a dependent type. In short, *greater than* x is not presented as an *alternative* type for y, nor is $y > x$ presented as an alternative *value* as if we are "casting" y from a wider to narrower type. However, we are asserting properties of y by certifying that such casts *would* be possible.

I think this may be a useful analogy to how type-casts work in practice in Natural Languages, especially in complex cases where multiple word-senses are involved. Not every type associated with a word makes sense in every conceptualization. When, for instance, we attend to the conceptual properties of a book as an intellectual object, there may be physical details which are conceptually incompatible with this attitude. It would be simpler if there were a neat partition among senses, and some overarching cognitive order — Ok, now we're figuring the book as physical; now it's an intellectual artifact; now it's a commodity — supervises the coercions back and forth. Neither semantic nor syntactic evidence warrants this simpler picture: it seems more as if conceptualization across types is a matter of networked cognitive procedures taking turns operating on one conceptual package, where latent type atttributions are available to each procedure whether or not they are "usable" in the sense of involving type structures that logically fit each procedure's purpose.

I will give concrete cases of word-senses that I think substantiate this picture in the next section. Here, though, I'll conclude as follows: Channel Algebra can perhaps model what is going on insofar as procedures can take "rider" channels that can add detail to procedural inputs. In a cognitive-linguistic setting, we can imagine these riders as multifaceted and complex. Because riders are not part of procedures' actual inputs, they do not necessarily need to use types that the procedure recognizes or knows about; the riders may only come into play as values are passed among procedures. The analogous computational case would be some extra data associated with a value that is only relevant for certain security-oriented validations; i.e., permissions to modify a file. Functions can pass around such values without considering the security-related data, except for a few procedures where security-sensitive operations are attempted. So the security details are "part" of the data carried by a value, but only become semantically salient parts in certain procedural contexts. Rider channels are a way to represent this kind of extra information within a type system directly. I think they are a plausible analogy for cognitive re-inscriptions that occur in the evolving significations in a sentence, according to analyses like I will entertain in the next section.

10 Cognitive Grammar and Type Theoretic Semantics

The emergence of Dependency Grammar as a *computational* approach has some broad implications. The historical preference for phrase-structure foundations — among those who actually build Natural Language Processing code libraries, in disciplines related to Artifical Intelligence — arguably reflects how phrase structure more cleanly models a theory of linguistic meaning and signification based on "symbolic logic" — a theory that the *meaning* of a complete and self-contained linguistic expression is the logical state of affairs which it asserts or in other ways connotes. Correlated with this assumption is the idea that phrase structure logically transforms its constituent parts; so from the word "students" we can form the phrase "many students" to designate a kind of plurality — a plural set but also, more specifically, a set which is reasonably large relative to some context. In the hierarchical model presented by these norms, phrases subsume the roles of individual words and represent discrete semantic units with respect to still larger phrases.

It is certainly true that one role for phrases is to satisfy a semantic niche — often a place occupied in other (or even the same) language with single words, or vice-versa. The French "laisse tomber" translates the English "drop", for example; and "parliamentarian" is a more exotic version of "Member of Parliament". There is no evident pattern for when a single concept is conveyed, in one language or another, by a single word or a multi-word phrase. Moreover, the meanings of phrases are influenced by semantic conventions no less than are individual words, and they are not solely a product of phrase constituents. Semantics is guided by what people need to talk and write about often; when events in a linguistic community call for some fairly rigid and repeatable designation for an important concept, the resources of language adjust to provide that role, either through a complete neologism, or a lexical variant — a new usage; or the entrenchment of a phrase. In current events, the expression "Syrian Refugees" recurs when discussing people displaced by the Syrian civil war, and potentially other interrelated conflicts also; convention seems to allow that nominal "Syrian" Refugees don't have to be Syrian nationals. The meaning of the phrase is fixed by its niche in familiar discourse more than by its literal form. Phrases exhibit conventionalization and usage pressures analogous to single words; which lends credance to the notion that phrases subsume the role of single words, and that the semantic contribution of words to sentences is determined through the phrases where they occur.

On the other hand, it is well established that words' contributions are not *wholly* subsumed by their surrounding phrase-structure. The famous joke about the Holy Roman Empire — or its reprise in the current line that the Islamic State is neither Islamic nor a State — point to evidence that as language-users we still hear the individual words outside their phrase context. To subsume a word into a phrase is also to suggest a particular semantic (and pragmatic, real world) interpretation, one which conversants may challenge.[13]

Arguably, joking or titular cases like "Holy Roman Empire" can be relegated to thematic margins, especially if we accept formal-logical construals of what semantics is all about, with an *a priori* contrast between Semantics and Pragmatics, the former rooted in *states of affairs* and only the latter addressing rhetoric and usage. Counter to this counter-argument, however, we can observe that different phrases imply different degrees of "autonomy" to their constituents, and different degrees of coherence or unification into a single idea. Some

[13] How literally to take phrases is a notorious source of political controversy: recall debates about the relevance of Afghanistan for Iraq, in US policy, and Rudy Giuliani saying "There *is* Al Qaeda in Iraq — it's called, 'Al Qaeda in Iraq'".

phrases act as direct substitutes for single concepts (like "Member of Parliament") where it seems mostly historical accident that a phrase rather than a word emerged as the most popular; but many other phrases have more complex usage scanarios, including everyday expressions that don't have special rhetorical or sociolinguistic conventions that would make them tangential to semantic or syntactic analysis proper. Moreover, many of these examples are similar to those used by Cognitive Grammar to challenge the syntax/semantic distinction and argue for "morphosyntactic" models as reciprocating cognitive formations, not abstract language-rules.

For example, in Ronald Langacker's *Foundations of Cognitive Grammar*, the sentence

(208) Three times, students asked an interesting question

is used to demonstrate how grammatical principles follow from cognitive "construals" of the relevant situations, those which language seeks to describe or takes as presupposed context.[14] In particular, Langacker argues that "students" and "question" can both be either singular or plural: syntax is open-ended here, with neither form more evidently correct. Langacker uses this example to make the Cognitive-Linguistic point that we assess syntactic propriety relative to cognitive frames and conversational context. In this specific case, we are actually working with two different cognitive frames which are interlinked — on the one hand, we recognize distinct events consisting of a student asking a question, but the speaker calls attention, too, to their recurrence, so the events can also be understood as part of a single, larger pattern. There are therefore two different cognitive foci, at two different scales of time and attention, a "split focus" which makes both singular and plural invocations of "student" and "question" acceptable.

Supplementing this analysis, however, we can additionally focus attention directly on grammatical relations. The words *student* and *question* are clearly linked as the subject and object of the verb *asked*; yet, contrary to any simple presentation of rules, no agreement of singular or plural is required between them (they can be singular and/or plural in any combination). Moreover, this anomaly is only in force due to the context established by an initial phrase like *three times*; absent some such framing, the singular/plural relation would be more rigid. For example, "A student asked interesting questions" would (in isolation) strongly imply *one* student asking *several* questions. So the initial "Three times" phrase alters how the subsequent phrase-structure is understood while remaining structurally isolated from the rest of the sentence. Semantically, it suggests a "space builder" in the manner of Gilles Fauconnier or Per Aage Brandt [29]; [17], but we need to supplement Mental Space analysis with a theory of how these spaces influence syntactic acceptability, which would seem to be logically prior to the stage where Mental Spaces would come in play. This complex interplay of phrase-structures is hard to accommodate from the grammar-hierarchy perspective. There seems to be no way to break down this example sentence into a tree-like phrase hierarchy wherein each phrase, considering the semantic concept which it is apparently tasked to put into words, can be seen to function in isolation. The mapping of the sentence to a logical substratum would be more transparent with a sentence like "Three students asked interesting questions"; that sentence is a more direct translation of the facts which the original sentence conveys. But this "more logical" sentence has different connotations than the sentence Langacker cites; the original sentence places the emphasis elsewhere, calling attention more to the idea of something temporally drawn-out, of a recurrence of events and a sense of time-scale. The "more logical" sentence lacks this direct invocation of time scale and temporal progression.

We can say that the "Three students" version is a more direct statement of fact, whereas Langacker's version is more speaker-relative, in the sense that it elaborates more on the speaker's own acknowledgment of belief. The speaker retraces the steps of her coming to appreciate the fact — of coming to realize that the "interesting questions" were a recurrent phenomenon and therefore worthy of mention. By situating expressions relative to cognitive processes rather than to the facts themselves, the sentence takes on a structure which models the cognition rather than the states of affairs. But this shift of semantic grounding from the factual to the cognitive also apparently breaks down the logical orderliness of the phrase structure. "Three times", compared to "three students", leads to a morphosyntactic choice-space which is "underdetermined" and leaves room for speakers' shades of emphasis.

[14] For example, [51, pp. 119 and 128], discussed by [16, p. 189], and [63, p. 9].

This is not an isolated example. Many sentences can be provided with similar phrase-structure complications, particularly with respect to singular/plural agreement.

- (209) Time after time, tourists (a tourist) walk(s) by this building with no idea of its history.
- (210) The streets around here are confusing; often people (someone) will ask me for directions.
- (211) Student after student came with their (his/her) paper to compain about my grade(s).
- (212) Student after student — and their (his/her) parents — complained about the tuition increase.

On a straightforward phrase-structure reading, *student after student* reduces to an elegant equivalent of *many students*, with the rhetorical flourish abstracted away to a logical form. But our willingness to accept both singular and plural agreements (his/her/their parents, grades, papers) shows that clearly we don't simply substitute *many students*; we recognize the plural as a logical gloss on the situation but engage the sentence in a more cogntively complex way, recognizing connotations of temporal unfolding and juxtapositions of cognitive frames. The singular/plural underdeterminism is actually a signification in its own right, a signal to the listener that the sentence in question demands a layered cognitive attitude. Here again, syntactic structure (morphosyntactic, in that syntactic allowances are linked with variations in the morphology of individual words, such as singular or plural form) serves to corroborate conversants' cognitive frames rather than to model logical form.

This is not to say that phrase-structure paradigms are refuted by these examples. Cases like these can be accommodated by layering new structural rules, such as allowing exceptions for singular/plural agreement in the presence of certain "lead-in" phrases like "Three times". It is not even accepted that these examples clearly favor inter-word relations (as language formalization, in preference over phrase-structure trees) — cases like *student after student* have also been used *against* Dependency Grammar on the argument that there is not a clear "single" word, in that phrase, which should be seen as linking with words elsewhere in the sentence [61, pp. 400-401], [60, p. 2]. It seems arbitrary to select either *student*, or *after*, as "the" representative of the phrase to link with — for example — the verb *complained*; on that argument, the least arbitrary analysis is to treat the phrase as a whole as a single unit for purposes of grammatic linkage. In short, both paradigms have potential problems with these example. Considering *student after student* as an encapsulated phrase leaves the singular/plural flexibility in the continuation of the sentence unexplained (*Many students compained about ?his grade* is clearly dubious, so "Many students" is not a direct substitution). But bracketing the phrase when decribing the sentences' "linkage" leads to an apparently arbitrary choice when it comes time to notate the subject/verb linkage for *complained*. I will address this particular ambiguity later; but for now I'll just point out that a simplistic reading of both Dependency and Phrase-Structure ideas seems to run aground.

10.1 *Comparing paradigms*

Since Computational-Linguistic paradigms find practical expression in code libraries, there are some options to assess competing theories empirically — comparing libraries' speed, accuracy, ease of use, and how readily can they be modified in light of new research. Arguably, however, the quality of a code library does not automatically reflect the accuracy of its underlying linguistic paradigms (as opposed to the skill, foresight, and resources of its programmers); not to mention that more complex analyses of human language may be both more correct and also harder to express in code. There is, in any case, no apparent consensus amongst linguists and programmers that one or another language theory has proven computationally preferable. Another approach to theory-comparison involves considering the range of linguistic phenomena which different methods can explain, without resorting to ad-hoc compilations of exceptions and special cases. Arguably, here, Dependency Grammar provides more straghtforward explanations. For example, the internal structure of phrases seems to lend specificity and nuance to their meaning in ways that get lost when trying to replace phrases with logico-semantic equivalents. "Student after student" is not losslessly substitutable with "Many students", and the former phrase has a temporal and multi-tier cognitive implication which the latter discards. The second phrase is compatible with "Many students" complaining *at one time*, as well as drawn out over time; the former phrase appears to clarify that the second kind of situation is the intended meaning, Of course, in context, the two phrases may be understood to have similar meanings; but this is a product of how the linguistic structure relates to its presumptive conversational context, not to an intrinsic semantic equivalence. I will now consider these and other examples to discuss the dependency/phrase-structure contrast in a little more detail.

The contrast between the phrases "Student after student" and "Many students" cannot be based on "abstract" semantics alone — how the evident temporal implications of the first form, for example, are concretely understood, depends on conversants' mutual recognition of a relevant time frame. The dialog may concern a single day, a school year, many years. We assume that the speakers share a similar choice of time "scale" (or can converge on one through subsequent conversation). *Some* time-frame is therefore presupposed in the discursive context, and the first phrase invokes this presumed but unstated framing. The semantics of the phrase are therefore somewhat open-ended: the phrase "hooks into" shared understanding of a temporal cognitive framing without referring to it directly. By contrast, the second phrase is less open-ended: it is consistent with both a more and less temporally protracted understanding of *many*, but leaves such details (whatever they may be) unsignified. The factual circumstance is designated with a level of abstraction that sets temporal considerations outside the focus of concern. The second phrase is therefore both less open-ended and also less expressive: it carries less detail but accordingly also relies less on speaker's contextual understanding to fill in detail.

Clearly the two phrases are therefore semantically different; but notice also that the semantic properties of the first phrase are due explicitly to its internal structure. The temporality implicatures could be expressed in a more "purely" semantic fasion with a choice of wording, like *a procession of students complained*. This would rely on the conventional meaning of *procession* (or *stream*, *sequence*, etc.) to provide the expressive "time" dimension. But the *student after student* phraseology achieves this effect more economically and with more "oomph" because the internal repetition in the phrase itself effectively models the recurrence it seeks to feature semantically. Here linguistic form actually does reproduce factual structure, like a syntactic version of onomatopoeia. This fact of internal structure clearly can only be fully modeled by taking seriously the exact composition of the phrase, not treating the phrase-structure as a convention fully subsumed by a semantic role.

In addition, aside from the expressive detail which depends on the actual phrase structure (which therefore cannot be summarized away), this inner structure also governs morphosyntactic possibilities over all. *A procession of students* captures a similar temporal progression but also fully absorbs *student* in a plural guise, and *A procession of students complained about ?his grade* is straightforwardly ungrammatical. In Langacker's "Three times" example, the inter-word "linkage" captures the aforementioned complexities in a reasonably non-arbitrary way, I believe. *Student* is linked as subject-to-verb with *asked*, and as subject-to-object with *question*. It is true that these link-pairs seem to violate agreement norms, but there is nothing in the Link Grammar paradigm — which practices Dependency Grammar with a rather detailed and intricate inventory of inter-word relations, or "links" — mandating that *all* link-pairs exhibit forced agreement (like singular/plural). Agreement, when it applies, is a property *of* link pairs. There is also an implicit (cross-phrasal) link between *student* and *Three* — clarifying that, considered in its entirely, the sentence is about three students precisely — and the presence of this kind of link alters how the other links connecting to the word *student* are assessed. In particular, this latter link stipulates that the word *student* is being simultaneously understood in both a plural and a singular sense, so it permits singular *and* plural link forms which, more commonly, could only be singular *or* plural. So link grammar can offer an elegant analysis of singular/plural "underdeterminism", expressed in the same underlying graph-context terminology as most other link-grammar theorizing. It would be unfair to use this as a case against Phrase Structure grammars without a detailed presentation of how these grammars would handle such a case in turn, but I'd argue that link grammar accommodates this complex example with relatively little departure from its underlying theoretical and notational or presentational commitments.

While my previous examples contrasted Phrase Structure and Dependency Grammars in terms of their resources for explaining sentences with unusual semantic patterns but relatively clear meanings (in context), another form of comparison can address actual ambiguity. Consider

(213) The Maple Leafs failed to win in overtime for the first

time this year.

(214) The Maple Leafs failed for the first time this year to win in overtime.

The first can mean either that the Leafs had won *all* or *none* of their prior overtime games. From a phrase-structure perspective, we have to image that *to win in overtime* can "migrate" so we hear it as in the second version of the sentence. For more inter-word grammars, the alternation is simpler: "for", initiating the phrase *for the first time*, can be linked with either *failed* or *win* — notationally, it amounts to the presence or absence of one graph-edge, when the syntax is represented as a graph with inter-word labels for link kinds. This could be a distinction without a real difference, since choosing which inter-word link to recognize triggers linking in the rest of the phrase along with it. But perhaps reflecting on how we process the ambiguity — realizing that there are two competing parses and deciding which is the one intended — we picture the alternatives more as "horizontal" options for connecting threads across the sentence, more so than a "vertical" organization where we hear *for the first time* as "contained" in a larger phrase. My own feeling is of exploring competing relational patterns more than exploring different ways that the phrases can be nested inside each other.

That being said, how much of our sense of ambiguity (or clarity, for that matter) is driven by meaning, not form? The "double parse" just examined does not always generalize to similar cases:

(215) The Maple Leafs failed to win two consecutive games for the first time this year.

The reading as in "this is the first time they failed to win two consecutive games" makes no sense — unless you've won every game, but perhaps the first, you've at some point lost after a win. Is this case anomalous, where a syntactic ambiguity idiosyncratically fails to yield logically plausible readings? The ambiguity is found in *failed to make the playoffs for the first time since 2013*, and many *for the first time this season* cases, like *beat the Habs*, *sell out the arena*, *score a goal in the first period*. But "failed to score a goal" is almost surely read that they *did* score in every prior game. Do we hear the construction as intrinsically ambiguous, and reject one reading only when it is clearly flawed pragmatically?

If we believe that language understanding unfolds in a predictable operational sequence, then we should assume that both parses are deemed plausible, and semantic considerations only retroactively eschew one reading (if they do so at all). This would explain why in many cases the ambiguity persists enough to cast the practically intended meaning in doubt. But that account does not consider the temporality of language itself; the hearer does not know in advance that a trailing phrase like *for the first time this season* is coming, and starts to make sense of the sentence up to there; once then hearing or reading the addendum, the audience instinctively has to interpret the final phrase as deliberately inserted to modify an already-complete idea. On this analysis, the addendum is initially approached as a performative detail, something said for a reason to be determined — it is not structurally necessary to make the sentence well-formed. Perhaps we then try to fit the last phrase into the sentence both syntactically and semantically, together, triggered by a pragmatic phenomenon (the speaker's choice to add on to a seemingly complete thought) which then becomes logically prior to both syntax and semantics. If this is plausible, it supports an inter-word relational model because we are forming a picture of language structure relationally, assimilating new words and phrases to those already heard by linkings referring back in time, rather than waiting until we are sure we have a complete sentence and then treating it as a static structure to vertically reconstruct.

The examples I have used so far may also imply that a choice of phrase structure is always driven by semantic connotations of one structure or another; but seemingly the reverse can happen as well — speakers choose a semantic variant because its grammatic realization lends a useful organization to the larger expression. There are many ways to say "many", for example: *a lot of*, *quite a few*, not to mention "time after time" style constructions. Whatever their subtle semantic variations, these phrases also have different syntactic properties: *Quite a few* is legitimate as standalone (like an answer to a question); *A lot of* is not, and *A lot* on its own is awkward. On the other hand the "of" in *A lot of* can "float" to be replicated further on: "A lot of students, of citizens, believe education must be our top priority" sounds more decorous than the equivalent sentence with the second "of" replaced by "and". If the cadence of that sentence appeals to the speaker, then such stylistic preference will influence taking "A lot of" as the "many" variant of choice. So speakers have leeway in choosing grammatic forms that highlight one or another aspect of situations; but they also have leeway in choosing rhetorical and stylistic pitch. Both cognitive framings and stylistic performance can be factored when reconstructing what compels the choice of one sentence over alternatives.

One consequence of these analyses, should they be accepted, is that grammar needs to be approached holistically: the grammatic structure of phrases cannot, except when deliberate oversimplification is warranted, be isolated from surrounded sentences and still larger discourse units. Semantic roles of phrases have some effect on their syntax, but phrases are nonetheless chosen from sets of options, whose variations reflect subtle semantic and syntactic maneuvers manifest at super-phrasal scales. The constituent words of phrases retain some autonomy, and can enter into inter-word and phrasal structures with other words outside their immediate phrase-context. We can still apply formal models to phrase structure — for example, Cognitive and Applicative Grammar (CAG) considers phrases as "applications" of (something like) linguistic or cognitive "functions", in the sense that (say) an adjective is like a *function* applied to a noun, to yield a different noun (viz., something playing a noun's conceptual role) [26]. I will consider related "functional" and (by extension) Type-Theoretic approaches in the next section. But we should not read these transformations — like *Syrian refugee* from *refugee* — too hastily as a purely semantic correlation within a space of denotable concepts — *such that* the new concept wholly replaces the contained parts, which then cease to have further linguistic role and effect. Instead, applicative structures represent shifts or evolutions in mental construal, which proceed in stages as conversants form cognitive models of each others' discourse. Even if phrase structure sets landmarks in this unfolding, phrases do not wholly subsume their constituents; the parts within phrases do not "vanish" on the higher scale, but remain latent and may be "hooked" by other, overlapping phrases. This argument rests on a vantage point from semantics as well as syntax; therefore, I will discuss it briefly at present (I return to this analysis at greater length in the next section).

Consider the effect of "Many students complained". Propositionally, this appears to say essentially that *students* complained; but, on hermeneutic charity, the speaker had *some* reason to say "many". The familiar analysis is that "many" suggests relative size; but this is only half the story. If the speaker chose merely *students complained*, we would hear an assertion that more than one student did, but we would also understand that there were several occasions when complaints happened. Adding "many" does not just imply "more" students, but suggests a mental shift away from the particular episodes. In the other direction, saying *a student complained* is not just asserting how at least one student did so, but apparently reports one specific occasion (which perhaps the speaker wishes to elaborate on). In other words, we cannot really capture the singular/plural semantics, or different varieties of plural, just by looking at the relative size of implied sets; we need to track how representations of singleness or multitude imply temporal and event-situational details. So *a student complained* focuses not on the numeric count of one, but on a singular event (unlike "*only one* student complained"); *students complained* focuses not on the plural measure of students involved, but on the fact that a certain type of event happened several times. *Many students complained* focuses not on sheer number (unlike *a large number of students complained*), but rather on the implication that complaints were widespread enough to represent a significant sample, perhaps a majority sentiment, among the student body. The semantics of the former two forms seems to focus attention on the *events* of complaining, while the *many students* construction seems to focus more on their suggesting a prevailing attitude. *Students complained* appears to single out each event as distinct, even though there are several of them; whereas *Many students complained* appears to construe the events as each resembling the other, to the point where they partly lose their individuality. "Isolated events", in the English idiom, are those which are atypical; as we cognitively shift from the events as discrete to recurring patterns, they become suggestive of a larger state of affairs. By implication, if many students complained, many other students may be unhappy; the extent of students' unrest is no longer measurable by the multiplicity of the complaining-events.

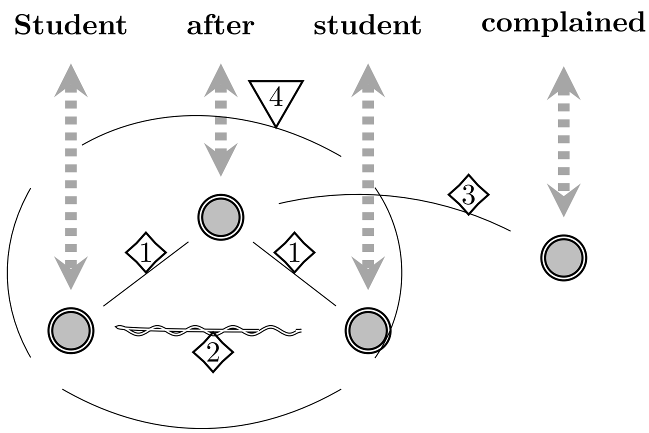
Against this backdrop, *Student after student complained* captures both dimensions, implying both a widespread unrest among the student body and also temporal recurrence of complainings. Formal models of syntax and semantics often borrow notation from formal language theory; for example, notations for Parts of Speech lifted from functional programming languages.[15] This notation can help us picture the "flow" of ideas building up to a complete sentence, formally represented via type theory (where sentences reveal a type hierarchy culminating in a self-contained idea, that is, a proposition); more informally we can picture a similar "conceptual" flow tracing how listeners come to make sense of the language they encounter enunciated by speakers. By way of illustration, Figure 1 shows a Dependency-style destructuring, with implicit type annotations. As this shows, the "Student after Student" idiom can be notated as, say, `after` :: $N^{\odot} \dot{\rightarrow} N^{\odot} \ddot{\rightarrow} N^{+}$ (using $N^{\odot}$ and N^{+} to mean singular and count-plural nouns, respectively), but with the special case that the "argument" to *after* is repeated in both positions, suggesting an unusual degree of repetition, something frustratingly recurrent: *He went on and on*; *Car after car passed us by*; *Time after time I got turned down.* Although I have no problem treating these constructions as idiomatic plurals, I also contend (on the premise of phrase-overlap) that the dependent constituents in the ——`after`—— construction can be hooked to other phrases as well (which is why "and [their/his/her] parents" can also be singular, in this case). I dwell on this example because it shows how type/functional accounts of phrase structure can be useful even if we treat phrases more as frames which overlay linguistic structure, not as rigid compositional isolates. Each "students" variation uses morphology to nudge cognitive attention in one direction or another, toward events or the degree to which events are representative of some global property (here of a student body), or both. The $N^{\odot} \ddot{\rightarrow} N^{+}$ transformation is not *the* morphosyntactic meaning, but instead the skeleton on which the full meaning (via cognitive schema) is designed, its hints solicited.

If this analysis has merit, it suggests that a CAG approach to phrases like *many students* or *student after student* (singular-to-plural or plural-to-plural mappings) should be understood not just as functions among Part of Speech (POS) types but as adding cognitive shading, foregrounding or backgrounding cognitive elements like events or typicality in some context. In other words, *many students* is type-theoretically $N \ddot{\rightarrow} N$ or $N^{+} \ddot{\rightarrow} N^{+}$; but, in more detail, it adds a kind of cognitive rider attached to the mapping which focuses cognition in the subsequent discourse onto events (their recurrence and temporal distribution); similarly "student after student" has a "rider" suggesting more of a temporal unfolding. The second form implies not only that many students complained, but that the events of these complainings were spread out over some stretch of time. Each such functional application (mappings between POS understood as linguistic types) produces not only a resulting POS "type", but also a reconfiguration of cognitive attitudes toward the relevant situation and context. Language users have many ways to craft a sentence with similar meanings, and arguably one task for linguistic analysis is to model the space of choices which are available in a given situation and represent what specific ideas and effects are invoked by one choice over others. It would be an argument in favor of Dependency Grammar if Dependency-oriented representational models, like Link Grammar, prove to be especially adept in this modeling.

In this analysis, I am already switching to functional and type notions that will be discussed in greater detail below; my current emphasis is on link grammar as a syntactic conception, although I have also tried to argue that separating syntax from semantics can be at most provisional. Inter-word "link pairs" are vehicles for expressing syntactic rules (like singular/plural agreement) but are also a ground level for semantic analysis, since we can explain how semantic nuances are carried, in specific sentences, by the actual link-pairs in evidence (violations to agreement norms, for example). These semantic nuances in turn can be given cognitive interpretations, revealing the syntax-semantics-cognition pattern which I am sketching here through specific perspectives like Link Grammar and Type Theory. Returning to the initial grammatic stage of analysis, however, my tactics for contrasting overall Dependency and Phrase-Structure paradigms rest on an implicit picture of how theories should be evaluated. While such a picture is probably fairly consistent across perspectives, it is still worth making a little more explicit.

[15] A note on notation: I adopt the Haskell convention (referring to the Haskell programming language and other functional languages) of using arrows both between parameters and before output notation, but for visual cue I add one dot above the arrow in the former case, and two dots in the latter: $Arg_0 \dot{\rightarrow} Arg_1 \dot{\rightarrow} \cdots \ddot{\rightarrow} Result$. I use N for the broadest designation of nouns (the broadest noun type, assuming we are using type-theoretic principles), with extra markings for more specific types (in principle similar notation could be adopted for verbs, propositions, and so on).

Figure 1: Dependency-style graph with argument repetition



♦ 1 Head/dependent relation
♦ 2 Argument repetition (——`after`—— idiom)
♦ 3 Propositional completion ($V :: N \dashrightarrow \mathcal{P}rop$)
▼ 4 Phrase (modeled as applicative structure), typed as N^{+}

10.2 *Explanation and Formality*

Both Dependency and Phrase Structure grammars presuppose that the fundamental exposition and achievement of their theory involves formal transformation of linguistic givens, resulting in a more complex data structure which, to the extent that the theory is correct and useful, models something of the inner structure of language (*qua* abstract formal system and/or cognitive phenomenon). The "data structure" might be a phrase-structure "tree" or a graph-like dependency "linkage", but while these representations have different form they share certain criteria: they are formally describable systems which allow some structures but reject others; they are rigorous enough to be given a mathematical (e.g., algebraic) definition; and they can be expressed in computer code which builds these structures out of Natural Language artifacts, can verify that an instance of the relevant data structures satisfies the system rules, and can execute operations which modify the structures. The phrase trees or word-link graphs are "formal substrata" which encapsulate Natural Language patterns but also are rigidly mathematical and computational. How thoroughly these substrata capture linguistic meaning is therefore directly relevant to questions of whether and in what degree natural language itself, as social and cognitive, is also formal and computational.

Translating NL content into (say) a linked-grammar graph does not make software capable of "understanding" language. If Dependency Grammar is a reasonable foundation for linguistics in general, then properly parsing sentences into their auxiliary graphs is, at most, a step in the direction toward "understanding". Even this may beg the question of what constitutes a "correct" parse: linguists appear to rely principally on their own intuitions, based on familiarity with the underlying theory; the idea they have of what a *correct* "re-presentation" looks like (for link grammar, of the correct collection of link types between the various words). When developing NLP software, they then try to ensure that the human-generated representation is indeed identified by the software in specific examples, and try to do so in such a way as to generalize to other examples. This methodology can be gleaned from observing internet chat sites and other informal research venues; one can witness developers painstakingly constructing systems which "work right" in the sense of producing the interpretation for each sentence which corresponds with what the human linguists perceive, even for sentences which the software has never encountered before. The code is considered reliable the more that new sentences are "correctly" parsed. Again, "correctly" here means, conformant to linguists' own interpretations; insofar as these are subjective, such conformance is not conclusive evidence that the transformational algorithms are "correct".

In order to assess linguistic "competence" (or whatever computational ability may simulate it), it is needed to check specific "behavior" and compare it to some expectation. The gold standard for linguistic behavior is just participating in a linguistic community, judged by the community at large as fully competent and included. Unfortunately, however — at least for those who want to profit from Artificial Intelligence — achieving true "language-like behavior" may be impossible. Scholarship therefore has to turn toward more limited notions of competence, such as representational transformation of sentences — but since each theory has its own picture of what sentences should be transformed *into*, the justification of competence measures can be circular. It is the theory which dictates how the software should act, and the software is deemed "intelligent" if it acts accordingly. We can be skeptical of such non-theory-neutral conceptions of "intelligence". Nonetheless it does count in theories' favor if they both propose accounts of language structure which are independently defensible and also can produce computing systems that reliably and without external direction map language onto those structures. Language-like behavior then involves producing a transformed representation of language embodying a particular theoretical conception of linguistic "deep structure".

It would serve Computational-Linguistic theories still further to create systems that demonstrate behavior which is "language-like" on terms less wedded to their own hypotheses. More satisfying definitions of linguistic behavior would involve intuitions of language users in general, not just language experts. For example, document classifiers — which typically use statistical analysis to predict which topic will be deemed most relevant for documents like news stories and technical articles — again illustate a kind of transformational representation, converting Natural Language to a formal data structure (in this case a relatively simple one, naming one or multiple topics from a predefined list). In this case however a broad user public can provide feedback on how well the system performs. For another example, artificial translators map language onto formal structures but then attempt an opposite map, translating the formalized representation into natural-seeming expressions in a different language. This case is different in that formal representation is an intermediary rather than end point of the transformation, but like document classifiers it is a kind of behavior whose effectiveness can be judged by a large community of speakers. People who interact with text "chat" bots, or talking robots, and feel that the experience is similar to talking with another person, are also providing evidence of more complete and larger-scale language-like behavior. Again, though, it is not now and may never be possible to engineer intelligent behavior to this level of perfection. Existing language AI platforms are flawed but useful, which suggests both that formal re-presentation is an important step toward language understanding but also that attempts to use these formalisms as a springboard to more holistic behavior — like automated translation, but also extracting practical information, or gleaning emotion and sentiment — are missing something essential. Doing useful things with or gleaning useful insight from the re-presentational target structures appears to be a separate problem from that of generating them — which calls into question the degree to which the target structures sufficiently encapsulate linguistic meaning, even if they reveal structures which are essential to linguistic meaning.

This does not have to mean that Natural Language Processing is basically impossible, only that more modest criteria of "correct" NLP systems need to be adopted. This is complicated by the fact that artifical language behavior can be flawed but meaningful: "Urine shift one step forward" is an awkward English sentence but its meaning seems clear enough (this real example comes from a shopping center in New York's Flushing, Queens Chinatown). We have an intuition that some expressions are "incorrect" but not so completely off-base that they fail to signify anything at all — but in this case we need criteria for how a linguistic performance can be both incorrect *and* nonetheless coherent.

These issues influence any theory which approaches linguistic competence from the viewpoint of formal representations, and therefore effectively all branches of Computational Linguistics. The reigning assumption appears to be that transformational representation which converts language to theory-regulated data structures, for which in many cases the transformation achieved by mechanical algorithms matches that intuited as most accurate by human experts, serves as *prima facie* evidence of something like computationally-engineered "intelligent (language) behavior". This leaves room for language-like behavior to productively replicate dimensions of language understanding while also being very incomplete: language-like relative to experts' opinions on deep linguistic structure, not real-world communication. Structures like link grammar graphs can be essential formal substrata that linguistic expression relies on to achieve communication, without being the sole medium of this expression.

My arguments so far have used Link Grammar as a representative example of "transformational representation" where a computational system can be judged to reveal some level of language competence, some kind of "language like behavior", insofar as it translates natural language expressions to data structures conformant to Dependency Grammar (and particularly Link Grammar) theory. As I also just argued, performance vis-à-vis structural transformation may be only tangential to human language, so whatever theory is built up needs a separate, more philosophical or metatheoretical analysis to consider how the theory is purported to engage with its phenomena. But I now take this as a starting point for pivoting the discussion from grammar to semantics; and will defer until after that speculating on philosophical implications of the theory thus extended.

11 Link Grammar and Type Theoretic Semantics

From one perspective, grammar is just a most top-level semantics, the primordial Ontological division of language into designations of things or substances (nouns), events or processes (verbs), qualities and attributes (adjectives), and so forth. Further distinctions like count, mass, and plural nouns add semantic precision but arguably remain in the orbit of grammar (singular/plural agreement rules, for example); the question is whether semantic detail gets increasingly fine-grained and somewhere therein lies a "boundary" between syntax and semantics. The mass/count distinction is perhaps a topic in grammar more so than semantics, because its primary manifestation in language is via agreement (*some* wine in a glass; *a* wine that won a prize; *many* wines from Bordeaux). But are the distinctions between natural and constructed objects, or animate and inanimate kinds, or social institutions and natural systems, matters more of grammar or of lexicon? Certainly they engender agreements and propriety which appear similar to grammatic rules. *The tree wants to run away from the dog* sounds wrong — because the verb *want*, suggestive of propositional attitudes, seems incompatible with the nonsentient *tree*. Structurally, the problem with this sentence seems analogous to the flawed *The trees wants to run away*: the latter has incorrect singular/plural linkage, the former has incorrect sentient/nonsentient linkage, so to speak. But does this structural resemblance imply that singular/plural is as much part of semantics as grammar, or sentient/nonsentient as much part of grammar as semantics? It is true that there are no morphological markers for "sentience" or its absence, at least in English — except perhaps for "it" vs. "him/her" — but is this an accident of English or revealing something deeper?

To explore these questions it is first necessary to consider how a grammar theory can be extended to and/or connected with a formal or, to some measure, informal semantics. Here I will present one approach to make this extension vis-à-vis Link Grammar.

Insofar as grammatic categories do provide a very basic "Ontological" viewpoint, it is reasonable to build semantic formalization on top of grammar theories. Link Grammar, for example, explicitly derives "link types" — species of word-to-word relations — by appeal to "Categorial" grammars which define parts of speech in terms of their manner of composition with other, more "fundamental" parts of speech [46], [73], [56], [28]; [14]; [21]. The most primordial grammatic categories are generally seen to be nouns and "propositions" (self-contained sentences or sentence-parts which assert individual states of affairs), and categories like verbs and adjectives are derived on their basis. For example, a verb "combines" with a noun to produce a proposition. *Students* is an abstract concept; "Students complained", tieing the noun to a verb, tethers the concept to an assertorial flesh, yielding something that expresses a belief or observation. Meanwhile, Categorial Grammar models not only the semantic transition from abstract to concrete, but surface-level composition: in English and other SVO language for example the verb should immediately follow the noun; in German and all SOV languages the verb tends the come last in a sentence, and can be well apart from its subject. The semantic pattern in the link is how the verb/noun pair yields a new semantic category (propositional) whereas the grammatic component lies in how the link is established relative to other words (to the left and not the right, for example, and whether or not the words are adjacent).

Assuming that surface-level details can be treated as grammar rules and abstracted from the semantics, we can set aside Categorial Grammar notions like connecting "left" vs. "right" or "adjacent" (near) vs. "nonadjacent" (far). With this abstracting, Categorial Grammar becomes similar to a Type-Theoretic Semantics which recognizes, in Natural Language, operational patterns that are formally studied in mathematics and computer science [55], [70], [57]. A verb, for example, *transforms* a noun into a sentence or proposition (at least an intransitive verb; other kinds of verbs may require two, or even three nouns). In some schematic sense a verb is analogous to a mathematical "function", which "takes" one or more nouns and "yields" propositions, much like the "square" function takes a real number and yields a non-negative real number. To make this analogy useful, however, it is necessary to clarify how "types" in a mathematical or computational context may serve as appropriate metaphors for syntactic and/or semantic groupings in language.

11.1 *Types, Sets, and Concepts*

Most Computer Science rests on types rather than (for example) sets, because abstract reasoning about data types requires some abstraction from practical limitations about how particular values may be digitally encoded. Types can be defined as sets of both values and "expectations" [15] (meaning assumptions which may be made about all values covered by the type); alternatively, we can (perhaps better) consider types as *spaces* of values. Types' extensions have internal structure; there can be "null" or "invalid" values, default-constructed values, and so forth, which are "regions" of type-space and can be the basis of topological or Category-Theoretic rather than set-based analyses of type-extension. Also, expectations intrinsically include functions which may be "called on" types. There is definitional interdependence between types and functions: a function is defined in terms of the types it accepts as parameters and returns — rather than its entire set of possible inputs and outputs, which can vary across computing environments. These are some reasons why in theoretical Computer Science types are not "reduced" to underlying sets; instead, extensions are sometimes complex spaces that model states of, or internal organization of comparisons among, type instances.

An obvious paradigm is organizing type-extensions around prototype/borderline cases — there are instances which are clear examples of types and ones whose classification is dubious. I will briefly argue later, however, that common resemblance is not always a good marker for types being well-conceived — many useful concepts are common precisely because they cover many cases, which makes defining "prototypes" or "common properties" misleading; this reasoning arguably carries over to types as well. Also, sometimes the clearest "representative" example of a type or concept is actually not a *typical* example: a sample latter or model home is actually not (in many cases) a real letter or home. So resemblance-to-prototype is at best one kind of "inner organization" of concepts' and types' spaces of extension. Computer Science develops other pictures of types' "state space", reflecting the trajectory of symbols or channels which hold type instances, which at different moments in time become initialized — acquiring a value obtained from a *constructor* function (one "type space region" is then demarcated by which values can be direct results of constructors) — then possibly subject to change in the value they hold, and finally (often) transitioning to a state where the held value is no longer "valid".[16] Type *spaces* have potentially complex patterns of regions and equivalence classes of inter-value mappings (in the sense of behavioral equivalence relative to code analysis, testing, or security) — the *conceptual* properties of types are expressed in the *internal structuration* of their associated state-space. Putting this in mathematical language, an in-depth treatment of types cannot work "in the Category" of sets, even for basic type-extension, but rather (for instance) the Category of Topological Spaces.

Moreover, expectations in a particular case may be more precise than what is implied by the type itself — it is erroneous to assume that a proper type system will allow a correct "set of values" to be stipulated for each

[16] Managing the "lifetime" of values from many types, especially "pointer" types (that hold a numeric value representing the current memory address of some other value), has been a notorious source of programming errors, especially in older computer languages. Of late, also, data types often need to be designed to minimize the risk of data corruption, theft, and malicious code. For these reasons, Cybersecurity takes particularly interest in studying types' extensions and transitions between different values (morphisms within a type space) to formally describe states or state-transitions which are security vulnerable.

point in a computation (the kind of contract enforced via by documentation and unit testing). So state-space in a given context may include many "unreasonable" values, implying that within the overall space there is a "reasonable" subspace, except that this subspace may not be crisply defined. A value representing someone's age may be assigned a type for which a legal value is, say, 1000 years, which is obviously unreasonable — the conceptual role served by the *particular* use of a type in some context can be distinct from the entire space of values exhibited by the type. It is possible to construct types which are narrowed down to more precise ranges, but in many cases this is unnecessary or poorly motivated: while 1000 years is clearly too large for an age, it would be arbitrary to specify a "maximum allowed" age (recall that assuming a "maximum allowed" year of 1999 — so that the year in decimal only required two digits — led to costly reprogramming of archaic legacy code during Y2K). In this kind of situation programmers usually assign types based on properties of binary representation — what number of binary digits is optimal for memory and/or speed, even if this allows "absurd" values like 1000 years old. Run-time checks, rather than type restrictions, may be used to flag nonsensical data and prevent data corruption. In these scenarios, types represent a compromise between *concepts*, which can be fuzzy and open-ended, and *sets*, which conceptually are nothing more than the totality of their extension.[17]

Sets, concepts, and types represent three different primordial thought-vehicles for grounding notions of logic and meaning. To organize systems around *sets* is to forefront notions of inclusion, exclusion, extension, and intersection, which are also formally essential to mathematical logic and undergird the classical interdependence of sets, logic, and mathematics.[18] To organize systems around *concepts* is to forefront practical engagement and how we mold conceptual profiles, as collections of ideas and pragmas, to empirical situations. To organize systems around *types* is to forefront "functions" or transformations which operate on typed values, the interrelationships between different types (like subtypes and inclusion — a type can itself encompass multiple values of other types), and the conceptual abstraction of types themselves from the actual sets of values they may exhibit in different environments. Sets and types are formal, abstract phenomena; whereas concepts are characterized by gradations of applicability, and play flexible roles in thought and language. The cognitive role of concepts can be discussed with some rigor, but there is a complex interplay of cognitive schema and practical engagements which would have to be meticulously sketched in many real-world scenarios, if our goal were to translate conceptual reasoning to formal structures on a case-by-case basis. We can, however, consider in general terms how type-theoretic semantics can capture conceptual structures as part of the overall transitioning of thoughts to langauge.

A concept does not merely package up a definition, like "restaurant" as "a place to order food"; instead concepts link up with other concepts as tools for describing and participating in situations. Concepts are associated with "scripts" of discourse and action, and find their range of application through a variegated pragmatic scope. We should be careful not to overlook these pragmatics, and assume that conceptual structures can be simplistically translated to formal models. Cognitive Linguistics critiques Set-Theoretic or Modal Logic reductionism (where a concept is just a set of instances, or an extension across different possible worlds) — George Lakoff and Mark Johnson, prominently, argue for concepts' organization around prototypes ([49, p. 18]; [41, p. 171, or p. *xi*]) and embodied/enactive patterns of interaction ([49, p. 90]; [41, p. 208]). Types, by contrast, at least in linguistic applications of type theory, are abstractions defined in large part by quasi-functional notions of phrase struture. Nevertheless, the *patterns* of how types may inter-relate (mass-noun or count-noun, sentient or non-sentient, and so forth) provide an infrastructure for conceptual understandings to be encoded in language — specifically, to be signaled by which typed articulations conversants choose to use. A concept like *restaurant* enters language with a collection of understood qualities (social phenomena, with some notion of spatial location and being a "place", etc.) that in turn can be marshaled by sets of allowed

[17] Nevertheless, there is interesting (and potentially practically useful) research in how formal type-constructions model conceptual organization: for example, Gärdenfors Conceptual Space Theory has seen formal implementations [2], and it is very interesting to juztapose scientific and mathematical treatments of Conceptual Spaces (as in [90] or [32]) with mathematical (e.g., topological) thoeries of data types [27], [74].

[18] Recent work in mathematics, however (partly under the influence of computational proof engines and foundations research like Homotopy Type Theory) shows that type and/or Category theory may replace sets as a groundlevel for logico-mathematical reasoning (if not notation) in the future [40] (It is worth pointing out that despite their similar ordinary meanings, mathematically *type* is much different from *Category* even though these respective theories can be usefully integrated).

or disallowed phrasal combinations, whose parameters can be given type-like descriptions. Types, in this sense, are not direct expressions of concepts but vehicles for introducing concepts into language.

Concepts (and types also) are not cognitively the same as their extension — the concept *restaurant*, I believe, is distinct from concepts like *all restaurants* or *the set of all restaurants*. This is for several reasons. First, concepts can be pairwise different not only through their instances, but because they highlight different sets of attributes or indicators. The concepts "American President" and "Commander in Chief" refer to the same person, but the latter foregrounds a military role. Formal Concept Analysis considers *extensions* and "properties" — suggestive indicators that inhere in each instance — as jointly (and co-dependently) determinate: concepts are formally a synthesis of instance-sets and property-sets [106], [10], [104]. Second, in language, clear evidence for the contrast between *intension* and *extension* comes from phrase structure: certain constructions specifically refer to concept-extension, triggering a mental shift from thinking of the concept as a schema or prototype to thinking of its extension (maybe in some context). Compare these sentences (216 repeats 191):

▾ (216) Rhinos in that park are threatened by poachers.

▾ (217) Young rhinos are threatened by poachers.

Both sentences focus a conceptual lens in greater detail than *rhino* in general, but the second does so more intensionally, by adding an extra indicative criterion; while the former does so extensionally, using a phrase-structure designed to operate on and narrow our mental construal of "the set of all rhinos", in the sense of *existing* rhinos, their physical place and habitat, as opposed to the "abstract" (or "universal") type. So there is a familiar semantic pattern which mentally transitions from a lexical type to its extension and then extension-narrowing — an interpretation that, if accepted, clearly shows a different mental role for concepts of concepts' *extension* than the concepts themselves.

There is a type-theoretic correspondence between intension and extension — for a type $\mathfrak{t}$ there is a corresponding "higher-order" type of *sets* whose members are $\mathfrak{t}$.[19] If we take this (higher-order) type gloss seriously, the extension of a concept is not its *meaning*, but a different, albeit interrelated concept. Extension is not definition. *Rhino* does not mean *all rhinos* (or *all possible rhinos*) — though arguably there are concepts *all rhinos* and *all restaurants* (etc.) along with the concepts *rhino* and *restaurant*. Concepts, in short, do not mentally signify sets, or extensions, or sets-of-shared-properties. Concepts, rather, are cognitive/dialogic tools. Each concept-choice, as presentation device, invites its own follow-up. *Restaurant* or *house* have meaning not via idealized mental pictures, or proto-schema, but via kinds of things we do (eat, live), of conversations we have, of qualities we deem relevant. Concepts do not have to paint a complete picture, because we use them as part of ongoing situations — in language, ongoing conversations. Narrow concepts — which may best exemplify "logical" models of concepts as resemblance-spaces or as rigid designators to natural kinds — have, in practice, fewer use-cases *because* there are fewer chances for elaboration. Very broad concepts, on the other hand, can have, in context, too *little* built-in *a priori* detail. (We say "restaurant" more often than *eatery*, and more often than *diner*, *steakhouse*, or *taqueria*). Concepts dynamically play against each other, making "spaces" where different niches of meaning, including levels of precision, converge as site for one or another. Speakers need freedom to choose finer or coarser grain, so concepts are profligate, but the most oft-used trend toward middle ground, neither too narrow nor too broad. *Restaurant* or *house* are useful because they are noncommittal, inviting more detail. These dynamics govern the flow of inter-concept relations (disjointness, subtypes, partonymy, etc.).

Concepts are not rigid formulae (like instance-sets or even attributes fixing when they apply); they are mental gadgets to initiate and guide dialog. Importantly, this contradicts the idea that concepts are unified around instances' similarity (to each other or to some hypothetical prototype): concepts have avenues for contrasting different examples, invoking a "script" for further elaboration, or for building temporary filters ("Let's find a restaurant that's family-friendly"; allowing such one-off narrowing is a feature of the concept's flexibility). No less important, than acknowledged similarities across all instances, are well-rehearsed ways vis-à-vis each concept to narrow scope by marshaling lines of *contrast*, of *dissimilarity*.

[19] Related constructions are the type of *ordered sequences* of $\mathfrak{t}$; unordered collections of $\mathfrak{t}$ allowing repetition; and stacks, queues, and deques (double-ended queues) as $\mathfrak{t}$-lists that can grow or shrink at their beginning and/or end.

A *house* is obviously different from a *skyscraper* or a *tent*, and better resembles other houses; but there are also more nontrivial *comparisons* between houses, than between a house and a skyscraper or a tent. Concepts are not only spaces of similarity, but of *meaningful kinds of differences*.

To this account of conceptual spaces we can add the conceptual matrix spanned by various (maybe overlapping) word-senses: to *fly*, for example, names not a single concept, but a family of concepts all related to airborn travel. Variations highlight different features: the path of flight (*fly to Korea*, *fly over the mountain*); the means (*fly Korean air*, *that model flew during World War II*); the cause (*sent flying (by an explosion)*, *the bird flew away (after a loud noise)*, *leaves flying in the wind*). Words allow different use-contexts to the degree that their various *senses* offer an inventory of aspects for highlighting by *morphosyntactic* convention. Someone who says *I hate to fly* is not heard to dislike hand-gliding or jumping off mountains.[20] Accordant variations of cognitive construal (attending more to mode of action, or path, or motives, etc.), which are elsewhere signaled by grammatic choices, are also spanned by a conceptual space innate to a given word: senses are finer-grained meanings availing themselves to one construal or another.

So situational construals can be signaled by word- and/or syntactic form choice (locative, benefactive, direct and indirect object constructions, and so forth). Whereas conceptual organization often functions by establishing classifications, and/or invoking "scripts" of dialogic elaboration, cognitive structure tends to apply more to our attention focusing on particular objects, sets of objects, events, or aspects of events or situations. *Conceptual* is more abstract and belief-oriented; *Cognitive* is more concrete and phenomenological. Concepts organize our "background knowledge" [86]; cognitions allow it to be latent against the disclosures of material consciousness [84], [85], [107], [42]. So the contrast between singular, mass-multiples, and count-multiples, among nouns, depends on cognitive construal of the behavior of the referent in question (if singular, its propensity to act or be conceived as an integral whole; if multiple, its disposition to either be divisible into discrete units, or not). Or, events can be construed in terms of their causes (their conditions at the outset), or their goals (their conditions at the conclusion), or their means (their conditions in the interim). Compare *attaching* something to a wall (means-focused) to *hanging* something on a wall (ends-focused); *baking* a cake (cause-focus: putting a cake in the oven with deliberate intent to cook it) to *burning* a cake (accidentally overcooking it).[21] These variations are not random assortments of polysemous words' senses: they are, instead, rather predictably distributed according to speakers' context-specific knowledge and motives.

I claim therefore that *concepts* enter language complexly, influenced by conceptual *spaces* and multi-dimensional semantic and syntactic selection-spaces. Concepts are not simplistically "encoded" by types, as if for each concept there is a linguistic or lexical type that just disquotationally references it — that the type "rhino" means the concept *rhino* ("type" in the sense that type-theoretic semantics would model lexical data according to type-theoretic rules, such as *rhino* as subtype of *animal* or *living thing*). Cognitive schema, at least in the terms I just laid out, select particularly important gestalt principles (force dynamics, spatial frames, action-intention) and isolate these from a conceptual matrix. On this basis, we can argue that these schemata form a precondition for concept-to-type association; or, in the opposite logical direction, that language users' choices to employ particular type articulations follow forth from their prelinguistic cognizing of practical sce-

[20] People, unlike birds, do not fly — so the verb, used intransitively (not flying *to* somewhere in particular or *in* something in particular), is understood to refer less to the physical motion and more to the socially sanctioned phenomenon of buying a seat on a scheduled flight on an airplane. The construction highlights the procedural and commercial dimension, not the physical mechanism and spatial path. But it does so *because* we know human flight is unnatural: we can poetically describe how the sky is filled with flying leaves or birds, but not "flying people", even if we are nearby an airport. Were "flying people" used jokingly, it would be in bad taste, like "cat all over all over the driveway" from Pinker [69] on page 119 and Langacker's "Nouns and Verbs" [50] on page 67.

[21] We can express an intent to bake someone a cake, but not (well, maybe comedically) to *burn* someone a cake ("burn", at least in this context, implies something not intended); however, we *can* say "I burnt your cake", while it is a little jarring to say "I baked your cake" — the possessive implies that some specific cake is being talked about, and there is less apparent reason to focus on one particular stage of its preparation (the baking) once it is done. I *will* bake a cake, in the future, uses "bake" to mean also other steps in preparation (like "make"), while, in the present, "the cake *is* baking" emphasizes more its actual time in the oven. I *baked your cake* seems to focus (rather unexpectedly) on this specific stage even after it is completed, whereas *I baked you a cake*, which is worded as if the recipient did not know about the cake ahead of time, apparently uses "bake" in the broader sense of "made", not just "cooked in an oven". Words' senses mutate in relation to the kinds of situations where they are used — why else would *bake* mean "make"/"prepare" in the past or future tense but "cook"/"heat" in the present?

narios as this emerges out of collections of concepts used to form a basic understanding of and self-positioning within them.

In this sense I called types "vehicles" for concepts: not that types *denote* concepts but that they (metaphorically) "carry" concepts into language, as a bus carries people into a city. "Carrying" is enabled by types' semi-formal rule-bound interactions with other types, which are positioned to capture concepts' variations and relations with other concepts. To express a noun in the benefactive case, for example, which can be seen as attributing to it a linguistic type consistent with being the target of a benefactive, is to capture the concept in a type-theoretic gloss. It tells us, I'm thinking about this thing in such a way that it *can* take a benefactive (the type formalism attempting to capture that "such a way"). A concept-to-type "map", as I just suggested, is mediated (in experience and practical reasoning) by cognitive organizations; when (social, embodied) enactions take linguistic form, these organizing principles can be encoded in how speakers apply morphosyntactic rules. So the linguistic structures, which I propose can be formally modeled by a kind of type theory, work communicatively as carriers and thereby signifiers of cognitive attitudes. The type is a vehicle for the concept because it takes part in constructions which express conceptual details — the details don't emerge merely by virtue of the type itself. I am not arguing for a neat concept-to-type correspondence; instead, a type system provides a "formal substrate" that models (with some abstraction and simplification) how properties of individual concepts translate (via cognitive-schematic intermediaries) to their manifestation in both semantics and syntax.

Continuing with benefactive case as a case study (no pun intended), consider how an ontology of word senses (which could plausibly be expressed by types and subtypes) can interrelate with the benefactive. A noun as a benefactive target most often is a person or some other sentient/animate being; an inanimate benefactive is most likely something artificial and constructed (cf., *I got the car new tires*). How readily hearers accept a sentence – and the path they take to construing its meaning so as to make it grammatically acceptable – involves interlocking morphological and type-related considerations; in the current example, the mixture of benefactive case and which noun "type" (assuming a basic division of nouns into e.g. animate/constructed/natural) forces a broader or narrower interpretation. A benefactive with an "artifact" noun, for example, almost forces the thing to be heard as somehow disrepaired:

- (218) I got glue for your daughter.
- (219) I got glue for your coffee mug.

We gather (in the second case) that the mug is broken — but this is never spelled out by any lexical choice. It is implied indirectly by benefactive case along with notions of classification, on the grammar/semantic border, that have a potential type-theoretic treatment. It is easy to design similar examples with other cases: a locative construction rarely targets "sentient" nouns, so in

- (220) We're going to Grandma!
- (221) Let's go to him right now.
- (222) Let's go to the lawyers.
- (223) Let's go to the press.

we mentally substitute the person with the place where they live or work. Morphosyntactic considerations are also at play: *to the lawyers* makes "go" sound more like "consult with", partly because of the definite article (*the* lawyers implies conversants have some prior involvement with specific lawyers or else are using the phrase metonymically, as in "go to court" or "to the courts", for legal institutions generally; either reading draws attention away from literal spatial implications of "go"). *Go to him* implies that "he" needs some kind of help, because if the speaker just meant going to wherever he's at, she probably would have said that instead. Similarly, the locative in *to the press* forces the mind to reconfigure the landmark/trajector structure, where *going* is thought not as a literal spatial path and *press* not a literal destination — in other words, the phrase must be read as a metaphor. But the "metaphor" here is not "idiomatic" or removed from linguistic rules (based on mental resemblance, not language structure); here it clearly works off of formal language patterns: the landmark/trajector relation is read abstracted from literal spatial movement because the locative is applied to an expression (*the press*) which does not (simplistically) meet the expected interpretation as "designation of place". We need to analyze syntactic details like noun case and forms of articles, but also finer-grained (though not purely lexicosemantic) classifications like sentient/nonsentient or spatial/institutional.

One way to engage in classification in this kind of example is just to consider subtyping: divide nouns into sentient and non-sentient, the former into human and animal and the latter into artifacts and natural things, and so forth. But other options are less blunt. For example, notions like sentient/nonsentient can be construed as "higher-order types", meaning that for broadly-hewed types like nouns or verbs, there are sentient (and non-sentient) variants, just as for a type $\mathfrak{t}$ there are mass-plural and count-plural collections of $\mathfrak{t}$, ordered and unordered $\mathfrak{t}$ collections, and so on. Subtyping, higher-order types, inter-type associations and various other formal combinations are options for encoding grammatic and semantic classification in something like a formal type theory. The key properties of type systems are not only meanings atttached to individual types but notions of functionality (according to the central notion that a type system includes "function" types which are mappings between other types; in Category Theory, any formal type system is "Cartesian Closed", meaning that if $\mathcal{T}_1$ and $\mathcal{T}_2$ are types, there is necessarily a type $\mathcal{T}_2^{\mathcal{T}_1}$ of functions between them). So if adjectives, say, are most basically $N \dashrightarrow N$ (they modify nouns and yield noun-role phrases), we can then consider how adjectives should be modeled when their modified nouns are associated with or attributed sentience, mass-plural, or any other variation (whether via subtyping or some other association). How these "variations" are modeled in accord with one single type is less important than how they "propagate" via applicative structures, where "function-like" types apply transformations and produce phrases.

To build up a linguistic type theory, I assume, then, a framework of types and type associations with a few underlying properties, such as these:

- Types have a spectrum of granularity, from the very broad (Parts of Speech) to the much narrower, including (at the fine end of the scale) where they incorporate lexical data (types can potentially include *rhino*, *house*, and so on). In between are constructions related to "Ontology", like sentient/nonsentient, pointwise/extended, artifact/institution, among many others.

- Types are neither strictly grammatic nor strictly semantic, but their gradations of precision cross between grammar and semantics.

- Returning to "Ontology": types have associated qualities like sentient/nonsentient; spatially (and/or temporally) extended, pointwise, or nonspatial (/non-temporal); caused, self-causing, self-determining, affected by other things, affecting other things; objects, events, processes, or institutions; abstracta or spatetime present things; observables or subjectives like emotions or sensations, which are temporally present for someone but not (directly) encountered by others. These are qualities pertaining to the manner of referents' appearing, causing, and extending in the world and in consciousness, and to a "classification" of kinds of entities (like a metaphysical Ontology, though the point is not to reproduce Medieval philosophy but, more modestly, to catalog word senses). I will refer to these qualities generically as "associations". They may be introduced via subtyping or more complex type operators.

- Some types are "function like": this means that they are *applied* to senses which have their own types. This introduces one form of head/dependent relation, where a head word instances a function-like type and is applied to one or more "dependents".

- Type information "distributes over" Link Grammar pairs. For any pair of words which have a meaningful inter-word relation, we can consider types which may be applicable to both words, and how these types affect and are affected by the significance of the particular kind of link. Some kinds of links mandate particular type interpretations of the links elements: TS links,[22] to cite a narrow example, would only be formed between verb and $\mathcal{Prop}$ types (at least this is a plausible interpretation of the relevant Link Grammar rules. Other type/link combinations are more open-ended.

- Type information similarly "distributes" over clusters of link-pairs, where the presence of one such link influences how a connected link is understood (or whether it is allowed). Type-related qualifications can propagate from one link-pair to connected link-pairs.[23]

[22] http://www.link.cs.cmu.edu/link/dict/section-TS.html

[23] For example, we can say that the linkage structure in "Three times students asked an interesting question" alters the normal type-attribution of "students" as just a plural noun; relative to the connected structure

- Type information also "distributes over" applicative structures. Given a function-like type we can consider how associations for the head and dependent elements propagate to associations on the resulting phrase — again, via subtyping or some other mechanism.

Such a "linguistic type theory" needs to model (at the least) these aforementioned associations, the "distribution" of type details over link and applicative structures, and the "propagation" of associations and other type details. While informal analyses in any single case may be clear, integrating many case-studies into a unified theory can be advanced by drawing ideas from rigorous, quasi-mathematical type theories — relevant research has adopted technical formations like "dot-types", higher-order types, dependent types, Monoidal Categories, Tensors, Continuations, "Linguistic Side Effects", Monads, Combinatory Logic, and (Mereo)Topology/Geometry.[24] Such techniques can marshal type-theoretic ideas without falling back on simplistic type notions that can end up collapsing a type-system into a one-dimensional "Ontological" classification, rather than exploring more advanced formulations like higher-order types and (what I am callling) "associations".

With respect to Type Theory related to Link Grammar, consider again the TS links (there are dozens of potential link-grammar pairs, of which TS are among the less common, but they provide a useful example). First, note that $\mathcal{P}rop$ provides a type attribution for sentences, but also for sentence parts: *he is at school*, for example, presents a complete idea, either as its own sentence or part of a larger one. In the latter case, a $\mathcal{P}rop$ phrase would typically be preceded with a word like *that*; in the case of Link Grammar, we can define words relative to their semantic and/or syntactic role, which often lies primarily in linking with other parts of a sentence or helping those parts link with each other. Type-theoretically, however, we may want to assign types to every word, even those which seem auxiliary and lacking much or any semantic content of their own. Arguably, *that* serves to "package" an assertion, encapsulating a proposition as a presumed fact designated as one idea, for the sake of making further comments, as if "making a noun" out of it: $\mathcal{P}rop \dashrightarrow N$. Perhaps our intuitions are more as if *that he is at school* is also a proposition, maybe a subtly different kind, by analogy to how questions and commands are also potentially $\mathcal{P}rop$ variants. Since THAT-phrases are "arguments" for verbs, the choice then becomes whether it is useful to expand our type picture of verbs so that they may act on propositions as well as nouns, or rather type "encapsulated" propositions as just nouns (maybe special kinds of nouns).

In either case, *I know that ...* clearly involves a verb with subject and direct object: so either $V :: N \dashrightarrow N \dashrightarrow \mathcal{P}rop$ or $V :: N \dashrightarrow \mathcal{P}rop \dashrightarrow \mathcal{P}rop$. Consider the role of a TS-link here: specifically, TS connects the verb to the assertorial direct object (most directly, to *that*). The purely formal consideration is ensuring that types are consistent: either the TS target is $\mathcal{P}rop$, as I suggested above, with the verb type modified accordingly; or the TS target is a noun, though here it is fair to narrow scope. For this particular kind of link, the target must express a proposition: either typed directly as such or typed as, say, a noun "packaging" a proposition, which would then be a higher-order type relation (just as "redness" is a noun "packaging" an adjective, or "running" is an adjective packaging a verb). In other words, it is difficult to state the type restrictions on the link-pair without employing more complex or higher-order type formations.

On the other hand, this is another example of the fuzzy boundary between syntax and semantics: given a sentence which seems to link a verb calling for a belief or assertion (like "know", "think", "suggest", "to be glad") to something that is not proposition-like, is such a configuration ungrammatical, or just hard to understand? Clearly, the *semantic* norms around verbs like "know" is that their *subject* has some quality of sentience (or can be meaningfully attributed belief-states, even if speakers know not to take it literally: "The function doesn't know that this number will never be zero"); and their *object* should be somehow propositional. But applying type theory (or type theory in conjunction with Dependency Grammar) leaves open various analytic preferences: these requirements can be presented as rigid grammatic rules or as "post-parsing" semantic regulations. How to model

linking "three times" through "students" to "a question", we can say that *three times* modifies "students" so that it may function, as subject of "asked", as if typed as singular, because *three times* acts as a "space builder" and creates a mental frame wherein the students are singular, even if the word is plural. Because of this frame phenomenon, the singular/plural status of students does not propagate to "a question"; collectively they presumably did not all ask just one question. Type annotation for "students" has to be defined, in this case, relative to multiple "cognitive frames".

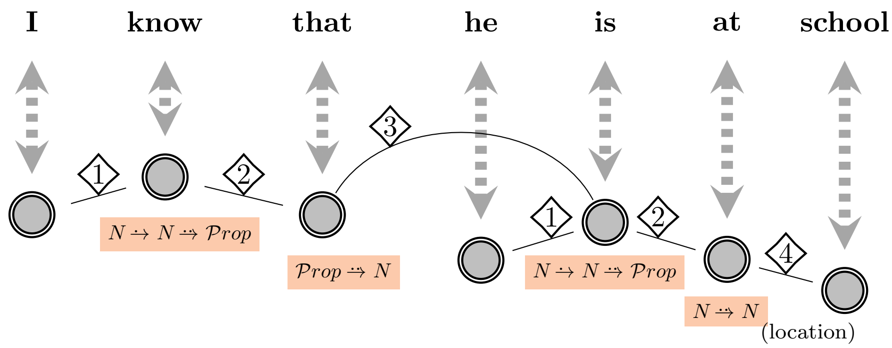
[24] Monoids: [25]; Tensors: [55]; Continuations: [9]; Combinators: [98]; Side Effects: [77]; Monads: [33], [76], [46]; Topology: [68], [18].

the qualities of sentience (or at least of having propositional attitudes broadly conceived), for the noun, and of propositionality, for the direct object, are again at the discretion of the analysis (subtypes, quality-associations, or etc.) — Figure 2 shows one potential, rather simplified unpacking of the sentence; from this structure details can be added perhaps as extra syntax constraints or perhaps more as cues to interpretation. If these requirements are seen as more syntactic, so qualities are incorporated into data like Part of Speech (say, a noun designating something with propositional attitudes being a subtype of of a generic N type), then we are more likely to analyze violations as simply incorrect (recall "The tree wants to run away from the dog" — ungrammatical or just somehow "exotic"?). Some examples suggest less incorrectness as clever or poetic usage — so a richer analysis may recognize expressions as type- and link-wise acceptable, but showing incongruities (which is not the same as impropriety) at a more fine-grained type level. That *to want* takes a subject *associated* with sentience does not force type annotations to inscribe this in grammatic or lexical laws; instead, these associations can be introduced as potential "side effects", *triggering* re-associations such as forcing hearers to ascribe sentience to something (like a tree) where such ascription is not instinctive. The type effect in this case lies more at the conceptual level, the language-user sifting conceptual backgrounds to find a configuration proper to the type requirements (in what sense can a tree "want" something?). In this "tree" case we probably appeal to concepts of "as if": if the tree *were* sentient, it would be nervous of the dog sniffing around — a humorous way of calling attention to the dog's actions (obliquely maybe alluding to people's background knowledge that dogs sometimes do things, like pee, in inconvenient places, from humans' perspectives).

In brief, it is certainly possible — though by no means mandatory — to model type requirements with greater flexibility at a provisional grammatical layer, and then narrow in on subtypes or extra accumulations of qualifications on type-instances in a transition from grammar to semantics. Perhaps cognitive schema occupy an intermediary role: progressing from basic recognition of grammaticality, through cognitive schema, to conceptual framing, with type machinery capturing some of the thought-processes at each "step" (not that such "steps" are necessarily in a temporal sequence). The basic verb-subject-direct object articulation sets up an underlying cognitive attitude (represented by a basic type-framing of verb, noun, and proposition, like the $V :: N \dashrightarrow N \dashrightarrow \mathcal{P}rop$ signature). Cognitive ascriptions fill this out by adding detail to the broader-hewed typing, associating sentience with the subject and propositionality with the object (sub- or higher-order typing modeling this stage). And how the actual lexical choices fit these cognitive expectations — I call them cognitive because they are intrinsically tied to structurational schema in the type, morphology, and word-order givens in the encountered language — compels conversants to dip into background beliefs, finding concepts for the signified meanings that hew to the intermediary cognitive manipulations (finding ways to conceptualize the subject as sentient, for example). This also has a potential type model, perhaps as forcing a type conversion from a lexical element which does not ordinarily fit the required framing (such as giving inanimate things some fashion of sentience). Type theory can give a window onto unfolding intellection at these multiple stages, although we need not conclude that the mind subconsciously doing this thinking mimics a computer that churns through type transformations mechanically and exactly.

I envision the unfolding that I have just sketched out as something Phenomenological — it arises from a unified and subjective consciousness, one marked by embodied personal identity and social situation. If there are structural stases that can be found in this temporality of experience, these are not constitutive of conscious reality but a mesh of rationality that supports it, like the veins in a leaf. Stuctural configurations can be lifted from language insofar as it is a conscious, formally governed activity, and lifted from the ambient situations which lend language context and meaning intents. So any analytic emphasis on structural fixpoints threaded through the lived temporality of consciousness is an abstraction, but one that is deliberate and necessary if we want to make scientific or in any other manner disputatable claims about how language and congition works. In that spirit, then, I will try to condense the three "layers" of unfolding understanding, which as I have sketched them are posited in the metaphysical order of temporal experience — "unfolding" in likely overlapping, blending ways — I will "read into" them a more static and logically stacked meta-structure. Where I have sketched three layers or stages of unfolding language understanding, I will transi-

Figure 2: Dependency-style graph with type annotations



- ⧫ 1 Verb's subject argument
- ⧫ 2 Verb's direct object argument
- ⧫ 3 Propositional "packaging" ("typed" as $\mathcal{P}rop \dashrightarrow N$)
- ⧫ 4 Locative auxiliary link
  (may be typed as converting nouns to place-designations)

tion to proposing three "tiers" of language organization, in particular three levels where type-theoretic models can be applied.

11.2 *Three tiers of linguistic type theory*

By three "tiers" of linguistic organization, I am thinking of different levels of granularity, distinguished by relative scales of resolution, amongst the semantic implications of putative type representations for linguistic phenomena. As I argued earlier, type-related observations can be grouped (not necessarily exclusively or exhaustively) into those I will call *macrotypes* — relating mostly to Parts of Speech and the functional treatment of phrases as applicative structures; *mesotypes* — engaged with existential/experiential qualities and "Ontological" classifications like sentient/nonsentient, rigid/nonrigid, and others I have discussed; and *microtypes* — related to lexemes and word-senses. This lexical level can include "microclassification", or gathering nouns and verbs by the auxiliary prepositions they allow and constructions they participate in (such as, different cases), and especially how through this they compel various spatial and force-dynamic readings; their morphosyntactic resources for describing states of affairs; and, within semantics, when we look toward even more fine-grained classifications of particular word-senses, to reason through contrasts in usage.[25] Microclasses can point out similarities in mental "pictures" that explain words' similar behaviors, or study why different senses of one word succeed or fail to be acceptable in particular phrases. There are *stains all over the tablecloth* and *paint splattered all over the tablecloth*, but not (or not as readily) *dishes all over the tablecloth*. While "stains" is count-plural and "paint" is mass-aggregate, they work in similar phrase-structures because both imply extended but not rigid spatial presence; whereas "dishes" can work for this schema only by mentally adjusting to that perspective, spatial construal shifting from visual/perceptual to practical/operational (we might think of dishes "all over" the tablecloth if we have the chore of clearing them). Such observations support microclassification of nouns (and verbs, etc.) via Ontological and spatial/dynamic/configuration criteria.

Type-theoretic semantics can also apply Ontological tropes to unpack the overlapping mesh of word-senses, like *material object* or *place* or *institution*. This mode of analysis is especially well illustrated when competing senses collide in the same sentence. Slightly modifying

[25] So, conceiving microclasses similar in spirit to Steven Pinker in Chapter 2 of [69], though I'm not committing to using the term only in the way Pinker uses it. Cf. also [97], which combines a microclass theory I find reminiscent of *The Stuff of Thought* with formal strategies like Unification Grammar.

two examples:[26]

- (224) The newspaper you are reading is being sued.
- (225) Liverpool, an important harbor, built new docks.

Both have a mid-sentence shift between senses, which is analyzed in terms of "type coercions". The interesting detail of this treatment is how it correctly predicts that such coercions are not guaranteed to be accepted:

- (226) The newspaper fired the reporter and fell off the table (?).
- (227) Liverpool beat Tottenham and built new docks (?).

(again, slightly modifying the counter-examples). Type coercions are *possible* but not *inevitable*. Some word-senses "block" certain coercions — that is, certain sense combinations, or juxtapositions, are disallowed. These preliminary, motivating analyses carry to more complex and higher-scale types, like plurals (the plural of a type-coercion works as a type-coercion of the plural, so to speak). As it becomes structurally established that type rules at the simpler levels have correspondents at more complex levels, the use of type notions *per se* (rather than just "word senses" or other classifications) becomes more well-motivated.

Clearly, for example, only certain kinds of agents may have beliefs or desires, so attributing mental states forces us to conceive of their referents in those terms:

- (228) Liverpool wants to sign a left-footed striker.
- (229) That newspaper plans to fire its editorial staff.

This *can* be analyzed as "type coercions"; but the type-theoretic machinery should contribute more than just obliquely stating linguistic wisdom, such as maintaining consistent conceptual frames or joining only suitably related word senses. The sense of *sign* as in "employ to play on a sports team" can only be linked to a sense of Liverpool as the Football Club; or *fire* as in "relieve from duty" is only compatible with newspapers as institutions. These dicta can be expressed in multiple ways. But the propagation of classifications (like "inanimate objects" compared to "mental agents") through complex type structures lends credence to the notion that type-theoretic perspectives are more than just an expository tool; they provide an analytic framework which integrates grammar and semantics, and various scales of linguistic structuration. For instance, we are prepared to accept some examples of dual-framing or frame-switching, like thinking of a newspaper as a physical object and a city government (but we reject other cases, like *Liverpool voted in a new city government and signed a new striker* — purporting to switch from the city to the Football Club). The rules for such juxtapositions appear to reveal a system of types with some parallels to those in formal settings, like computer languages.

In short, "Ontological" types like *institution* or *place* serve in some examples to partition senses of one multi-faceted word. Here they reveal similar cognitive dynamics to reframing-examples like *to the press*, where Ontological criteria (like reading something as a place) are triggered by phrase-scale structure. But there are also interesting contrasts: the *newspaper* and *Liverpool* examples imply that some words have multiple framings which are well-conventionalized; newspaper-as-institution feels less idiomatic and metaphorical than press-as-place. So these examples suggest two "axes" of variation. First, whether the proper Ontological framing follows from other word-choices (like "fire" in *the newspaper fired the reporter*, which has its own semantic needs), or from morphosyntax (like the locative in *to the press*); and, second, whether triggered framings work by selecting from established word senses or by something more metaphorical. Metaphors like *to the press* do have an element of standardization; but apparently not so much so to be distinct senses: note how *the press* as metaphorical place does not work in general: $^{?}$*at the press*, $^{?}$*near the press* (but *at the newspaper*, *near the newspaper* — imagine two journalists meeting outside the paper's offices — sound quite reasonable).

The "type coercion" analysis works for mid-sentence frame-shifts; but other examples suggest a more gradual conceptual "blending". For example, the place/institution dynamic is particularly significant for *restaurant* (whose spatial location is, more so, an intrinsic part of its identity). Being a *place* implies both location and extension; most places are not single points but have an inside where particular kinds of things happen. I am not convinced that restaurant as place and as institution are separate word senses; perhaps, instead, conversations can emphasize one aspect or another, non-exclusively. As I have argued, we need not incorporate all framing effects via "subtypes" (restaurant as either subtype of

[26] [19, p. 40] (former) and [57, p. 4] (latter).

hypothetical "types of all" places or institutions, respectively). But "placehood", the Ontological quality of being a place — or analogously being a social institution — identify associations that factor into cognitive frames; types can then be augmented with criteria of tolerating or requiring one association or another. So if "restaurant" is a type, one of its properties is an institutionality that *may* be associated with its instances. In conversation, a restaurant may be talked about as a business or community, foregrounding this dimension. Or (like in asking for directions) its spatial dimension may be foregrounded. The availability of these foregroundings is a feature of a hypothetical restaurant type, whether or not these phenomena are modeled by subtyping or something more sophisticated. The "newspaper" examples suggest how Ontological considerations clearly partition distinct senses marked by properties like objecthood or institutionality (respectively). For "newspaper" the dimensions are less available for foregrounding from a blended construal, than "unblended" by conventional usage; that is why reframings evince a type *coercion* and not a gentler shift of emphasis. The example of *restaurant*, in contrast, shows that competing routes for cognitive framing need not solidify into competing senses, though they trace various paths which dialogs may follow. But both kinds of examples put into evidence an underlying cognitive-Ontological dynamic which has potential type-oriented models.

At the most general level — what I called *macrotype* modeling — a type system recognizes initially only the grammatical backbone of expressions, and then further type nuances can be seen as shadings and interpretations which add substance to the syntactic form. So in type-theoretical analysis at this more grammatic level, to which I now turn, we can still keep the more fine-grained theory in mind: the relation of syntax to semantics is like the relation of a spine to its flesh, which is a somewhat different paradigm than treating syntax as a logical or temporal stage of processing. Instead of a step-by-step algorithm where grammatical parsing is followed by semantic interpretation, the syntax/semantics interface can be seen as more analogous to stimulus-and-response: observation that a certain grammatic configuration appears to hold, in the present langauge artifact, triggers a marshaling of conceptual and cognitive resources so that the syntactic backbone can be filled in. Perhaps a useful metaphor is grammar as gravitation, or the structure of a gravitational field, and semantics is like the accretion of matter through the interplay of multiple gravitational centers and orbits. For this analogy, imagine typed lambda reductions like $\mathcal{P}rop \dashrightarrow N \twoheadrightarrow N$ taking the place of gravitational equations; and sentences' grammatic spine taking the place of curvature pulling mass into a planetary center.

Parts of speech have "type signatures" notionally similar to the signatures of function types in programming languages: a verb needing a direct object, for example, "transforms" two nouns (Subject and Object) to a proposition, which I have been notatating with something like $N \dashrightarrow N \dashrightarrow \mathcal{P}rop$. At the most basic level, the relation of Parts of Speech to "type signatures" seems little more than notational variants of conventional linguistic wisdom like a sentence requiring a noun and a verb (`S = NP + VP`). Even at this level, however, type-theoretic intuitions offer techniques for making sense of more complex, layered sentences, where integrating link and phrase structures can be complex. Even the most broadly scoped analysis of type signatures, dealing only with generic Parts of Speech like nouns and verbs, can lead to surprising complications. One example I have alluded to several times, and will return to shortly: the problem of applying Dependency Grammar where phrases do not seem to have an obviously "most significant" word for linkage with other phrases.

A tendency in both dependency and phrase-oriented perspectives is to define structures around the most "semantically significant" words — so that a phrase like *many students* becomes in some sense collapsible to its semantic core, *students*. Some of my earlier examples, however, argued that phrases cannot just be studied as replacements for semantic units. Incorporating type theory, we can instead model phrases through the perspective of type signatures: given Part of Speech annotations for phrasal units and then for some of their parts, the signatures of other parts, like verbs or adjectives linked to nouns, or adverbs linked to verbs, tend to follow automatically. A successful analysis yields a formal tree, where if (in an act of semantic abstraction) words are replaced by their types, the "root" type is something like $\mathcal{P}rop$ and the rest of a tree is formally a reducible structure in Typed Lambda Calculus: $N \dashrightarrow N \dashrightarrow \mathcal{P}rop$ "collapses" to $\mathcal{P}rop$, $\mathcal{P}rop \dashrightarrow N$ collapses to N, and so forth, with the tree "folding inward" like a fan until only the root remains — though a more subtle analysis would replace the single $\mathcal{P}rop$ type with variants that recognize different forms of speech acts, like questions and commands. In Figure 2, this can be seen via the type annotations: from right to left $N \dashrightarrow N$ yields the N as second argument for *is*, which in turn yields a $\mathcal{P}rop$ that is mapped (by *that*) to N, finally becoming the second argument to *know*. This calculation only considers the most coarse-grained classification (noun, verb, proposition) — as I have emphasized, a purely formal reduction can introduce finer-grained grammatical or lexico-semantic classes (like *at* needing an "argument" which is somehow an expression of place — or time, as in *at noon*). Just as useful, however, may be analyses which leave the formal type scaffolding at a very basic level and introduce finer type or type-instance qualifications at a separate stage.

In either case, Parts of Speech are modeled as (somehow analogous to) functions, but the important analogy is that they have *type signatures* which formally resemble functions'. Phrases are modeled via a "function-like" Parts of Speech along with one or more additional words whose own types match its signature; the type calculations "collapsing" these phrases can mimic semantic simplifications like *many students* to *students*, but here the theory is explicit that the simplification is grammatic and not semantic: the collapse is acknowledged at the level of *types*, not *meanings*. In addition, tree structures can be modeled purely in terms of inter-word relations (this is an example of embedding lambda calculii in process algebras), so a type-summary of a sentence's phrase structure can be notated and analyzed without leaving the Link Grammar paradigm.

As a concrete example, in the case of "many students", both "students" and the semantic role of the phrase are nouns (count-plural nouns, for where that's relevant). Accordingly, "many" has a signature $N \dashrightarrow N$ (or $N^+ \dashrightarrow N^+$, dependending on how narrowly we want to notate the types in context). Once we assign types and signatures to all words in a sentence, we can also see a natural hierarchy resembling an expression in typed lambda calculus, where some words appear as "functions" and others as "arguments". Often the less semantically significant words appear as "higher" in the structure, because they serve to modify and lend detail to more significant words. The kind of structure or *Charpente* which falls out of a sentence — adopting a term from Tesnière (cf. [93, p. 181]) — is typically different from a link-grammar "linkage", although the two structures can be usefully combined.

To return to the example of *Student after student*, where designating one word to "represent" the phrase seemed arbitrary, we can analyze the situation via type-signatures. I have teased a proposed solution repeatedly; here's what I had in mind. Insofar as *after* is the only non-noun, the natural conclusion is that "after" should be typed $N \dashrightarrow N \dashrightarrow N$ (which implies that "after" is analogous to the "functional" position, and in a lambda-calculus style reconstruction would be considered the "head" — Figure 1 is an example of how the sentence could be annotated, for sake of discussion). This particular idiom depends however on the two constituent nouns being the same word (a pattern I've also alluded to with idioms like *time after time*), which can be accommodated by invoking the (computationally rather complex and topical) concept of *dependent types* [12], [92] — in other words the parameters for *after* are a dependent type pair satisfied by an identity comparison between the two nouns. The signature for "after" has this added complication, but the nuances of this example can still be accommodated within the overall architecture of type theory. I would pair this argument with my earlier analysis of "many" variations which suggested how apparent complications can be accommodated largely within the extant theoretical resources of Link Grammar, and in combination suggest that the union of Link Grammar with Type-Theoretic Semantics seems poised to accommodate many complex real-world linguistic cases with a coherent abstract perspective.

Consider alternatives for "many students". The phrase as written suggests a type signature (with "many" as the "function-like" or derivative type) $N^+ \dashrightarrow N^+$, yielding a syntactic interpretation of the phrase; this interpretation also suggests a semantic progression, an accretion of intended detail. From *students* to *many students* is a conversion between two plural nouns (at the level of concepts and semantic roles); but it also implies relative size, so it implies some *other* plural, some still larger group of students from which "many" are selected. While rather abstract and formal, the $N^+ \dashrightarrow N^+$ representation points toward a more cognitive grounding which considers this "function" as a form of thought-operation; a refinement of a situational model, descriptive resolution, and so forth. If we are prepared to accept a cognitive underpinning to semantic classification, we can make the intuition of part of speech signatures as “functions” more concrete: in response to what “many” (for example) is a function *of*, we can say a function of propositional attitude, cognitive schema, or attentional focus. The schema which usefully captures the sense and picture of *students* is distinct (but arguably a variation on) that for *many students*, and there is a “mental operation” triggered by the *many students* construction which “maps” the first to the second. Similarly, *student after student* triggers a “scheme evolution” which involves a more explicit temporal unfolding (in contrast to how *many students* instead involves a more explicit quantitative *many/all* relation). What these examples show is that associating parts of speech with type signatures is not just a formal fiat, which “works” representationally but does not necessarily capture deeper patterns of meaning. Instead, I would argue, type signatures and their resonance into linkage acceptability structures (like singular/plural and mass/count agreement) *point toward* the effects of cognitive schema on what we consider meaningful.

In *Student after student came out against the proposal*, to *come out*, for/against, lies in the semantic frame of attitude and expression (it requires a mental agent, for example), but its reception carries a trace of spatial form: to come out *to* a public place, to go on record with an opinion (I analyzed this case in Section 6). Usually “come out [for/against]”, in the context of a policy or idea, is similarly metaphorical. But the concrete spatial interpretation remains latent, as a kind of residue on even this abstract rendition, and there sustains a chance that this undercurrent will actually figure in conversants’ mutual understanding — if there were not just columns being written and opinions voiced but demonstrations on the quad. The spatial undercurrent is poised to emerge as more literal, should the context warrant. However literally or metaphorically the “space” of the “coming out” is understood, however explicit or latent its cogitative figuration, is not something internal to the language; it is a potentiality which will present in different ways in different circumstances. This is not to say that it is something apart from linguistic meaning, but it shows how linguistic meaning lies neither in abstract structure alone, nor contextual pragmatics, but in their cross-reference.

11.3 *Levels of formalization*

Of the three type levels I have proposed, the macrotype “functional” level is the most quasi-mathematical; for other levels, formal type theory may provide interpretive tools and methodological guides, but formally representable framings and transformations may be only approximations of how people actually think, while they are understanding language. From this perspective, we are left with the metatheoretical question of clarifying how different kinds of analyses, which put different degrees of weight on formal or on interpretive argumentation, are to be joined in overarching theories. In particular, are the linguistic phenomena which seem to demand more “interpretive” treatment actually beyond formalization, or is it just impractical (but possible in theory) to provide formal analysis of each individual case-study, each real-world language formation? Is Natural Language actually no less formal than (for example) computer programming languages, except that the former have a much larger set of semantic and syntactic rules such that any analysis can uncover them only partially? Or is any rule-based model of language, no matter how complete, necessarily partial relative to real language?

Computer languages are a good case-study in what I might call “semiotic computability”. This designates the question of whether the operations of sign-systems — how sign-users express intentions by forming or modifying structured networks of signs that explicitly exhibit or are understood to have been formed according to collectively recognized signifying rules — can be modeled, at least to some substantial degree, by computable algorithms. Our notion of computation can be based on modern computer code, not just academic topics like pure functions: the behavior of computing systems where many functions run concurrently, with possible side-effects, is often non-computable via static analysis; such systems can only be understood by actually running them. Nevertheless the capabilities of software programmed in modern languages certainly deserve to be characterized as “computable” behaviors. A single function, which embodies a computable calculation, may be part of a process space whose evolution through time is nondeterministic, and computing environments which employ functional side-effects are difficult or impossible to evaluate in the abstract. I use “computability” therefore in this wider sense: operationally implementable according to theories underlying mainstream programming languages, which is conceptually (if perhaps not mathematically) distinct from "computability" in subjects like algorithm analysis.

Natural Langauge Processing, working with human languages from a computing platform, is then a step further, continuing beyond logico-mathematic abstractions and toward empirical language-use. We can consider at what point formal and computational methods reach a limit, beyond which they fail to capture the richess and expressiveness of Natural Language, or whether this limit itself is an illusion — whether even fully human language competence is (perhaps in principle if not in practice) no less reducible to formalizable patterns. Using the wording I just proposed, we can speculate on whether all language is "semiotically computable" or whether language merely depends on faculties which in some neurological and/or presentational sense are "computable" in those terms — faculties that, measured against linguistic fluency, are necessary but not sufficient. Whatever one's beliefs on this last question, a progression of subdisciplines — from formal-logical semantics through programming langauges and computational Natural Langauge Processing — is a reasonable scaffolding for a universe of formal methods that can build up, by progressive theoretical sophistication or assembly of distinct analyses which piece together jigsaw-like, to model real-world language understanding. Perhaps real language is an "emergent property" of many distinct algorithms that run and combine in the mind; or perhaps the relevant algorithms are a precondition, presenting cognition with essential signifying givens but fleshed out in other, more holistic ways, as we become conscious of language not just as a formal system but an interactive social reality.

I have (in the last two sections) sketched a similar theoretical progression, starting with a theory of grammar (Link Grammar), transitioning to a form of semantics (a type-theoretic semantics defining type hierarchies and signatures over linkage graphs), and finally proposing a cognitive interpretation of the resulting semantics. I will refer to this *interpretation* as "Cognitive State Semantics", meaning that such a theory adopts its *formal* structures from Link Grammar and type-theory but also attempts to *motivate* these structures by appeal to cognitive considerations. Both Link Grammar (through its specific Category of labeled graphs modeling sentence linkage-structures) and Type-Theoretic Semantics work with rigorous, algebraically formal models satisfying criteria I referenced at the end of the last section: translation of language content into these formats and subsequent review or transformation of the target structures can be programmed as a purely mechnical space of operations.

By itself, the superposition of type-theoretic semantics on link-grammar graphs does not cross a hypothetical "barrier" between the formal and the cognitive. But I intend here to suggest a cognitive *interpretation* for the formal structures; that they represent an outline of cognitive schema, or progressions, or represent linguistic "triggers" that a cognitive language ability (taking language as part of an environing world and produced by others, in rule-bound social situations, to communicate ideas and sentiments) responds to. This range of interpretations is deliberately open-ended: we can say that a formal infrastructure grounds the cognitive reception of language givens, without arguing specifically that formal structures identified in language therefore model cognitive operations directly, or that these are instead patterns identified in language that trigger a cognitive response, or any other paradigm for mapping cognition as process and activity to language structure as model and prototype. Leaving these options open, however, I will focus in the remainder of this paper on one interpretation, considering formal structures as "triggers" which get absorbed into language understanding via observatory propensities: as language users (on this proposal) we are disposed to identify certain formal structurations operating in language as we encounter it, and respond to these observations by building or refining mental models of the situations and signifying intentions we believe have been implied by the discourse, in evolving and intersubjective dialogic settings that involve joint practical activity as well as communication.

In this sense, I believe natural language reveals mutually-modifying juxtapositions of concepts whose full semantic effects are probably non-computable: I would work on the assumption that language *as a whole* and as human social phenomena is not "computable" in a semiotic sense, or any related practical sense (although I make no metaphysical claims about the "abstract" computability of mental processes merely by virtue of their neurophysical materiality). The aforementioned "linguistic side effects" can be *modeled* by tracing our reception of linguistic meaning through syntactic and semantic formations, like Link Grammar and Type Theory, but I argue for such models not as models *of* cognitive processes, but rather models of *observations* which trigger cognitive follow-up. Even if we believe in and practice a rigorous formalization of morphosyntactic structure, where the *pattern* of conceptual "side-effects" can be seen as unfolding in algorithmic ways, the cognitive *details* of these effects are too situational, and phenomenologically rich, for computability as ordinarily understood.

But the formal structure is not wholly irrelevant: to call up nuanced cognitive schema — or so I submit for consideration — may not be possible without algorithmically reproducible lexicosemantic and morphosyntactic triggers, at least modulo some approximation. A (perhaps non-computable) space of cognitive schema may be projected onto a (perhaps computable) set of affiliated morphological patterns, using notations like link-grammar pairs and type signatures to catalog them. For example, there may be a non-computable expanse of possible construals of pluralization; but any such construal, in context, is called into focus in conversants' minds by morphosyntactic invitations, by speakers' choices of, say, $N^{\odot} \dashrightarrow N^{+}$-pattern phrases. The important balance is to take formalization as far as is reasonable without being seduced into logico-symbolic reductionism — a methodological pas de deux I will explore further in the next section, a brief concluding coda to this paper.

Any word or usage invites various facets to either emphasize or deemphasize, and these subsumed concepts or foci are latent in potential meanings, brought into linguistic space by the play of differentiation [27] : *baked*, not *made*; *flew*, not *traveled*; *spill*, not *pour*. These undercurrents of subsidiary concepts and foci are selectively hooked onto by morphosyntactic selection, so in analyzing phrase structure we also have to consider how using syntax which constructs a given structure also brings to the forefront certain nested concepts and construals, which are latent in word-sense options; in the topos of lexicosemantic possibilia.

So, any talk about "side effects" of morphosyntactic functions — mapping verb-space to adjective-space, noun-space to proposition-space, singularity to plurality, and so forth — should consider a type-theoretic gloss like $N \dashrightarrow N$ as sketching just the motivating scaffold around an act of cognitive refocusing. The interesting semantics lies with *how* a sense crosses over, in conversants' minds, to some other sense or concept, wherein other aspects are foregrounded — for example, within temporal event plurality: multiplicity as frequency, or episodic distribution relative to some time span; or suggesting something that is typical or predominant; or relative count against some other totality — each such refocusing triggered by a phrasal construction of the form $N \dashrightarrow N^{+}$ or $N^{+} \dashrightarrow N^{+}$. Or we can map singulars, or count plurals, to mass nouns, and vice-versa (*shrubs* become *foliage*; *water* becomes *a glass of water*). The plural and the singular are a coarse-grained semantic that has not yet arrived as *meaning*. Conceptual spaces guide attention to classes and properties, defining a path of ascending precision as speakers add descriptive detail; cognitive construals negotiate relations between different kinds of aggregates/individuals; individuality, aggregation and multiplicity as phenomena and disposition. These construals are practical and embodied, *and* phenomenological — they direct attention (*qua* transcendental universal of mentality, if we like), to and fro, but in the course of intersubjective and goal-driven practical action (and in that sense particular, world-bound, historicized).

Given these considerations, I propose a "Cognitive State Semantics" — understanding phrase structure in terms of (or analogous to) functional effects (like [77]), but cognitive: word and syntax choice effectually steering cognitive appraisals of jointly experienced situations in specific directions. Cognitive State Semantics also has formal implications: the inner structuration of data "spaces", including unknown and undefined values, and including (side-effects-bearing) function types, can be understood as dynamic *states of knowledge* and their changes, grounding datatype semantics in human use/interactions. Linguistically, the "effects" of language "functions" are mutations/modifications in cognitive state, respondant to concrete or abstract scenarios which are topics of dialog. Sometimes, effects may tolerate mathematical analysis; but such analytical thematics tend to peter out into the ambient, chaotic worldliness of human consciousness.

[27] Alluding, in part, to Sausurrean "system of differences" [65, p. 15] — to choose a reference which introduces Sausurre in a rather unexpected context.

12 Conclusion

Without reducing linguistic *performance* to language qua field of propositional expression, and without collapsing linguistic meaning to a computable/propositional fragment, we can still allow interpretive-phenomenological and formal/mathematical perspectives to co-exist. In the theory I have sketched, Cognitive Schema summarize lived, situated judgments and intentions that (in concrete form) are not "computable" (again with the caveat that our mostly science-driven worldview may imply that all reality is "computable" in some infinitely-powerful computation; I understand "computability" to terminologically exclude such a purely speculative level of capacity). However, our propensity to call up certain construals rather than others is triggered by linguistic formations, and in broad outline the catalog of these triggers, and their compositional structure, can be formalized (and even used to improve formal systems, like programming languages). The challenge is to advocate for this co-existence without implying that formal systems, and mathematically provable system-properties, are the only kind of research tools which have scientific merit.

Subjective assessments are intrinsic to most linguists' argumentation — warranting claims not with empirical data or logico-mathematical proof but by appealing to speakers' intuitions, so that reading linguistic texts is also collaborating on an ongoing research project (partly because language evolves, so word-meanings change, and formations which are ungrammatical for one generation may be experienced differently by others). Nevertheless, linguistics, like economics, seems broadly accepted as a human *science*, not just an interpretive discipline. The claim that an economist's equation or a linguist's meta-grammar are accurate explanations, useful explanatory frameworks, seems generally evaluated in terms of whether their framework captures emergent higher-order structure, and offers an explanatory potential that does not merely reiterate lower-scale paradigms. A theory expressed in the language of linguistics (not, say, neural networks), if it meets general criteria of testability and refutability (not necessarily empiricist/quantitative), arguably carries even more weight than lower-level neurophysical explanation — precisely because the higher-scale "theory language" carries the burden of explaining emergent properties, which as *emergent* bear some descriptive/behavioral (if not causal) autonomy. Likewise, a subjectively plausible and theoretically motivated equation which fits economic data probably carries more weight than a mere statistical analysis. An explanatory focus on the higher-scale in terms of its own distinct (emergent) structures and theorized entities (like words and morphemes, in the case of linguistics, or markets and commodities, in the case of economics), reflects the linguist's or economist's charge to connect human phenomena with mental (and therefore, ultimately physical) law. Nonetheless, even with liberal use of subjective judgments, economics and linguistics (and some other human sciences as well, potentially) are attached to the overall sphere of natural science, by virtue of causal links in principle even if not in practice. Scientific rigor in this humanistic setting is neither reducible to the techniques of natural science, nor dualistically separate from them. Natural science and humanities are certainly not mutually irrelevant, but nor is the proper vehicle for scientific literacy to find a forum in the humanities merely to emulate numeric methods, as with statistics in sociology, or a retreat to narrow and behavioristic reductionism, in place of localized interpretation and situational particularism.

Subjective impressions (conscious experiences, emotions, intuitions, qualia, qualitative universals and particulars — the qualitative characteristic in itself, and the hyletic-spatial trace, the site in experiential space as the quale becomes a moment of consciousness) — these are not scientifically tractable and do not have obvious physical location or measurability, which makes them controversial as objects of scientific method. Yet, even so, we do have conscious experiences, we do subconsciously (and when needed consciously, or with deliberate conscious attention) make judgments about classifications, or how parts aggregate into wholes, or are individuated apart from a larger whole in context; we can reflect on patterns in these judgments, not *introspectively* examining thoughts as they occur, but marshalling an overall familiarity with mental processes. Consciousness is not only a kind of mentality, shared by humans and some animals; it is also a metacognitive tool, something we deploy to focus attention on a certain object or topic. We "practice" how to *be* conscious, how best to distribute attention, in each setting (like an athlete maintaining a meditative state of ambient awareness, poised to latch conscious attention onto playing technique which is optimally instinctive, but "feels" different when degraded by fatigue or distraction). Our faculty for these modulations, switching among sub- and passive consciousness, attentive consciousness, "ambient" awareness, and back again, reveals that consciousness is not only an aspect of mind but a tool; it has a meta-cognitive and epistemic dimension, an awareness of what is known or not-yet-known and a technique of directing attention to the latter.

A case-study: in a motel I unexpectedly find a newspaper outside the door. Next morning I look outside curious whether a paper is there; after several days I come to expect the paper. So I open the door not preoccupied with confirming this, but with (maybe rather distractedly) fetching it. Initially I do not expect the paper, but, generally poised to notice both expected and unexpected circumstances, I make a mental adjustment and interpret the situation quickly; by the third day the paper has become expected, like other things I anticipate finding in a motel hallway, and the thrust of my attention, during the brief episode of my picking it up, is kinaesthetic and motor-intentional more than visual and inquisitive. Only on the second morning is the question of a paper's presence intended in an epistemic mode; but, while it is so thematized, I direct attention to optimize my ability to resolve the question. How we engage attention is a deliberate choice, reflecting and responding to our metacognitive attitudes, what we think we know and do not know.

Because consciousness is in some ways a mental tool, we have an intimate familiarity with it, a familiarity which extends beyond our own minds: we can make reasonable guesses about what others do or do not know and perceive. Our ability to anticipate others' epistemic states is an intrinsic feature of social interaction, of intersubjectivity; we therefore understand consciousness not only via our own use and possession/experience of it, but as a general feature of the human mind. We can accordingly make structured claims about conscious processes, not in the sense of introspective reports but of retrospective suggestions — by analogy, a pianist on reflection may have alot to say about playing technique, but she does not acquire this wisdom from introspective study of her own playing while it happens; rather with accrued wisdom and reflection. In terms of phenomenological method, our study of thought and consciousness is analogous: it is reflective examination of what it means to be consciously intelligent beings, not introspective psychology, or meditative meta-experience.

The methodological implications of this retrospection (as opposed to *intro*spection), how phenomenological writing seeks reflective consensus on claims about consciousness — this fashion of constructing a research community, a discursive-methodological field, does not conform to empirical scientific method, but is arguably a quite valid and defensible means of meeting the criteriological goals — the discourse ethics, the democratization of scientific participation — which physical science achieves via empiricist Ontology. For all its limitations, Positivism has the one virtue of disputational inclusiveness, demanding potential observability (not some special revelation or insight) for theoretic ur-entities. The civic norms of phenomenology are more complex, because both "transcendental" analysis of consciousness — as a kind of philosophical ground zero, a neo-Cartesian fortress against skepticism and empiricism — and also a more pluralistic, enculturated, embodied, social phenomenology, are well-represented (and interpenetrate in complex ways) in the continuing post-Husserl tradition. That being said, even in its most neo-Idealist, reifying consciousness as a primordial frame on any cognitive-scientific reasoning, as human sciences' condition of possibility, phenomenology cannot help but textually acknowledge pluralism, and philosophical collaboration — precisely because its claims are not descriptive of empirically locatable/observable objects.

Interestingly, the phenomenological tradition reveals substantial interest in both the socio-political and the formal-mathematical: this is not so noteworthy in itself, because Analytic philosophy also connects (say) language with (say) logic, but phenomenology is distinct in that it joins the humanistic and the formal/mathematical without the same tendency to hone in on a overlapping, logico-semantic core. In writings where Analytic philosophers appear to address both social and mathematical concerns, usually their underlying motivation, or so it seems to me, is to find some logical underpinnings to linguistic or cognitive structure (say, *implicatures*) — logic, subject to formal treatment, also manifesting itself in the organization of thoughts and expressions. Amongst phenomenologists, however, for example Husserl, Merleau-Ponty (in his science-oriented writings; [59]), and Anglo-American writers in the "Naturalizing Phenomenology" tradition, there is evident interest in mathematics *apart* *from* logic: topology, differential geometry, mereotopology, multi-granularity.[28] Phenomenology therefore uncovers an arguably deeper and truer bridge between human and "eidetic" sciences, in Petitot's phrase, one which is not pre-loaded with logico-reductive presuppositions. If this is accurate, phenomenology can provide a deeper methodology for the humanities in their interactions with natural science. Even insofar as we stay committed to the idea that social/cultural/mental phenomena emerge from (neuro-)physical ones, we need to curate methods for these "emergent" sciences which have the requisite theoretical autonomy to actually extend the explanatory reach of the natural sciences on which they causally rest. Cognitive Linguistics, I would argue, is a good example of this notion of autonomy, and its methodology, I would also argue, bears an important resemblance to phenomenological research.

Another brief case-study (revisiting footnote **??**): our environing world mostly discloses itself through objects' visible exterior: as much as we have on occasion a palpable sense of volume as well (as when looking through a fog) — and as much as what we see is inextricable from our embodied interactions with objects, adding tactile and kinaesthetic dimensions, a canonical sense of perception is still the vision of distant objects, usually through their surface geometry. A canonical example of perceptual cognition is therefore reconstructing geometry from visual appearances, especially color gradations — mathematically, converting "color" vector fields to curvature vector fields (it's worth noting that color is an almost primordial example of a Conceptual Space Theory as developed by Gärdenfors and others [90]). This kind of transformation, described (say) via differential geometry, is *qua* theoretical device an example of semiotic morphism, a mapping between representation disciplines [35], [34]. The point is not, however, that there are precise correlates in the brain which "implement" this procedure; that the semiotic morphism takes a domain and codomain that quantify over empirically locatable, neurophysical entities. We can study how software reconstructs geometry from color data as an approximation to a *process*, a model-building whose semiotics of approximation is coarse-grained and holisitc.[29] Formal devices like vectors or vector fields need not mold symbolic systems by mapping individual symbols to spacetime objects, or processes, but rather afford representation-mappings that capture cognition indirectly and patternwise.

I make this point using visual consciousness as an example, but it applies also to cognitive grammar, where the color -to- curvature-vector morphism has an analogue in the mapping of word-sequences to tree- or graph-algebras. I do not intend to claim that there are specific, individuated neurophysical analogues to theoretical posits in the symbolic regime I sketched earlier, in terms of POS and lexical annotations, inter-word and inter-phrase connections, applicative structures, and the rest. There are not, necessarily, for example, little brain regions whose role is to represent different types of phrase structures (e.g., different flavors of pluralization). Our explanatory ambitions, instead, should be cognitive-linguistic models of a global process-structure, agnostic about one-to-one correspondence between the posits of the theory and the empirical stuff whose behaviors it wants to explain. Cognitive triggers bridge formal/empirical sciences with the phenomenolog-

[28] Not that logic is wholly unrelated to these subjects: consider topological and type/Category-theoretic embeddings of logical systems within certain categories, or technical domains, like toposes, sheaves, granules; but logic in this sense, mathematically founded within spaces otherwise discussed at least as metaphoric guides within phenomenology, does not appear to be the dominant understanding of logic in the Analytic philosophical tradition. To be fair, style may dictate that argumentation should be trimmed to its essential elements, and mathematical deductions are rarely if ever essential for defending phenomenological claims. In Jean Petitot, for example, mathematics is sometimes intrinsic to empirical backing for phenomenological ideas, but other times (say, sheaf mereology), the formal theories, while useful analogies, do not clearly pair up with logico-deductive justifications. But, I would reply, there is so much unexplained about consciousness, and cognition as it occurs in conscious minds — the controversial "Explanatory Gap" between mind and matter — that much of the important argumentation does not yet have deductive signposts; we need an effective methodology which is not so linear. As we approach beyond a simplifying, logico-functionalist vantage, which we eventually must transcend, both functionalization and empiricism fall by the wayside as reasonable methods for "Naturalizing" consciousness. We have to accept when the formal/mathematical stands as more intuitive than rhetorical, on pain of "Naturalization" being quarantined from a humanistic core entirely.

[29] The experiential verisimilitude of computer graphics is a phenomenological data point, but so is their obvious unreality — the mathematics reveals something about, but is not an all-encompassing model for, shape and color *qua* material phenomenon, still less the neuroscience of color experience. Morphism between structures may model *processes* more correctly than the structures themselves approximate their substrata — but this is no longer a semiotics of causal/physical reductionism, a use of mathematics (like differential geometry) to iconify empirical givens, the way that (say) the Navier-Stokes equations are understood to refer explicitly to (even while idealizing and abstracting from) fluid-mechanical dynamics. Our theory-semiotics has to locate the site of designation at a more oblique scale, a different Ontological register, of processes and transformations — seeing in phenomena the image of a theoretical model because of its global structure, as a sign in its own right, rather than a collage of symbols and numbers to which are reduced spatializations and trajectories of causation and physical influence.

ical/humanistic: their causal engenderings are physical and structural phenomena, but their manifestation in the world is not fully tractable without an interpersonal deliberation accounting for both the privateness of consciousness and the sociality of mind, and, so, something akin to phenomenology.

It may appear that I am describing a weak-functional theory (or metatheory) which uses functional description in lieu of precise micro-physical explanation — in other words, that in lieu of explaining precisely how the brain achieves vision or language, we describe functional capabilities that are prerequisite for these competences, and refactor the goal of scientific explanation as to describe the system of intermediate functionality as correctly as possible, rather than describe how this functionality is physically realized. In a strong form, this re-orientation yields functionalism in theories/philosophies of Mind, that try to refrain from Ontological commitments to mental states or properties *apart from* descriptions of their functional roles. In other words, according to the parameters of the field of study and its institutions, even if not deep metaphysical beliefs, mental states are reducible to functional states, and cognitive systems are scientifically equivalent if they reveal similar functional organization, whether they belong to human or animal minds or computers or extra-terrestrials. A more modest functionalism would reject the implied reductionistic (maybe eliminative) Ontological stance, and maintain that mental things are not wholly, metaphysically subsumed by their functional organization, while still practicing a kind of theory whereby this functional organization is the proper object of study; the specific aspect of the mental realm which is scientifically tractable.

I do not believe I am making even such weak-functionalist claims: either branch of functionalism can misattribute the methodological association between theoretical structures and explanatory goals. We may be led toward the stronger or weaker functionalist viewpoints if we understand that a cognitive theory should task itself with making symbolic icons for scientifically grounded referents, grounded in an abstract space of functional organization if not in empirical space-time. Of course, most scientific explanation does construct a specialized, technical semiotics whose signs refer into either formal spaces or accounts of empirical space-bound things, however abstracted or idealized. But, conversely, insofar as I propose to focus on functional structures, and particularly cross-representation-framework transformations, my intent is to "functionalize" the discursive norms of the theory, not the phenomena it investigates. In order to negotiate between the competing demands of scientific rigor and formalization — on the one hand — with the immediacy and etheriality and subjectivity of consciousness, on the other, we need to "attach" theoretical structures to mental phenomena without getting bogged down in questions of the scientific or Ontological status of mental things, how they are "scientific" individually and collectively (collectively as in the Ontology of "Mind" overall).

This suggests adopting functional attitudes not in the theory but the metatheory: to use functionalism as an organizing principle on the theoretical *discourse*, on the attitudes of the scientists and scholars who want to straddle the divide between natural and mathematical sciences and humanism and consciousness. The "semiotic morphism" of color-to-curvature vector fields, or word-sequences to typed semantic graphs, are recommendations for guidelines on how researchers should write and communicate about cognitive processes in their global structure. I have tried to outline a metadiscourse more than a metalanguage — not a template for building theory-languages whose signs refer into a realm of posited empirical or abstract entities, but a template for using certain formal-mathematical constructions (in domains like typed lambda calculus, type theory, or differential geometry) as a textual prelude, a way to position the norms of writing to be receptive to both scientific-mathematical and phenomenological concerns. If semiotic morphisms like color-to-curvature or word-sequence-to-semantic-graph have explanatory merit as ways to picture cognitive processes, this merit is intended to be judged according to how it affects discursive norms on this scientific borderlands between mathematics and humanities, rather than how it reduces empirical phenomena to mathematizable abstractions. If there is *something* in cognition analogous to these morphisms, even if "analogous" means merely that holding the morphisms as formally defined in our minds while thinking about cognition can show us philosophical ways forward, then we should be interested in refining these formalizations as part of the overall Cognitive-Phenomenological project.

The Cognitive-phenomenological project is very different, I believe, than the AI or Atificial General Intelligence projects. Nevertheless, as I noted to conclude Section 5, AI — for all its reductive ideology — does show the benefits of an intellectual framework where researchers can experiment, try things out, and write code. We should not underestimate the power of technology and experimentation to ground and engage the scholarly process: it allows the scholar to program her own research environment, autonomous as necessary from academic and institutional paradigms — which, notwithstanding a general acaemic commitment to innovation, can get mired in inertia: particularly when it comes to interdisciplinary methodology and particularly when it comes to reengineering the publishing process and the dissemination of scholarship. There is a lot of technical and technological potential which in the acaemic and publishing communities is not being realized.

This is not just a procedural claim tangential to actual scholarly argumentation: we need new generations of publishing tools to properly syntheize computational technology with nonreductive, humanities-based philosophies of mind and consciousness. We need to properly implement the technological tools that empowe individual scholars, without buying uncritically into academic and corporate appropriations of technology for regressive ends.

At the risk of seming to conclude with an infomercial, I'll cite as an example the Conceptual Space Type Theory and Type Expression Language (CSTX), which is currently used in the context of scientific data publication (see my forthcoming chapter in [20]). CSTX presents a flexible type theory that can model both natural-langauge phenomena (such as Link Grammar, the internal parsing formalism in OpenCog, and the type-theoretic semantics favored by linguists such as Zhaohuu Luo or James Pustejovsky) as well as formal-language specifications for Software Language Engineering and Requirements Engineering. CSTX allows linguists to consider a type-theoretic representation of linguistic data, or language-as-interface "intermediate structures", *without* presuming that automated (AI/machine-learning) systems could necessarily generate Intermeiate Representations without human intervention. It is not a "practical" software system in the AI sense of enabling useful human-like behavior.

On the other hand, since CSTX *also* provides concrete software-development tools, it does have practical uses outside the AI paradigm. In this sense it perhaps serves as a case-study in concrete software whose practical dimension spurs hands-on experimentation and decentralized, extra-institutional open-source collaboration, but whose theoretical commitments gravitate to cognitive linguistics and phenomenology — while bypassing an AI paradigm that underestimates the cognitive importance but complexity of social-situational awareness and of sensate consciousness. AI is not a canonical arbiter of software practicality (our contemporary instinct toward measuring all software around AI-driven analytics and "Big Data" reflects a clever marketing campaign by companies with financial incentives to prioritize AI research over other disciplines). Nor is AI a value-neutral or politically progressive vision of what human mind and society are like.

Perhaps this is part of what it means to be a phenomenologist in the 21st century: not to reject technology or computational models or to believe in a mode of phenomenological research carried by pure thought, but to embrace — as part of the research infrastructure, of our own respective academic identities — practical software that suggests interesting cognitive-humanistic paradigms without endorsing reductive AI hypotheses. Insofar as scholarship is a social phenomenon, the metaphilosophy of "pure thought" is an illusion anyhow: theory is inevitably mediated by the disciplinary expectations of its audience. Given this reality, software offers a renewed agency and autonomy to the researcher: computer code does not intrinsically know from disciplinary norms, and the code-writer is programming a medium where disciplinary boundaries can fade out — if the program compiles. The programmer does not *argue* for interdisciplinarity; she *implements* it.

Technology, in conclusion, can liberate scholarship from disciplinary inertia in the same gesture as open-source software liberates technology itself from commercial oligarchizing. Good open-source software programs monetary inequalities out of existence; as humanities scholars we have an analogous duty to program disparaties in intellectual capital and influence out of existence. Open-source software is the fiat currency of the digital commons; by analogy, phenomenology is the liberation theology of the intellectual commons. We don't argue for a just and existential foundation of the humanities and the natural/social science interface: we implement it.

Sophisticated but philosophically and morally responsible cognitive-computational paradigms are probably more likely to arise from adding formal methodology and open-sourc experimentalism to a fundamentally humanities foundation, rather than bringing sensitivity to human nuance to a natural-science academic tradition. The reasons for this are institutional as well as intellectual: insofar as formal-computational models are still rather unfamiliar in humanities contexts, practitioners in a hybrid cognitive-computational-humanities orientation can have a level of autonomy that helps us distinguish sophisticated computational models from simplistic philosophical (and commercial) paradigms. And the affordances of open-source code and digital publishing supports a robust but low-cost technological environment, tangential to academic laboratories and hierarchies.

Perhaps this open-source ecosystem is a worthy 21st-century field wherein to continue 20th-century phenomenology. Let's not forget that phenomenology began as a philosophy of mathematics but evolved into a moral, political, and Existential system. Honoring the subtelty of human consciousness is a way to respect the technical priorities of phenomenological philosophy but also the political activism that — certainly often rendered into praxis by the intersectionality of lived experience with race, class, and gender — follows from phenomenological ethics.

Kant's critical philosophy did not only inspire generations of abstract Idealism; it spurred the cosmopolitan ideal of a Community of Nations and the municipalist axiology of, in particular, Kant's 19th century French translator, Jules Barni. Our communal existence is not intrinsically, cognitively, tribal or chauvinistic: the basic adaptation of human minds to ecologies transcends race, class, and culture. Cultural differences are real, but extrnal: enculturation is minds being shaped by the natural and civil infrastructure around us. While preserving nation and comunity as a practical medium, Kantianism unmasks nationalism as a metaphysical gambit. This is perhaps how, for Barni, Critical Philosophy flows organically into municipalist activism: to understand the mind we have to embed ourselves into the cognitive patterning of mind, which means the environs where cognition is honed, which means our urban and neighborhood ecologies. The architecture of cognition lies not only in the cultures we receive via transmission — religion, education, inter-generational ideologies — but in the grid of the streets outside our front door.

The axis from Kant to Barni has 21st century analogs: Husserl as our Kant, and progressive ethical frameworks like Murray Bookshin's libertarian municipalism taking the mantle from Barni's post-1848 variety. But one key difference is that communities are now partly (though of course not entirely) digital, virtual, and technological. So, I believe, part of being a phenomenologist in the 21st century is to — as much as we can, and virtually if need be — implement a municipalism in our time that metastatizes Husserl in a recapitulation of how, for example, Barni metastatized Kant. This is not just an abstract exercise, because intellectuals are performing their commitment to humanities scholarship, to the progressive and cosmopolitan spirit of humanitis discourse, in environments far mor challenging than we associated with Western academia — Budapest; Rojava. This is part of what I had in mind referring to "phenomenological ethics".

Wes Enzinna, a New York Times reporter who taught a journalism class at the Mesopotamian Social Sciences Academy in Qamishli, told a story (in the Times Sunday Magazine, November 29 2015) about his reconciliation with students after a brief culture-shock-like falling out:

> "We reject the master-and-slave relationship as a model for the teacher-and-student relationship," Ali said. "But we've decided that you're welcome to continue teaching us." Ramah, the atheist, stood up and said, "I'm so happy you're here." They all approached my desk and turned in their assignments.

Sherhad Naaima, another Kurdish activist a few months earlier, put it this way (in an interview with Eleanor Finley from the Institute for Social Ecology in Vermont):

> History is a river, it cannot be cut. We have no West or East, but rather one history which is moving and retaining all human culture ... [T]he Left needs to dive deeper into hidden history and revive their own traditions of freedom and the idea of a utopia of freedom. They then must build a holistic theory provided by the unity of natural sciences and social sciences.

> That new theory can be called "the epistemology of freedom".

These testimonies are what "to the things themselves" means today.

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