Language and Conceptual Reanalysis
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In a series of papers, I have argued that phrasal meanings are instructions for how to build conjunctive monadic concepts whose conjuncts correspond to the phrasal constituents.[1] On this view, modification by relative clause is a paradigm of semantic composition: a relative clause, as in 'cow which sneezed' or 'dog that chased cows', calls for construction of a monadic concept that is to be conjoined with another. Many cases of adjectival/adverbial modification are similar. Of course, many phrasal concepts are not *merely* conjunctive: 'chase cows' does not direct construction of a concept that applies to things that are both chases and cows. But if a cow was chased, some event was a chase that involved a cow. And the idea is that open class lexical items fetch monadic concepts like CHASE(_), even if the concepts lexicalized were not monadic, while some grammatical relations introduce thematic concepts like PATIENT(_, _) and a restricted form of existential closure. The verb phrase $[\text{chase}_V\ [\text{cow+pl}]_N]_V$ is thus understood as an instruction for how to build a concept like CHASE(_) & ∃X[PATIENT(_, X) & [COW(X) & PLURAL(X)]].[2] I grant that animal cognition employs singular and polyadic concepts in complex representations like CHASE(FIDO, BESSIE). But I think lexicalization is often a formally creative process in which nonmonadic concepts are used to *introduce* concepts like CHASE(E), which can be systematically conjoined with others, given a few thematic concepts and a suitable kind of existential closure.

In section one, I review some motivations for this claim about the expression-generating procedures that humans naturally acquire. In describing these procedures as tools for introducing and assembling concepts, as opposed to mere tools for communication, I'll also draw on Frege's (1879, 1884, 1892) conception of logic and Chomsky's (1965, 1986, 1995) conception of linguistics. But while Frege introduced higher-order polyadic concepts to make claims about the foundations of arithmetic, my proposal concerns the human language faculty and the mental representations with which this faculty ordinarily interfaces. My aim, in the spirit of Chomsky's (1995, 2000a) minimalist approach to the study of natural language syntax, is to reduce the stock of composition operations that semanticists regularly appeal to—see, e.g., Montague (1974), Higginbotham (1985), Larson and Segal (1995), Heim and Kratzer (1998)—if only to make it more plausible that our innate endowment supports these operations, and perhaps to help identify the uniquely human aspects of this endowment; cp. Hauser et.al. (2002).

In section two, I focus on the requisite conjunction/closure operations, distinguishing them from more general operations that theorists often invoke. For certain purposes, semanticists can employ any computational descriptions that seem adequate to the facts concerning how linguistic expressions are understood. But I think the study of natural language meaning, conceived as part of a broader biolinguistic study of human language, has progressed far enough to pursue the kind of reduction urged here in the broader context of asking which composition operations are fundamental and hence actually implemented; cp. Poeppel and Embick (2005), Hornstein and Pietroski (2009), Berwick et.al. (in press), Pietroski et.al. (in press).

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[1] See Pietroski (2005a, 2005b, 2010, 2011, in press), Hornstein and Pietroski (2009). I take concepts to be composable mental representations that exhibit "valences" or adicities; see, e.g., Fodor (1975, 1986, 2003).
[2] Cp. Castañeda (1967) on Davidson (1967); see also Carlson (1984), Higginbotham (1985), Taylor (1985), Parsons (1990), Dowty (1991), Krifka (1992), Schein (1993, 2002). More precisely, I think the direct object introduces the formal concept INTERNAL(E, X); the verb specifies that Internals of chases are Patients. In any case, a phrase need not *merely* conjunctive. A big ant is an ant and big for one. An alleged criminal is a person such that some event was an allegation and one whose content is that the person is a criminal; see Higginbotham (1985).

1. Human Languages as Instruction Generators

If one wants to compare the languages that children acquire with the languages that logicians invent, or with various systems of animal communication, it is useful to begin with a generous conception of what languages are. Then one can ask what sort(s) of languages humans naturally acquire. This highlights the need to distinguish conventionally determined sets of expressions from biologically implemented procedures that generate expressions. Children certainly acquire the latter. So whatever languages are, we face questions concerning the mental representations that expression-generating procedures interface with.[3] In particular, if at least some of these representations are conjunctive, semanticists face questions concerning the *form(s)* of potential conjuncts and the *kind(s)* of conjunction that can be invoked by generable expressions. As we'll see, plausible answers invite the independently motivated and defensible hypothesis that phrasal meanings are quite generally instructions for how to build conjunctive monadic concepts.

1.1 'I' Before 'E'

At the risk of boredom for some readers, I want to be explicit about some terminology and background assumptions, which other readers may find tendentious.

Let's be overgenerous, and count as a language anything that associates signals of some kind with interpretations of some kind. Let's also say that an expression of a language pairs a signal (type) with an interpretation (type), allowing for abstract signals/interpretations and mediated pairings. An expression might pair a certain sound or gesture or inscription with a certain object or property or concept. A complex sound, of a sort that can be produced by a mezzo soprano or a basso profundo, might be paired with a complex concept via some algorithm. A slightly different kind of expression might pair an instruction for how to generate a complex gesture with an instruction for how to generate a complex concept, thereby pairing an instruction-relative gesture type with an instruction-relative concept-type.[4] This allows for bee languages, languages of thought, mathematical languages with gothic scripts, and various conceptions of human phonology/semantics. It also allows for languages of various ontological sorts: *sets* of expressions; *procedures* that generate expressions; physical *implementations* of such procedures; classes of similar sets, procedures, or implementations; etc.

A language can have finitely many expressions. But children acquire languages that are "finite-yet-unbounded" in the sense of having endlessly many complex expressions that can be characterized recursively. Let a *naturally acquirable human language*—henceforth, a Naturahl—be a finite-yet-unbounded language with two further properties: its signals are overt sounds or gestures, as in spoken English or ASL; and it can be acquired by any biologically normal child given an ordinary course of human experience. While 'Naturahl' inherits the vagueness of its

[3] One can stipulate that procedures and expression are abstracta that do not interface with mental representations. But then 'acquire' and 'generate' should be understood accordingly, allowing for acquisition and generation of abstracta. One can say that children acquire a capacity to generate certain *representations of* expressions. Then the question is how the (acquired, abstract but somehow implemented) capacity to generate expression-representations is related to other aspects of human psychology, including various nonlinguistic mental representations that interface with generated expression-representations. I find it simpler to say that children acquire expression-generating procedures, and ask how expressions (lexical and complex) are related to (other) mental representations.

[4] For these purposes, instructions include strings of '1's and '0's used in a von Neumann machine to access other such strings and perform certain operations on them: '0100110101' might be executed by performing *operation two* (010) on the *number* (0) *fifty-three* (110101), while '1101011010' calls for *operation six* (110) on the *number stored in* (1) register *twenty-six* (011010) And instead of arithmetic operations performed on accessible/generable numbers, one can imagine operations like conjunction on accessible/generable concepts.

defining terms, the initial point is to set aside any languages of thought whose signals are all mind-internal, along with any overt languages that children cannot acquire without special talent or training. In the end, one may want a more refined notion of human language, partly described in terms of the interpretations that children pair with sounds or gestures. And the natural kind in this vicinity may include some distinctively human languages whose signals are all covert. But instead of starting with substantive assumptions about linguistic interpretations, I want to *discover* what they are, in part by asking which operations are employed to combine them.

Framing the issue this way does suggest that expressions of a Naturahl link phonological representations to semantic representations. But this mentalistic perspective allows for the externalist idea that expressions (thereby) pair represented signals with represented aspects of the environment.[5] My own suspicions are more internalist: minds are related to the rest of reality in complicated ways that make word-world relations theoretically intractable; see Pietroski (2005b, 2008, 2010) drawing on Chomsky (1977, 2000b). I find it hard enough to say how words are related to human concepts, much less the things we can have concepts of. But I won't argue here against construing semantic theories externalistically. We should just be clear that such construal is not required by the fact that speakers communicate and use language to coordinate activities.

Let's grant that Naturahls link phonological representations of some kind to semantic representations that permit adequate triangulation on communicatively important aspects of the environment that speakers share. By using language, we can arrange to look for a missing cow tomorrow after breakfast. But nothing yet follows about whether spoken expressions like 'cow' ('brown', 'breakfast', 'look', 'missing', 'justice', 'unicorn', etc.) pair sounds with things. Even if many *concepts* pair certain representational forms with language-independent objects or properties, the phenomenon of polysemy suggests that lexical items are related to concepts in complex ways. A word like 'book' (or 'France') may indicate a family of representations that include a concept of spatiotemporal things and a formally distinct concept of intentionalia. In which case, it distorts the facts to say that 'book' expresses the concept BOOK, which is satisfied by an entity e if and only if e is a book. So let's at least leave room for the idea that expressions of a Naturahl pair phonological instructions with instructions for how to access and assemble certain concepts; where this neither implies nor denies that such expressions pair signals with language-independent entities in the fashion of a standard model for an invented language.

Returning to the point that Naturahls are finite-yet-unbounded, a child who acquires a Naturahl evidently acquires a *procedure that generates* expressions. So following Chomsky (1986), I'll take Naturahls to *be* the expression-generating procedures that children can naturally acquire, absent good reasons for taking Naturahls to be distinct (yet intimately related) things acquired. From this perspective, the study of Naturahls includes—at its core—the study of certain biologically implementable operations employed to form expressions. In which case, specifying these operations is a fundamental task of linguistics; cp. Chomsky (1995, 2000a).

Let me briefly address the contrasting idea that children acquire *sets of* expressions, which pair signals with interpretations in conventionally governed ways; see, e.g., Lewis (1975). Even if each child acquires an infinite set of expressions by acquiring a generative procedure, and actual children converge on similar procedures despite variance in experience, one might prefer to focus on generated expressions. For one might be interested in communication, as opposed to Naturahls or human nature; and perhaps possible minds that form the same

[5] See Higginbotham (1985), Larson and Segal (1995), Ludlow (2011). In perceiving cows, perceivers are related to cows *via* representations. Perhaps understanding 'cow' is similar.

expressions via different procedures could, other things equal, communicate as well as minds that form the same expressions via the same procedure. Correlatively, one might hope to specify expression interpretations that communicators can agree on, abstracting from how humans assign these publicly available construals to linguistic sounds/gestures. But this is not yet any argument that linguistic communication is supported by shared (languages that are) sets of expressions, as opposed to biologically implemented procedures. One can stipulate that speakers "share a language" if and only if they can communicate linguistically. But then positing shared languages does not *explain* successful communication; and appeal to Naturahls, which may not be languages in the stipulated sense, may be required to explain how humans can share languages.

One can imagine a Naturahl that differs from yours or mine only in that the sound of 'beech' is linked to the concept ELM, while the sound of 'elm' is linked to BEECH; where by hypothesis, these concepts differ only in what they are concepts of, and this difference is rooted in factors external to us (cp. Putnam [1975]). One can also insist that the imagined Naturahl is not an idiolect of English, since it violates the following convention: 'beech' (expresses BEECH, which) applies to beeches; 'elm' (expresses ELM, which) applies to elms. Perhaps anyone who speaks an idiolect of English is somehow bound by some such social norm, modulo polysemy. But then 'idiolect of English' may classify Naturahls in an arbitrary way. Conventional differences may reflect theoretically unimportant differences in how a generative procedure gets used; cp. Chomsky (1977, 1986, 2000b), Pietroski (2008). And if children acquire expression-generating procedures that exhibit striking commonalities not due to the environment—for reviews, see Berwick et. al. (2011), Pietroski and Crain (2012)—then one needs reasons for ignoring the commonalities and identifying Naturahls with alleged sets of generated expressions.

In thinking about whether such reasons are likely to emerge, it is useful to follow Chomsky (1986) in applying Church's (1941) intensional/extensional distinction—regarding mappings from inputs to outputs, as discussed by Frege (1892)—to the study of Naturahls and the aspects of human cognition that support acquisition of these languages. We can think of functions as *procedures* (intensions) that determine outputs given inputs, or as *sets* (extensions) of input-output pairs. Consider the set of ordered pairs $<x, y>$ such that x is a whole number, and y is the absolute value of $x - 1$. This infinite set, $\{ \ldots (-2, 3), (-1, 2), (0, 1), (1, 0), (2, 1) \ldots \}$, can be characterized in many ways. One can use the notion of absolute value, and say that $F(x) = |x - 1|$. But one can instead use the notion of a positive square root: $F(x) = {}^{+}\sqrt{}(x^2 - 2x + 1)$. These descriptions of the same set correspond to different procedures for computing a value given an argument. And a mind might be able to execute one algorithm but not the other.

In Church's idiom, one can use lambda expressions to indicate functions-in-intension, saying that $\lambda x.|x - 1|$ and $\lambda x.{}^{+}\sqrt{}(x^2 - 2x + 1)$ are distinct but extensionally equivalent procedure; or one can use lambda expressions to indicate functions-in-extension, saying that $\lambda x.|x - 1|$ is the same set as $\lambda x.{}^{+}\sqrt{}(x^2 - 2x + 1)$. Though as Church noted, one needs to talk about procedures in order to specify the space of *computable* functions. And given the procedural construal of lambdas, which lets one say that Extension[$\lambda x.|x - 1|$] = Extension[$\lambda x.{}^{+}\sqrt{}(x^2 - 2x + 1)$], the set-theoretic construal is dispensible.[6] Marr (1982) likewise distinguished "Level One" descriptions, of functions computed, from "Level Two" descriptions of the algorithms employed to compute those functions. And while Level One descriptions can have a certain primacy in the order of discovery, making it fruitful to ask what a system does before worrying about how the system does it, a function cannot be computed without being computed in some way. So one must not

[6] For Frege (1892), functions as procedures are logically prior to the more set-like *courses of values of* functions.

confuse the methodological value of Level One descriptions, in characterizing certain cognitive systems, with any suggestion that the corresponding extensions are themselves targets of inquiry.

Echoing Church, Chomsky contrasted I-languages with E-languages: an I-language is a procedure that pairs signals with interpretations; an E-language is a set of signal-interpretation pairs. This distinction applies to invented languages, even those with finitely many expressions (cp. Evans [1981]), and languages of thought. But the distinction is especially important, for two related reasons, with regard to Naturahls. First, to *specify* a set with endlessly many elements, one must somehow specify a procedure that determines the set. (Earlier, I was able to talk about *the* infinite set { . . . (–2, 3), (–1, 2), (0, 1), (1, 0), (2, 1) . . .} only because the context included reference to a determining procedure.) Second, while many procedures determine sets—arithmetic procedures defined over numbers being paradigm cases, along with any invented procedure that generates a set of well-formed formulae—a biological system might pair sounds with interpretations, yet *not* determine any set of expressions, if only for lack of a fixed domain of inputs. As a familiar illustration, consider (1).

(1) *The child seems sleeping

Speakers of English know that this string of words is defective, but meaningful. In particular, even though (1) is presumably ungrammatical—and not hard to parse, or otherwise grammatical but unacceptable—speakers hear (1) as having the interpretation of (2) *and not* the interpretation of (3); see Chomsky (1965), Higginbotham (1985).

(2) The child seems to be sleeping

(3) The child seems sleepy

The defect does not preclude *understanding* (1), which is neither word salad like (4)

(4) *Be seems child to sleeping the

nor an expression like (5) that is grammatical but bizarre given what it means.

(5) Colorless green ideas sleep furiously

So a Naturahl can, qua implemented procedure, assign an interpretation to the sound of (1). But it seems wrong to say that (1) is therefore an expression of the Naturahl. One can and perhaps should introduce a graded notion of expressionhood, and speak of sound-interpretation pairs being more or less grammatical, with word-strings like (1) corresponding to sound-interpretation pairs that are generable in some second-class way. This does not threaten the idea of Naturahls as procedures, which apply to whatever they apply to with whatever results. But it does challenge the idea that such procedures determine sets of expressions, in any theoretically interesting sense.

If (1) is a second-class expression of my I-language, is (4) an especially degenerate expression, or not an expression at all? Are translations of (3), in Japanese or Walpiri, terrible expressions of my idiolect? The point here is not merely that the "expression of" relation is *vague* for Naturahls. The point is rather that absent stipulations, it is hard to see how theorists could ever specify what it is to *be* an expression of a Naturahl (to any given degree) without relying on a prior notion of Naturahls as implemented procedures that interface (via the inputs they can take, and the outputs they can deliver) with other cognitive systems. To even say which E-Naturahl a speaker has allegedly acquired, it seems that one must first say which I-Naturahl she acquired. This casts further doubt on the idea that there *is* any set of English expressions, somehow determined conventionally, that different speakers might acquire by acquiring different generative procedures. And if Naturahls are not languages that determine sets of well-formed formulae, which can be specified in multiple ways, theorists may have to focus on the implemented operations that permit generation of fully grammatical expressions like (2) and (3)—recognizing that these operations may be applied more widely with various effects.

1.2 Executable Expressions

Focusing on generative operations as opposed to generated expressions has become increasingly common in the study of Naturahl syntax, especially in light of minimalist thinking and suspicion of grammatical "levels" (e.g., Deep Structure and Surface Structure) beyond those required by the following truism: Naturahls interface with other cognitive systems in ways that support articulation and perception of sounds/gestures that can be intentionally used to express concepts in contexts; cp. Chomsky (1995). But focusing on I-Naturahls not only highlights questions concerning how phonological representations (PHONs) are paired with semantic representations (SEMs), it also highlights questions concerning how SEMs are used to assemble whatever complex mental representations speakers do assemble in comprehension.

Given an I-perspective, semanticists cannot say merely that speakers associate expressions with entities/satisfiers/functions that can be represented in various ways. At best, this characterizes what speakers represent (cp. Marr's Level One), raising questions about how they represent it and how the relevant forms of representation are related to generable SEMs. And if there are no E-Naturahls for speakers to share, then even if humans unconsciously represent satisfaction conditions of the sort that Tarski (1933) represented explicitly, children who acquire a spoken language like English do not acquire sets of representation-neutral sound-interpretation pairs. Put another way, regardless of whether or not generable SEMs are used to assemble concepts that are individuated externalistically, semanticists face questions concerning the *forms* of these concepts. In particular, we face two related questions: what kinds of concepts can lexical items access; and which modes of conceptual composition can be invoked by phrasal syntax?

This extends the notion of I-Naturahl to include not just implemented procedures that generate PHON-SEM pairs, but also more inclusive procedures that (in contexts) generate sound-concept pairs; cp. Hauser et. al. (2002). But the more restrictive notion remains available. Syntacticians may often set aside questions of the sort addressed here, and focus on I-Naturahls in the narrow sense, even if their data often concerns unavailable interpretations for word-strings. But semanticists, I assume, want the broader—though perhaps not yet externalistic—notion of I-Naturahl. This may well require a theoretical distinction between cases of a single PHON that can be paired with more than one SEM (narrow homophony), and cases of a single SEM that can invoke more than one concept (broad polysemy); see Hornstein and Pietroski (2002) for discussion in the context of scope ambiguities. But I'll assume that this distinction can be drawn, even if it is often hard to sort out the details in practice.

From this perspective, an obvious suggestion is that SEMs are instructions for how to assemble concepts, with concepts taken to be composable mental representations of some kind (see note 1): lexical SEMs call for (copies of) concepts stored in memory at lexical addresses that are also associated with PHONs; phrasal SEMs call for assembly, via certain composition operations, of concepts accessed via lexical SEMs. In principle, a composition operation might be "direct" in the sense of calling for concepts to be combined without invocation of any *other* concept, or "indirect" in the sense of calling for concepts to be combined via some other concept (e.g., conjunction). One might imagine the direct operation **SATURATE**: given a "predicative" concept $\Phi(\_)$ that can take some concept α as an "argument," applying **SATURATE** to $\Phi(\_)$ and α yields the complex concept $\Phi(\alpha)$, whose adicity is one less than that of $\Phi(\_)$. Given COW(_) and BESSIE as inputs, applying **SATURATE** yields COW(BESSIE)—i.e., the thought that Bessie is a cow, ignoring tense for simplicity. For these purposes, polyadic concepts like CHASED(_, _) are also predicative. Applying **SATURATE** to CHASED(_, _) and BESSIE yields CHASED(_, BESSIE);

applying **SATURATE** to this complex concept and FIDO yields CHASED(FIDO, BESSIE), the thought that Fido chased Bessie.[7]

As a potential indirect composition operation, consider **M-CONJOIN**: given two monadic concepts Φ(_) and Ψ(_) as inputs, applying **M-CONJOIN** yields +[Φ(_), Ψ(_)], which applies to whatever both Φ(_) and Ψ(_) apply to; +[__ , __] is a second-order dyadic concept that can be saturated by a pair of monadic concepts, perhaps unordered, to yield a third. Applying **M-CONJOIN** to COW(_) and BROWN(_) yields +[COW(_), BROWN(_)]. So one can say, as a first pass idealization, that 'brown cow' calls for M-conjunction of concepts fetched with 'brown' and 'cow'. This assumes an underlying cognitive operation of saturating some concepts with others, but without yet positing the sophisticated operation **SATURATE**, much less positing it as the mode of semantic composition invoked by 'brown cow'; cp. note 7. Though of course, Naturahls may invoke both direct and indirect composition operations. Combining a predicative SEM with a (grammatical) argument SEM may call for the operation **SATURATE**, while combining a predicative SEM with an adjunct SEM calls for **M-CONJOIN**.[8]

1.3 Available Operations

Elsewhere, I have stressed that the operation **SATURATE** does not itself impose any constraints on the kinds of concepts that can be fetched via lexical SEMs, and that this should make us wary of positing **SATURATE** as a basic composition operation for I-Naturahls; see Pietroski (2005, 2010, in press, forthcoming). The point is not merely that we lack words for many saturatable concepts of high order and high adicity. One expects there to be endlessly many potential concepts that humans do not have, and hence do not have words for. But humans seem to have many polyadic concepts, corresponding to actual words, that are not fetched with lexical items.

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[7] This assumes that CHASED(_, _) takes *two* arguments in a fixed *order*, and that CHASED(_, BESSIE) is a formable concept. In this respect, CHASED(_, _) is like 'λy.λx.Cxy'. But then CHASED(_, _) may not be available for simple *labeling* in lexicalization, even ignoring tense. One can imagine a mind that would have to *introduce* CHASED(_, _) via some prior concept CHASED(<1, 2>) that must be saturated (all at once) by a concept of an ordered pair of things. If CHASED(<1, BESSIE>) is not a formable concept, yet 'chased Bessie' calls for saturation of a concept fetched with 'chase' (by a concept fetched with 'Bessie'), then lexicalization may require some conceptual reformatting even if **SATURATE** is the basic composition operation. If CHASED(<FIDO, BESSIE>) is a concept of a *truth value*, it is even clearer that CHASED(_, _) may have to be introduced as a concept of type <e, eT>; cp. Church's (1941) use of Tarskian sentences like 'Cxy', which have no truth values, to specify functions like λy.λx.1 if Cxy and 0 otherwise. Likewise, one can imagine a mind that would have to introduce any quantificational concept of type < eT, < eT, T>> via independently available concepts like INCLUDES(<1, 2>), which must be saturated (all at once) by a concept of an ordered pair of sets. In general, any proposed bundle of composition operations may require reformatting of concepts available to infants. Of course, we know very little about the format of infant concepts. But it may be that neither the event concept CHASE(_) nor the <e, eT> concept CHASED(_, _) is available without some reformatting.

[8] See, e.g., Heim and Kratzer (1998). Their proposal is largely encoded in terms of functions-in-extension. But their treatment of relative clauses and quantifiers suggests an algorithm for assembling *mental representations* that have externalistic/extensional contents; see Pietroski (2011), which includes discussion of a minimal abstraction operation that accommodates relative clauses and quantifiers. Higginbotham (1985) appeals to event variables, speaking of theta-binding vs. theta-linking. This makes it clearer that at least in the first instance, the posited operations concern representation formation, not things represented—with the relevant analogy being manipulation of '1's and '0's by a Turing machine, not arithmetic operations that map abstracta to abstracta. One can say that 'brown cow' calls for *saturation* of a concept fetched with 'brown' (by a concept fetched with 'cow'), and that 'brown' can call for a concept of type <eT , eT> like λΦ.λX.+[BROWN(X), Φ(X)]; cp. Parsons (1970), Kamp, (1975), Montague (1974). This assumes a cognitive operation that supports (M-)conjunction of some concepts with others, while maintaining that combining 'brown' with 'cow' calls for the operation **SATURATE**. Though it seems that the concept λΦ.λX.+[BROWN(X), Φ(X)] would have to be introduced via some concept like λX.BROWN(X); cp. note 7.

Prima facie, we have a concept BETWEEN(_, _, _) that could be saturated by singular concepts to form thoughts like BETWEEN(FIDO, BESSIE, REX). Yet to express this thought—that Fido *is* between Bessie *and* Rex—we use a copular phase that includes 'and', as opposed to a ditransitive verb 'betwixt' that could simply fetch BETWEEN(_, _, _) and combine with three grammatical arguments as in (6).

(6) Fido betwixts Bessie Rex

Such examples cast doubt on the idea that I-Naturahls invoke **SATURATE** to combine concepts that can be fetched with lexical items. And in my view, this kind of circumlocution—with polyadic concepts being expressed in indirect ways, instead of simply fetching and saturating the concepts—is ubiquitious. To take another obvious example, we use comparative constructions like 'is bigger than Rex' instead of simply lexicalizing the presumably relational concept with a dyadic predicate 'bigs' that takes a subject and an object as in 'Fido bigs Rex'; see note 13.

Moreover, inquiry suggests that the actual ditransitive construction (7)

(7) Chris gave Fido a bone

does not include a verb that simply fetches a triadic concept GAVE(_, _, _) that applies to triples consisting of a giver, a recipient, and a thing given; see Larson (1988) and references there. Here, I'll just assume that (7) has the same logical form as (8), with the prepositional phrase indicating a conjunctive adjunct as in (8a) or (8b) or (8c), still ignoring tense.

(8) Chris gave a bone to Fido

(8a) ∃E[GAVE(E, CHRIS, A BONE) & RECIPIENT(E, FIDO)]

(8b) ∃E[AGENT(E, CHRIS) & GAVE(E, A BONE) & RECIPIENT(E, FIDO)]

(8c) ∃E[AGENT(E, CHRIS) & GAVE(E) & THEME(E, A BONE) & RECIPIENT(E, FIDO)]

By way of comparison, consider (9-14), which invite the hypothesis that 'kick' fetches KICK(E),

(9) Chris kicked Fido a bone
(10) Chris kicked a bone to Fido
(11) Chris kicked a bone
(12) Chris kicked
(13) A bone was kicked
(14) Chris gets a kick out of Fido

which can be conjoined with PAST(E) and thematic concepts like those in (8c).[9]

If at least one variable position in GAVE(_, _, _) does not appear in the concept fetched with 'gave', one wants to know why, especially if combining a verb with a grammatical argument calls for direct saturation of concepts. Why not use 'gave' to fetch GAVE(_, _, _)—or some tetradic analog that adds an event variable—and eschew (8), letting 'Fido' in (7) indicate a saturater of the polyadic concept fetched with the verb, as in GAVE(CHRIS, FIDO, A BONE)? But as stressed below, those who analyze (7) as in (8) must say *which* conjunction operation the ampersand indicates. Recall that **M-CONJOIN** is defined (only) for pairs of monadic concepts.

One can say that I-Naturahls invoke a powerful Tarskian operation, **T-CONJOIN**, which can connect any (open or closed) sentences as in (15).

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[9] See Schein (1993, 2002, forthcoming) and other references in note 2. Kratzer (1996) argues—stressing subject/object asymmetries in passivization and idioms (see Marantz [1984])—that while agent variables are "severed" from the semantic contribution of verbs, this contribution remains polyadic: combination with a direct object indicates saturation of a variable, yielding a concept like KICK(E, X); see also Harley (2006). I return to this idea. But note that it still presupposes creative lexicalization, unless the hypothesis is that (i) concepts like KICK(E, X) are available for labeling, *and* (ii) concepts of higher adicity are not. So absent independent arguments for (i), one might accept arguments for severing all participant variables from the contributions of verbs, and blame any asymmetries on cognitive factors independent of semantic composition, instead of positing distinct composition operations for subjects and objects. Williams (2007, 2009) defends such a diagnosis, arguing that Kratzer's claims to the contrary are unpersuasive for English and implausible when applied to good test cases in other languages.

(15) COW(BESSIE) & BROWN(X) & DOG(Y) & KICKED(Y, Z) & BETWEEN(Z, Y, W)

But again, this does not constrain lexical concepts, and (15) may not be a naturally generable tetradic predicate. Moreover, concepts like AGENT(_, CHRIS) can be recast in terms of existential closure and conjunction: ∃X[AGENT(_, X) & CHRIS(X)]; where CHRIS(X) is a monadic predicate—perhaps introduced, complex, and akin to CALLED(X, 'CHRIS') & DEMONSTRATED(X)—that applies only to the individual thought about with the singular concept CHRIS; cp. Quine (1963), Burge (1973), Katz (1994), Elbourne (2005).[10] Since AGENT(_, _) and CALLED(_, _) are dyadic concepts, generating representations like (8c) still requires more than **M-CONJOIN**. But as we'll see, a minimally more sophisticated form of conjunction can allow for some dyadicity in a constrained way. For now, though, just let '&' signify a conjunctive operation that I-Naturahls can invoke, leaving further specification of this operation for section two.

The more important point here is that if the verb in (7-8) is not used to fetch a concept that has a variable for recipients, but the concept lexicalized with 'give' has such a variable, then the concept fetched with a lexical SEM can differ formally from the corresponding concept lexicalized. Likewise, if the verb in (9-13) is not used to fetch a concept that has a variable for agents and/or themes, then on the assumption that the concept lexicalized with 'kick' does have such variables, the concept fetched with a lexical SEM can differ formally from the corresponding concept lexicalized. And it is not hard to imagine a mind that works this way.

The triadic concept GIVE(_, _, _)—which can be used to think about one thing giving a second to a third—might be available for lexicalization, but ill-suited for combination with other concepts via the available composition operations. Suppose in particular, that **SATURATE** is not available, but that event concepts like GIVE(_) can be easily combined with other fetchable concepts. And suppose that GIVE(_, _, _) can be used, along with some logical and thematic concepts, to *introduce* GIVE(_) along the following lines indicated below.

GIVE(X, Y, Z) ≡ ∃E[GIVE(E) & AGENT(E, X) & THEME(E, Y) & RECIPIENT(E, Z)]

Such introduction might be metaphysically dubious if the quantifier is read with its usual existential import. Nonetheless, a certain kind of mind might take it to be truistic that one thing gives a second to a third iff there is a give (or giving) by the first of the second to the third. Such a mind might also be able to introduce DONATE(_), perhaps as a special kind of giving, yet treat the verbs 'donate' and 'give' differently so that (16) is comprehensible but a little strange.[11]

(16) Chris donated Fido a bone

The moral is that in thinking about whether I-Naturhals invoke **SATURATE**, as an operation of conceptual composition, one needs to think about the adicities *not* exhibited by lexical items despite the apparent availability of relevant concepts. To take another familiar kind of example, one could invent a language in which (17) is a sentence with the meaning of (18).

(17) *Mrs. White sold a knife Professor Plum ten dollars

(18) Mrs. White sold a knife to Professor Plum for ten dollars

But in English, (17) is anomalous, and 'sold' can combine with *two* arguments as in (19).

(19) Mrs. White sold a knife

One can insist that 'sold' fetches a tetradic concept, and that (19) has two covert grammatical

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[10] I assume that such recasting is independently plausible, given predicative uses of proper nouns, as discussed by Burge (1973) and many others. But if proper nouns do not fetch singular concepts, one wants to know why, especially *if* **SATURATE** is available as a composition operation.

[11] Unless, say, Fido is a museum (the Florida Institute for Dismal Objects) specializing in ancient bones. In which case, it would be odd to say that Fido chased a cow—unless, say, the long dead cow belonged to a potential donor.

arguments. But then what is *wrong* with (17)? Similar remarks apply to 'bought'. Though note that (20) paraphrases (21), using 'for' to signify a beneficiary, in contrast with (22).

(20) Professor Plum bought Miss Scarlet a knife

(21) Plum bought a knife for Scarlet

(22) Plum bought a knife for ten dollars

Moreover, while (23) is acceptable, it is roughly synonymous with (24),

(23) Mrs. White sold Professor Plum a knife

(24) Mrs. White sold a knife to Professor Plum

suggesting a shared logical form in which 'Professor Plum' corresponds to a conjunct of the form ∃X[RECIPIENT(_, X) & **Π**(X)]; where **Π**(X) applies to the relevant professor called 'Plum'. In which case, 'sell' is not an instruction to fetch a triadic concept with a variable for recipients. One can say that 'sell' is an instruction to fetch a nonmonadic concept like SELL(E, X, Y) as opposed to a monadic concept like SELL(E). But if the concept lexicalized has variables for the recipient and/or the payment, one wants to know why the concept fetched differs in this respect.

My suggestion is that open-class lexical items fetch monadic concepts because **SATURATE** is not available as a composition operation. If compositional semantics is fundamentally conjunctive, then reformatting is required for many concepts lexicalized. But appeal to **SATURATE** may require its own kind of reformatting; see note 7. And in any case, let me end this section by stressing that there is nothing new in idea that minds can use extant concepts to introduce new ones, thereby making new use of available composition operations. In section two, I'll return to logical forms like (8b/8c) and ask what the ampersand signifies.

(8b) ∃E[AGENT(E, CHRIS) & GAVE(E, A BONE) & RECIPIENT(E, FIDO)]

(8c) ∃E[AGENT(E, CHRIS) & GAVE(E) & THEME(E, A BONE) & RECIPIENT(E, FIDO)]

1.4 Illustrating Introduction

Frege (1879, 1884) invented his *Begriffsschrift*, which can be viewed an idealized language of thought that permits certain deductions, largely in order to introduce "fruitful definitions" of central arithmetic notions. Given such definitions, one can deduce (suitable encoded versions of) the Dedekind-Peano axioms for arithmetic from more general principles. To provide such deductions, Frege introduced some higher-order polyadic correlates of concepts like NUMBER(_). In this sense, he "analyzed" many apparently simple concepts in terms of logically complex concepts. By contrast, I think humans naturally introduce simple monadic correlates of polyadic concepts like SELL(_, _, _, _). On this view, lexicalizers introduce concepts that exhibit *less* formal variation than the concepts lexicalized. But Frege's project still illustrates two points that are important here: concept introduction, which need not follow the pattern of defining VIXEN(_) in terms of FOX(_) and FEMALE(_), can be cognitively useful; and complex polyadic concepts can be used to introduce simple monadic concepts.

Frege was especially interested in concepts that figure in proofs by induction—e.g., proofs that there are infinitely many primes, given the axioms of arithmetic, and derivations of these axioms from a more compact representation of any nonlogical basis for arithmetic. One of his main insights, concerning such proofs, was that arithmetic induction is a special case of logical induction applied to entities of a special sort. To show this, he defined the (natural) numbers so that for any property Φ: if (i) zero has Φ, and (ii) if any given number has Φ, so does its successor, then (iii) every number has Φ. But to *derive* this arithmetic truth from more basic principles and definitions, Frege needed a way of thinking about numbers that let him go beyond thinking about them with a logically unstructured monadic concept of certain abstract objects.

Formally, NUMBER(_) is like COW(_). Yet replacing 'number' with 'cow' in (ii) and (iii) does not preserve the compellingness of the inference. So Frege introduced a relational concept, NUMBER-OF[_, Φ(_)], that applies to certain *object-concept* pairs. For example, 0 is (defined as) the number of (things that fall under) the concept NONSELFIDENTICAL(_)—a.k.a. ~[=(X, X)]; 1 is the number of the concept =(0, _); 2 is the number of OR[=(0, _), (1, _)]; etc. Frege also introduced **ANCESTRAL-**R(_, _) as a higher-order concept that can be saturated by a first-order relational concept like PREDECESSOR(_, _) to yield a concept like PRECEDES(_, _) whose extension is the transitive closure of the more basic concept. For any relation and any entities: if R(α, β) and R(β, γ), then **ANCESTRAL-**R(α, γ); and similarly for any "chain of R-links." Given these concepts, one can formulate the biconditional (25): _ is a number iff 0 *is or precedes* _.

(25) NUMBER(_) ≡ OR[=(0, _), **ANCESTRAL-**PREDECESSOR(0, _)]

Whether (25) counts as analytic depends in part on whether one allows for analysis by abstraction, as opposed to decomposition; see Horty (2007). But the suggestion is not that we naturally think about numbers via mental analogs of the right hand side of (25). Rather, (25) reflects Frege's attempt to say what numbers *are*—and how we *can* think of them—in a way that reflects our capacity to appreciate the validity of certain inductive inferences. In this sense, his *Begriffsschrift* is a language in which we can conduct recognizably human thought. But acquiring the relevant concepts requires intellectual work. Of course, we must entertain a thought—e.g. that every number is the predecessor of another—in order to analyze it. But we can use concepts like NUMBER(_) and PREDECESSOR(_, _) to think thoughts, and then introduce technical analogs of these more natural concepts, with the aim of re-presenting our initial thought contents in ways that let us describe more inferences as formally valid. We can use (25) to replace NUMBER(_) with a more structured relational concept, when this is useful in a proof, and then go back to NUMBER(_) when the further structure is irrelevant.

Frege went on to define/analyze the predecessor relation inductively, given his key concept NUMBER-OF[_, Φ(_)] and the central arithmetic concept of one-to-one correspondence, via the following generalization: two concepts have the *same* number if and only if the things that fall under them correspond one-to-one. (The key insight was that since 0 is the first number, each number *n* is also the number of numbers that precede *n*, making the predecessor of *n* the number of numbers apart from zero that precede *n*. For example, three numbers precede 3, two of which are not zero.) Frege thus showed how a mind furnished with certain concepts and logical capacities could reconstruct our concept NUMBER(X), in a way that would permit agreement on the Dedekind-Peano generalizations. Initially, *we* might view NUMBER-OF[_, Φ(_)] as mental shorthand: *n* is the number of a concept iff *n* is a number such that the things falling under that concept correspond one-to-one with the numbers preceding *n*. But this takes the monadic concept of numbers as objects, NUMBER(_), as given. And for Frege, the point is not to reduce NUMBER-OF[_, Φ(_)] to more familiar numeric concepts. The point is to show how an ideal thinker might define NUMBER(_)—and the other concepts we initially use to entertain arithmetic principles—in terms of more logically basic concepts.

Given a mind that can introduce concepts in any such way, theorists can distinguish the (i) "first concepts" used to think about things and introduce new ways of thinking about things from (ii) "second concepts" that are introduced in terms of first concepts. It may be that animals have been introducing concepts, unconsciously, for a long while. So perhaps we'll need to speak of "third concepts," and so on. But in any case, we should at least consider the possibility that lexicalization often includes a process that is some respects like the process of an ideal Fregean mind introducing the formally simple concept NUMBER(_): a nonmonadic concept is used, along with other reformatting resources, to define a monadic concept that can figure in simple conjunctions like +[NUMBER(_), PRIME(_)]. Of course, infants do not have ideal Fregean minds. But there may be a sense in which infants "dumb their concepts down," to achieve a stock of concepts that are systematically combinable via the composition operations that I-Naturahls can invoke; see Pietroski (2010), drawing on Spelke (2002) and Carruthers (2002). And while revealing the foundations of arithmetic may require higher-order polyadic concepts that combine via saturation, understanding expressions of an I-Naturahl may require monadic concepts that combine via some form of conjunction. But which form?

2. Limited Conjunction Can Do a Lot

There are many ampersands, and correspondingly, many possible concepts of conjunction. We want to know which such concept figures in logical forms like (8b/8c),

(8b) ∃E[AGENT(E, CHRIS) & GAVE(E, A BONE) & RECIPIENT(E, FIDO)]

(8c) ∃E[AGENT(E, CHRIS) & GAVE(E) & THEME(E, A BONE) & RECIPIENT(E, FIDO)]

taking these to reflect thoughts that can be assembled by executing SEMs; where concepts like THEME(E, A BONE) have further analyses as in ∃X[BONE(X) & THEME(E, X)], which has a dyadic conjunct. The idea will be that a severely constrained concept of conjunction, appeal to which is hard to avoid, can still let us characterize an indirect composition operation that makes appeal to **SATURATE** seem otioise. Though if I-Naturahls invoke this composition operation, we need to rethink the notions of variable and closure that are relevant for I-Naturahl semantics. In short, the Frege-Tarski notions may be far too powerful if the goal is to describe the concepts assembled by executing naturally acquirable biologically implemented procedures.

2.1 Varieties of Conjunction

The ampersand of a propositional calculus, as in (25), can be characterized via *truth* tables.

(25) P $\underline{\&}$ Q

But while humans may enjoy a corresponding concept—and perhaps an operation **P-CONJOIN**, implementable with AND-gates, that takes pairs of truth-evaluable sentences as inputs and yields sentences like (1) as outputs—this simple ampersand cannot combine constituents that have nonzero adicities as in (8b/8c).

In a first-order predicate calculus that includes open sentences like (26-29),

(26) Bx **&** Cx (27) Bx **&** Cy

(28) Axy **&** Gx (29) Fxy **&** Uzw

the ampersand can be characterized in terms of Tarski's notion of *satisfaction* by sequences, which assign values to variables. Then (25) can be described as a special case like (30a) or (30b),

(30) Cb **&** Fab (30b) ∃xCx **&** ∀x∃yFxy

with truth characterized in terms of satisfaction. The corresponding operation **T-CONJOIN**, mentioned above, maps pairs of sentences (open or closed) onto their Tarskian conjunctions. But the bold ampersand has a striking property illustrated with (27) and (29): it can be used to form an open sentence that has *more* free variables than any conjunct. And prima facie, combining expressions in a Naturahl cannot *increase* semantic adicity in this way. Note that 'brown cow' is not ambiguous, with (27) as a potential reading. Likewise, 'from under' cannot be understood as an open sentence like (29). So if one describes the meaning of 'brown cow' or 'gave Fido a bone' with the bold ampersand, one needs to say more about why conjunctive meanings are so limited in Naturahls.

Many things might be said, in this regard, and I won't try to rebut them here. My point is simply that the bold ampersand allows for great freedom: '**&**' can link sentences that have arbitrarily many free variables, and any number of shared variables. This raises the question of whether phrases like 'brown cow' and 'gave Fido a bone' invoke a conjunctive concept that also affords such freedom—or whether the bold ampersand lets theorists describe a space of logically possible construals for expressions, and then discover that I-Naturahl meanings reflect a proper part of that larger space. The latter suggestion will be attractive to anyone who finds it hard to believe that biology gave us Tarski-conjunction, much less that we regularly use this operation of semantic composition without exploiting its combinatorial power.

It is worth being explicit about why the adicity of a Tarskian conjunction can exceed that of any conjunct. Think of a Tarskian sentence as the result of "faux-saturating" each slot of an unsaturated Fregean concept with a variable, treating constants as special variables. Note that the slots in CHASED(_, _) cannot yet be bound by quantifiers; at best, '∃_' would bind both slots. Inserting variables yields an open sentence like CHASED(X, X′).[12] But a Tarskian language has endlessly many variables: X, X′, X″, etc. Each conceptual slot can be replaced with any variable; consider CHASED(X″, X‴) vs. CHASED(X″, X″). So for each predicative Fregean concept, there are endlessly many formally distinct Tarskian sentences. And a polyadic concept will correspond to open sentences that exhibit different adicities, since variables can be repeated. The flip side of this point is that the adicity of conjuncts will not determine the adicity of conjunctions, which depend on how many variables appear in *both* conjuncts. Consider the range of conjunctions that can be formed from CHASED(_, _) and CAUGHT(_, _): the dyadic CHASED(X, X′) **&** CAUGHT(X, X′); the triadic CHASED(X, X′) **&** CAUGHT(X′, X″); and the tetradic CHASED(X, X′) **&** CAUGHT(X″, X‴). Setting aside the possibility of using a variable twice in the same "primitive" open sentence—as in CHASED(X, X) or CAUGHT(X′, X′)—a Tarskian conjunction of CHASED(_, _) and CAUGHT(_, _) may have two, three, or four open variables.

While Tarski's conjoiner affords great freedom, one can also invent a restrictive language that does not generate any conjunctive sentences—much less sentences like (26-29)—but instead generates monadic predicates like (31), with each slot obligatorily linked to the other.

(31) B(_) *&* C(_)

This italicized ampersand, which might be characterized in terms of intersection, is a notational variant of the '+' used earlier to describe the operation **M-CONJOIN**. In an important sense, such a language lacks variables, even though there are predicative slots that allow for saturation by different saturaters. For within any predicate, no such slot can be bound or saturated independently of any other: necessarily, this restricted conjunction of B(_) with C(_) yields another one-slot predicate. By contrast, Tarskian variables and conjunction would permit endlessly many two-variable sentences: Bx **&** Cx′; Bx′ **&** Cx; Bx **&** Cx″; Bx′ **&** Cx″; etc. But again, even if humans have access to pure monadic predicate conjunction, this operation cannot be used to form concepts like ∃X[THEME(_, X) & BONE(X)] or ∃X[FROM(_, X) & CHICAGO(X)]; where at least one of the conjoined constitutents is dyadic. While relative clauses (e.g, 'cow that arrived') may call for simple conjunction of monadic concepts, other forms of modification (e.g., 'big ant') may well call for a kind of conjunction that permits some relationality, as in ANT(_) & BIG(_, *ONE*); where BIG(_, __) is saturated by a concept and an object—cp. NUMBER-OF(_, __)—and the pronominal concept *ONE* stands in for the head concept ANT(_).[13]

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[12] Which might be abbreviated as 'Cxy'. But I-Naturahls may not let us build concepts like ∃X[CHASED(X, X′)], corresponding to 'thing that was chased', as opposed to ∃E{∃X[AGENT(E, X)] & CHASE(E) & THEME(E, A1)}; where 'A1' stands for an assignment relative value, but can also be a variable for quantification of assignment variants.

[13] See note 2 and Kennedy (1998). Developing this idea in detail would require a digression into Boolos' (1998) interpretation of the *second-order* monadic predicate calculus, in which a (capitalized) variable can have *many* values relative to one assignment of values to variables; see Pietroski (2005a, 2006, 2011) for discussion.

We face a kind of "Goldilocks Problem." Some conjoiners are too restricted to do what I-Naturahls do. Others seem too permissive for purposes of I-Naturahl semantics. One suspects that the answer lies somewhere between **M-CONJOIN** and **T-CONJOIN**. And this at least suggests a research strategy: find a minimal modification of **M-CONJOIN** that will do the job.

Another familiar conjoiner traffics in functions, types, and truth *values* as in (32);

(32) $^{\langle eT, \langle eT, eT\rangle\rangle}$&(λx.1 iff Bx, λx.1 iff Cx)

where (32) describes the same function in extension as (33), which has (26) as a constituent.

(33) λx.1 iff Bx **&** Cx

This superscripted ampersand does not itself accommodate any polyadicity. It can only take predicates of type <eT> as inputs. And this does not help with examples like (8b/c),

(8b) ∃E[AGENT(E, CHRIS) & GAVE(E, A BONE) & RECIPIENT(E, FIDO)]

(8c) ∃E[AGENT(E, CHRIS) & GAVE(E) & THEME(E, A BONE) & RECIPIENT(E, FIDO)]

involving dyadic conjuncts. But one can posit other fixed-type conjoiners as in (34);

(34) $^{\langle\langle e, \underline{e}T\rangle, \langle eT, \langle e, \underline{e}T\rangle\rangle\rangle}$&[λX.λE.1 IFF THEME(E, X), λX.1 IFF BONE(X)]

where this superscripted ampersand, with '*e̲*' suggesting an event variable, permits conjunction of THEME(E, X) and BONE(X) to form a dyadic concept that is extensionally equivalent to (35);

(35) λX.λE.1 iff THEME(E, X) **&** BONE(X)

cp. Kratzer (1996), Chung and Ladusaw (2003).

Likewise, this conjoiner permits (36), which is extensionally equivalent to (37);

(36) $^{\langle\langle e, \underline{e}T\rangle, \langle eT, \langle e, \underline{e}T\rangle\rangle\rangle}$&[λX.λE.1 IFF AGENT(E, X), λX.1 IFF CHRIS(X)]

(37) λX.λE.1 iff AGENT(E, X) **&** CHRIS(X)

where as discussed above, CHRIS(X) is a potentially complex (and context-sensitive) monadic concept that applies to exactly one person (in any context of use). I think this suggestion is on the right track. But appealing to this particular ampersand raises the question of why other forms of type-restricted conjunction, as in (38), are not equally available.

(38a) $^{\langle\langle e, \underline{e}T\rangle, \langle \underline{e}T, \langle e, \underline{e}T\rangle\rangle\rangle}$&[λX.λE.1 IFF AGENT(E, X), λE.1 IFF VIOLENT(E)]

(38b) $^{\langle\langle e, eT\rangle, \langle\langle e, eT\rangle, \langle e, eT\rangle\rangle\rangle}$&[λX′.λX.1 IFF FROM(X, X′), λX′.λX.1 IFF LIKES(X, X′)]

Moreover, one needs a sophisticated kind of existential closure to convert (37) into (39).

(39) λE.1 iff ∃X[AGENT(E, X) **&** CHRIS(X)]

The requisite quantifier is not of type <eT, T>, but rather <<e, e̲T>, e̲T>. One can get around this by positing suitable displacement and abstraction on variables. But for reasons that will emerge, I want to explore the idea that I-Naturahls let us build event concepts like (40);

(40) ∃X[AGENT(_, X)^CHRIS(X)]^GAVE(_)^∃X[THEME(_, X)^BONE(X)]^
∃X[RECIPIENT(_, X)^FIDO(X)]

where '^' stands for a conjoiner that permits one dyadic conjunct as in (34) and (36), but each open slot is necessarily linked to the others as in (31).

(31) B(_) & C(_)

Then (8c) can viewed as an existential closure of the *one* open slot in (40).[14]

Note that for these purposes, the difference between (8c) and (8b) is small. The choice concerns whether the variable corresponding to 'bone' is *separated* from the concept fetched via the verb; cp. Schein (1993, 2002), Kratzer (1996). But either way, a dyadic concept is conjoined

[14] And as discussed in Pietroski (2011), this simple kind of existential closure can be encoded as an operator that converts a given monadic concept into a special monadic concept that applies to everything or nothing. This echoes Tarski's insight that truth/falsity can be described as satisfaction by all/no sequences.

with a monadic concept—BONE/BONES/GRASS(X)—that may itself be complex. Like Schein, I think there are good arguments for separation: verbs fetch monadic concepts like GAVE(_), which can conjoin with complex monadic concepts like ∃X[THEME(_, X)^BONE(X)], as opposed to dyadic concepts like GAVE(_, _) that can conjoin with complex monadic concepts like BONE(_); see Pietroski (2005, 2011, in press). But either way, the requisite *form* of conjunction is basically the same, since apparent polyadicity is handled by dyadic-monadic conjunction along with some form of existential closure. The crucial contrast is with GAVE(_, _, _)—which applies to *trios* consisting of some past event of giving, a giver, and a thing given—and the tetradic GAVE(_, _, _, _) which adds a variable for the recipient; cp Davidson (1967). The assumption here, increasingly common, is that 'gave' fetches a concept with at most two variables, at least one of which is an event variable; in which case, the variables corresponding to the grammatical subject and indirect object of (7) are separated from the concept fetched via 'gave'.

(7) Chris gave Fido a bone

If this assumption is correct in general—and each verb fetches either a monadic concept or a dyadic concept whose second variable is for "internal" participants of the event-like values of the first variable—then inferences from (7) to (41) are instances of conjunction reduction,

(41) Fido was given a bone

much like inferences from (42) or (43) to (7).

(42) Chris gave Fido a red bone

(43) Chris gave Fido a bone yesterday

And if that's right, one would like to blame the same underlying circuitry in each case.

2.2 Minimal Dyadicity

As suggested by (40),

(40) ∃X[AGENT(_, X)^CHRIS(X)]^GAVE(_)^∃X[THEME(_, X)^BONE(X)]^
∃X[RECIPIENT(_, X)^FIDO(X)]

let '^' indicate a conjoiner that differs minimally from the italicized conjoiner of (31).

(31) B(_) *&* C(_)

The idea is that '^' can also link a single dyadic concept to a single monadic concept, subject to the following constraint: the second slot of the dyadic concept must be linked to the (slot of the) monadic concept; then the monadic concept must be existentially closed, immediately, yielding a complex monadic concept that can be conjoined with others. A system that permits this smidgeon of dyadicity, while remaining massively monadic, would permit (44) and (45),

(44) BROWN(X)^COW(X) (45) ∃X[ABOVE(X′, X)^COW(X)]

but not (46) or (47), much less (48) or (49).

(46) ∃X[ABOVE(X, X′)^COW(X)] (47) ∃X′[ABOVE(X′, X)^COW(X)]

(48) *BROWN(X)^COW(X′) (49) *FROM(X, X′)^UNDER(X, X′)

Note that (40) can be recast as shown below,

∃[AGENT(_, _)^CHRIS(_)]^GAVE(_)^∃[THEME(_, _)^BONE(_)]^∃[RECIPIENT(_, _)^FIDO(_)]

with the links reflecting constraints on '∃' and '^': '∃' must bind the monadic concept in its scope; and the second variable of any dyadic conjunct must link to the adjacent monadic concept. There is no choice about which conceptual slot '∃' binds, or which slot is left open. So there is no Tarskian quantifier binding a variable in an open sentence, and (40) can be rewritten as (40a).

(40a) ∃[AGENT(_, _)^CHRIS(_)]^GAVE(_)^
∃[THEME(_, _)^BONE(_)]^∃[RECIPIENT(_, _)^FIDO(_)]

Despite the lack of variable letters, this is unambiguously a concept of events, each of which meets four conditions: its agent is Chris; it is a past event of giving; its theme is a bone; and its recipient is Fido.[15] Correlatively, (50) is not a notational variant of the more sophisticated (51).

(50) ∃[AGENT(_, _)^CHRIS(_)]

(51) ∃X[AGENT(E, X)^CHRIS(X)]

Don't think of (50) as the result of applying a quantifier to an open sentence, with a tacit understanding about how the variable slots are linked. Think of (50) as the mental representation that results when AGENT(_, _) is ^-conjoined with CHRIS(_); where **^-CONJOIN** is a biologically implemented operation that creates a certain monadic concept, given a dyadic and monadic input. In (50), '∃' targets CHRIS(_) because '∃' must target a monadic concept, not because '∃' is somehow indexed with a variable that faux-saturates CHRIS(_) as in (51).

One can say that **^-CONJOIN** incorporates a kind of existential closure, as a way of describing the end result. But the suggestion is not that **^-CONJOIN** is a complex operation that can be decomposed into Tarskian conjunction and closure. On the contrary, the suggestion is that biochemistry can create concepts like (50) *without* implementing Tarskian conjunction and closure. I don't know *how* **^-CONJOIN** is implemented. But I don't see how I-Naturahls could do what they do without invoking this operation, one way or another. By contrast, we can begin to see how I-Naturahls could do what they do without invoking **T-CONJOIN** or **SATURATE**; see Pietroski (2005a, 2011) for details concerning relative clause, quantificational, causal, and attitude-ascribing constructions. So perhaps we should try to reduce semantic composition operations to a small bundle that includes **^-CONJOIN**, or some such relatively simple operation of conjunction, but not the more traditional and more powerful operations.

On a more straightforwardly empirical note, suppose that the "participant slot" of each thematic concept invoked—by a grammatical argument or prepositional phrase—is indeed linked to a monadic concept that is (in effect) existentially closed via the operation **^-CONJOIN**. Then the indefinite article in (7) marks 'bone' as a singular count noun (cp. Borer [2005]),

(7) Chris gave Fido a bone

but 'a' does not itself call for an existential quantifier; cp. Higginbotham (1987). I mention this not because the semantic status of indefinites is easily resolved, but to stress that appealing to **^-CONJOIN** has real consequences. Plural and mass noun analogs, as in (52-53), can also be analyzed as simple existential closures of the event concepts;

(52) Chris gave Fido (sm) bones

(52a) ∃[AGENT(_, _)^CHRIS(_)]^GAVE(_)^
∃[THEME(_, _)^BONE(_)^PLURAL(_)]^∃[RECIPIENT(_, _)^FIDO(_)]

(53) Chris gave Bessie (sm) hay

(53a) ∃[AGENT(_, _)^CHRIS(_)]^GAVE(_)^
∃[THEME(_, _)^HAY(_)]^∃X[RECIPIENT(_, _)^BESSIE(_)]

where the existential force of bones/hay need not come from any lexical constituent.

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[15] This simplifies: GIVE(_) may be "number neutral" in a way that lets many events *together* satisfy the concept; cp. Boolos (1998), Schein (1993, 2001), Pietroski (2005, 2006, 2011). And (40a) may be satisfied, plurally, by some events that together were/constituted past events of giving in which Chris was the agent, a bone was the theme, and Fido was the recipient; where BONE(_) may turn out to be like TRIO(_), in that satisfying the concept may be a matter of some things together falling under the concept, as opposed to some one thing falling under the concept.

In this regard, note that the untensed (54)

(54) Chris give Bessie (sm) hay

can be embedded as in (55), which can initially be analyzed as in (55a),

(55) hear Chris give Bessie (sm) hay

(55a) HEAR(_) & ∃E{THEME(_, E) & ∃X[AGENT(E, X)^CHRIS(X)]^GAVE(E)^
∃X[THEME(E, X)^HAY(X)]^∃X[RECIPIENT(E, X)^BESSIE(X)]}

with an event as the "thing" heard; cp. Higginbotham (1983). This event analysis captures an otherwise puzzling ambiguity of (56), since 'in the barn' could modify 'heard' or 'give'.

(56) I heard Chris give Bessie (sm) hay in the barn

The relevance is that the clausal direct object of 'hear' carries a kind of existential force, as indicated with (55a), which can be rewritten as (55b).

(55b) HEAR(_) & ∃{THEME(_, _) & ∃[AGENT(_, _)^CHRIS(_)]^GAVE(_)^
∃[THEME(_, _)^HAY(_)]^∃[RECIPIENT(_, _)^BESSIE(_)]}

But if this existential force is not plausibly due to any lexical constituent, perhaps we should say the same about (57) and (52-53).

(57) I heard cows

Again, my point is not that these implications of appealing to **^-CONJOIN** are obviously correct; cp. Chierchia (1998). But a very simple conception of semantic composition, motivated by various empirical considerations, has testable consequences that are not obviously wrong. And that seems promising.

2.3 Final Remarks

In thinking about what makes humans linguistically special, it is tempting to focus on how spoken/signed languages are used for interpersonal communication. So one might stress the fact that humans can generate articulable/perceivable expressions that are in some sense conventionally governed, while treating intrapersonal uses of the human language faculty as somehow secondary or derivative on this faculty's role in communication. I have been urging a different perspective according to which humans have a capacity to generate expressions that are distinctively meaningful/comprehensible. Expressions can be used in speech. But meanings are instructions for how to build concepts, not abstractions from communicative situations.

I have also suggested that lexicalization is a large part of what makes humans linguistically special, and that lexicalization is a formally creative process that lets us make productive use of relatively simple composition operations. Specifically, the indirect composition operation **^-CONJOIN** may allow for enough nonmonadicity to accommodate verb-argument (as well as verb-adjunct) combinations in I-Naturahls, without being as sophisticated as **SATURATE** or **T-CONJOIN**. Indeed, **^-CONJOIN** does not even require variables in the Tarskian sense. And if the goal is to describe biologically implementable composition operations, as opposed to doing interesting logic, lack of sophistication may be a virtue.[16]

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[16] My thanks to the many students and audience members who commented on earlier versions of this material. But I owe a special debt to Norbert Hornstein for many conversations, over many years, that triggered and then helped refine the ideas presented here.

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