Introduction to a new paradigm

Based on cognitive processing

For a theory of logic that also provides a foundation for language and mathematics

Erik Thomsen

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LC Type Logic

1 Introduction to a new paradigm

LC Type Logic is built on a new paradigm of "Cognitive processing". One part of LC Type Logic is process – the process of answering a question, testing an assertion or executing a command. Also, the process of linking publicly exchangeable symbols with internal logical roles. And doing so, perhaps from memory or by following a rule or by interacting with the world. Whether or not the process is known, *assertions* are treated as the result of having executed a *process*.

In fact there is no way to know within an assertion what is the predicate and what is the argument absent knowing the process whose output generated the assertion. (Grammatical form gives a clue - the standard parsing, but no guarantee.) Extending beyond so-called pure logic, there's no way to account for linguistic or surface symbols other than as the output of interpretation processes. Nor is there any way to connect surface symbols with internal logical grammar absent yet another layer of interpretation processes. Many of the problems in Canonical Logic described earlier stem from failing to recognize the interdependency of process and structure.

Another part (the cognitive part) of LC Type Logic[1] is a generative basis for all kinds of logical (as opposed to machine) types. *Integers* and *Rationals* are examples of logical types (as distinguished from machine types such as 'Short Ints' or '8 Byte Floats'). So too are *Categoricals,* O*rdinals* and *Booleans.* Notions of hierarchy, containment, resolution, network, and process are naturally supported within the LC typing framework. Consistent with the notions of 'group' or 'category' in mathematics, each type has its own set of values, value relationships and operators. Furthermore, all types have both logical and physical representations. Linking these representations within the very specification of types provides the mapping between publicly exchanged symbols such as words and their internal logical or 'mentalese[2]' representations. It also treats private non-verbal symbols such as the signature for a car that might exist in someone's mind the same as any publicly exchangeable symbol so sensory-motor 'scene' parsing/understanding and natural language parsing/understanding follow the same rules . Additional problems in Canonical Logic stem from failing to recognize the central role that types play in logic.

These two orthogonally related parts combine to form a two dimensional 'grid' of logic scopes. Each scope comprises some types and some processes. The most general and thus the starting point is any type by any process. This is the closest to what Quine might have called core logic or logic as narrowly defined as possible.

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[1] The term 'logic' and its variants have multiple uses/meanings which are best to clearly distinguish between prior to the first instance of a "second use". Thus here:

- Logic is the name for an organized academic discipline dating back to around the beginning of the 20th century. Frege, Russell, Wittgenstein thought, discussed and wrote about the field of logic.
- Logic is also the name for a topic (expressible in units as small as a single word or sentence), that at various times was considered to be a part of philosophy, theology, history and mathematics
- Mathematical logic refers to the use of an algebraic symbology for logical expressions
- Logician refers to someone who specializes in logical issues. Carnap, Church and Quine might have thought of themselves as logicians
- Logical refers to a logical/abstract representation as opposed to a physical or concrete representation. Software design and implementation needs to systematically recognize and manage the distinction between logical and physical representations.

[2] A term used by Pinker in "…."

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In a nutshell[3] , LC Type logic accepts certain elements of Canonical propositional logic[4]; specifically where propositions are treated as undifferentiated truth value-bearing entities (e.g., P XOR Not P) and certain assumptions about those propositions such as independence hold true. Relative to the predicate calculus, however, it separates from the implicit 'knowable object'-centric paradigm introduced in Frege's Begriffshift (e.g. where the 'x' refers to some knowable object-in-the-world whether in a function argument notation f(x) or whether in a quantified state (e.g., $\forall$ x , or $\exists X$)). And, in a radical departure from the canonical paradigm, LC Type Logic is grounded in the process of purposeful interpretation and the logical (language or mindful) artifacts required to fulfill that purpose[5]. In LC Type Logic, "F's" and "x's" are treated as functional distinctions in the use of logical types for the purposes of specification and calculation. There are no objects beyond what are individuated in language through explicit cognitive processes. The world does not come pre-packaged[6].

As a result of this Copernican shift, LC Type Logic would extend canonical logic in a number of areas while simultaneously eliminating a variety of logical 'epicycles'. The result is a Logic that at the theoretical level appears to:

- Resolve all major inconsistencies and paradox,
- Provide a robust criteria for well formedness, and equivalence or identity
- Naturally encompass all major extensions to logic (e.g., temporal, spatial, modal, dialetheist, mereological, multi-valued, many sorted and sub structural),
- Ground mathematics more cleanly than canonical approaches (e.g., and discussed herein Frege, Russell, Wittgenstein, Carnap, Church, and Quine), and
- Link the rational world of definitions and certainty with the empirical world of sensory-motor experience and doubt

without giving up bivalent truth functions.

While at an applied level, LC Type Logic has either shown or shown promise that it can provide:

- ♣ A more powerful target language than anything grounded in Chomskian linguistics or the predicate calculus, for extracting meaning and knowledge from sensory-motor data such as words and visual objects
- ♣ A more consistent and more complete language (DDL/DML) than anything grounded in the predicate calculus (OWL, Prolog, Datalog, SQL)
- ♣ A clean way to unify rules, stored values and new experience
- ♣ A robust multi level world model with direct support for conflicting sensory streams

Of course the proof is in the pudding as the reader will have to judge.

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[3] See Susan Haack Philosophy of Logics and Deviant Logic

[4] and it accepts certain well established/canonical critiques

[5] In this sense, LC Type Logic is committed to the existence of functional distinctions or relationships, regardless of whether or how embodied, that are capable of producing interpretations and relationships between interpreations (which could also be called knowledge or knowing). If there were no such embodiment, my/the author's act of writing this or you/the reader's act of reading it could not take place.

[6] Though this has more of a Continental Rationalist feel ala DesCartes > Liebniz > Spinoza > Kant > than a British empirical feel ala Hume > Locke > Mill, and moreover keeping Wittgenstein as a 20th century rationalist which is one reason he suffered such deep disagreements with Russell, LC Type Logic attempts to subsume the best of both rationalist and empiricist philosophies. Only naïve realism assumes the world is pre-composed of objects.

1.1 A new paradigm map

Topics discussed under the auspices of Logic range over quite a broad territory. So where to begin? Since there is no consensus as to the boundaries between logic and other adjacent disciplines - most notably mathematics and language, nor is there any consensus as to boundaries that may exist within logic, in the interests of clarity, I will explicitly link different topics canonically discussed with the kinds of logical artifacts that need to be in place within logic to support even just the existence of those same topics. For example, if the challenges of mapping from natural language words to a logical symbolism are considered to be a part of logic, logic must include an understanding of word symbols. Stated alternatively, the narrower is one's conception of the boundaries of logic, the smaller is the number of topics that can be discussed within logic.

To do this, and before jumping into a constructive exposition of LC Type Logic we are going to build a functional map or architecture (based on a layered group of distinctions) that shows the main components that need to be recognized any cognitive processing-based logic and how they relate to various elements of the canonical view. In addition to providing context that should facilitate the exposition's comprehension, it should also serve to clear up confusions of meaning and reference in pure canonical logic, (e.g., where are objects, where are facts, where are concepts, where are extensions or intensions) which in turn should reinforce the first intent. First we need to build out that map.

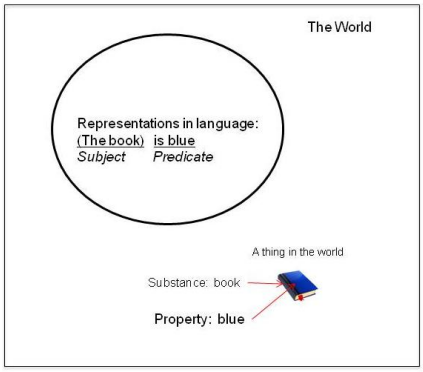
Let's begin with the underlying canonical ontology originally expounded by Aristotle that over the ages has been re-worded in the ongoing, if relative, spirit of modernity but has never clearly been altered:

> The world is composed of substances that have properties.
> The world is represented in language with assertions composed of subjects that have predicates[7].

The ontology contains two primitive bifurcations:

1. Between the world and language
2. Between whatever is either a substance or subject and whatever is either a property or predicate.

Visually it could be represented in the following way.



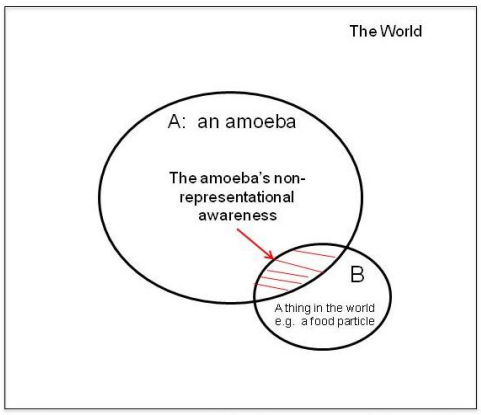
[7] 20th century language philosophers such as Wittgenstein have certainly ascribed more attributes to language than just representation (and more statement forms to be concerned with than just declarative) but the classical view still treats representation as primary.

This is a great start. But it is incomplete as a map for what needs to be explained. So let's continue.

Representational vs. non-representational awareness

Consider first, the distinction between representational and non-representational language. Most if not all of what is typically considered language is representational. This includes, for example, all human, animal and machine languages. In representational languages, the physical being (or world aspect), of a representation need not have any particular spatio-temporal relationship with what is represented. A person on the earth today can make an assertion not just about some immediate context like the view out her/his window but also about contexts far away such as that of other galaxies in space, or the origin of our solar system in time. In contrast, with non-representational languages, the physical being of a representation must have a particular spatio-temporal relationship with what is represented: namely that of adjacency. That adjacency can be, or move between being positional (e.g., an amoeba coming into contact with food, or photons coming into contact with a leaf) or resolutional (e.g., an amoeba having surrounded food, or nutrient transport in a plant).

Awareness in a non-representational language can be visually represented like this.



A has a non-representational awareness of some of B

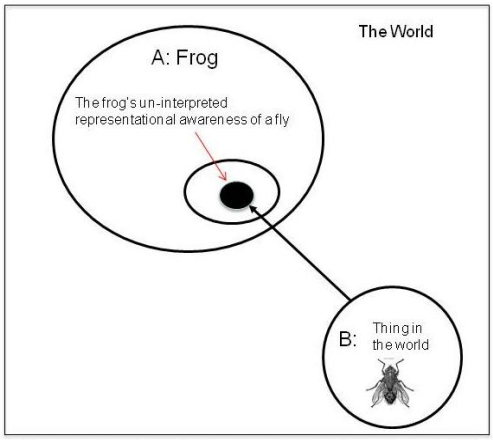
For A to have awareness of B, A must be touching B. The distinction between representational and non-representational languages is important because

- All representational language is embedded in some non-representational language which in turn is embedded in the world and because
- Any serious model of logic, cognition (whether insect-like or higher level or symbolic), or information systems, needs to include a mapping from the world to non representational language and another mapping from non-representational language to representational language. So for example, all animals (e.g., we humans) need to have an outermost non-representational layer that is next to and touches the world (e.g., skin, surface of the eye, tongue). Going back to our starting example, if the sensor devise is visual, the book first makes an impression as a pattern of reflected photons hitting the retina of the observer. This outermost layer receives the first sensory impressions from the world and in the case of motor

activity is the final stage in executing our prior representational intent. Without an outer non-representational layer, there would be no way for inner cognitive processes to have any interaction with the world; solipsism would reign supreme.

Interpreted vs. un-interpreted representational awareness

Consider second, within representational languages, the distinction between singly interpreted (or unambiguous) and multi- interpreted (or potentially ambiguous) representations. In singly interpreted representations, (e.g. individual reflexes) the information that is mapped (or published) from the source representation to the arguments of the subscriber functions (in the mathematical sense of the term 'function') in the target representation has the same logical truth structure as the logical truth structure required by the subscriber function arguments. Typically this is one of exclusive OR. Consider a target function that determines whether or not a frog extends its tongue in a certain direction. Imagine there are only two possible values for the argument: black and not black. And now consider sense data that exposes color information. A singly interpreted representation of that sense data, (for the purposes of the target argument that might be triggered), produces a value of black XOR not-black. So long as the input flow rate does not exceed the trigger function processing rate, representation can occur on a continuous basis. A visual depiction of the frog's un-interpreted representational awareness could look like this.

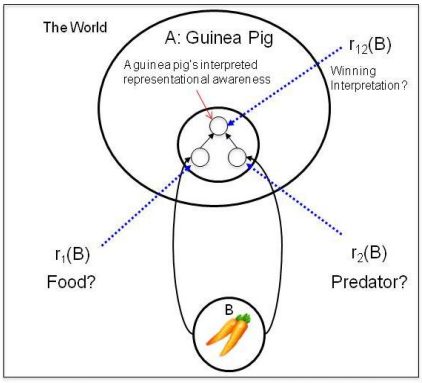


A has an un-interpreted representational awareness of B

As to the blue book, after passing through many stages of hardwired pre-processing the photons that hit the retina would be mapped to a field of color dots as an uninterpreted representation of the so-called book.

In contrast, with multi-interpreted representations, multiple conflicting interpretations can be produced for a single collection of sense data. For example, if a critter has a 'next movement' function that is triggered by the awareness of 'food XOR predator' and visual sense data is interpreted as *food* while olfactory sense data is interpreted as *predator* the 'next movement' function is being presented with conflicting argument prospects. To resolve the conflict, a requisite for triggering the function, some independent function needs to be executed whose output selects a single argument (this could all be part of a single detection program). And the maximum processing rate for the inputs to the target function will be slower than the processing rate for the target function owing to the time that needs to

be spent resolving conflict. Multi-interpreted representations are inherently slower to execute and are frequently embedded within an outer layer of faster to execute single interpreted representations. A visual depiction of a guinea pig's interpreted representational awareness could look like this.



A has multiply interpreted representational awareness of B

This distinction is important because it suggests a genesis for consciousness in the reflective processing required to choose between conflicting representations of the world.

Symbol awareness vs understanding

Consider third, the distinction within multi-interpreted representational language between sensory-motor pattern or symbol awareness, and logical understanding or expressions. For example, we humans have a rich model of recognized sensory-motor symbols: both non-verbal (e.g., objects and actions of all kinds), and as a specialized part of that, a rich model of word symbols in particular. Looked at this way, our non verbal recognition of objects, the supposed world of which we are aware, sits inside of language. And it sits at the same level so to speak as word objects, that is to say the specific visual and/or audio and/or tactile patterns that we have come to recognize as words. They are all symbols (or designators or names or identifiers or signatures). The real differences are that

- Words are public symbols that can be exchanged. So we can compile large collections of words (and word-based sentences etc..) aka social knowledge
- As public symbols words have both a sensory form and a motor form.

Our non-verbal symbols that represent to ourselves the act of recognizing a house or a tree or a person and which make up our perception of the world are not shared; nor do they typically have a motor form.

As to the understanding into which it maps, this is where we find logical verbal assertions such as Blue(Book) that derived from word symbols. And it is also where we find logical non-verbal assertions such as 'Fast moving(Object)' if we are a squirrel trying to cross the road. These are important distinctions for logic. Most of canonical logic has been focused here. All theories of logic provide at least some method of mapping natural surface language to an internal logic representation that supports reasoning (and other expression processing)[8]. Something has to be offered as a constructive account.

[8] So-called logical constants such as OR, AND, If Then, etc. are typically derived from natural language expressions. See for example, Formal Logic Richard Jeffrey p 2; Logic; The theory of formal inference Alice Ambrose, Morris Lazerowitz pps 4-11

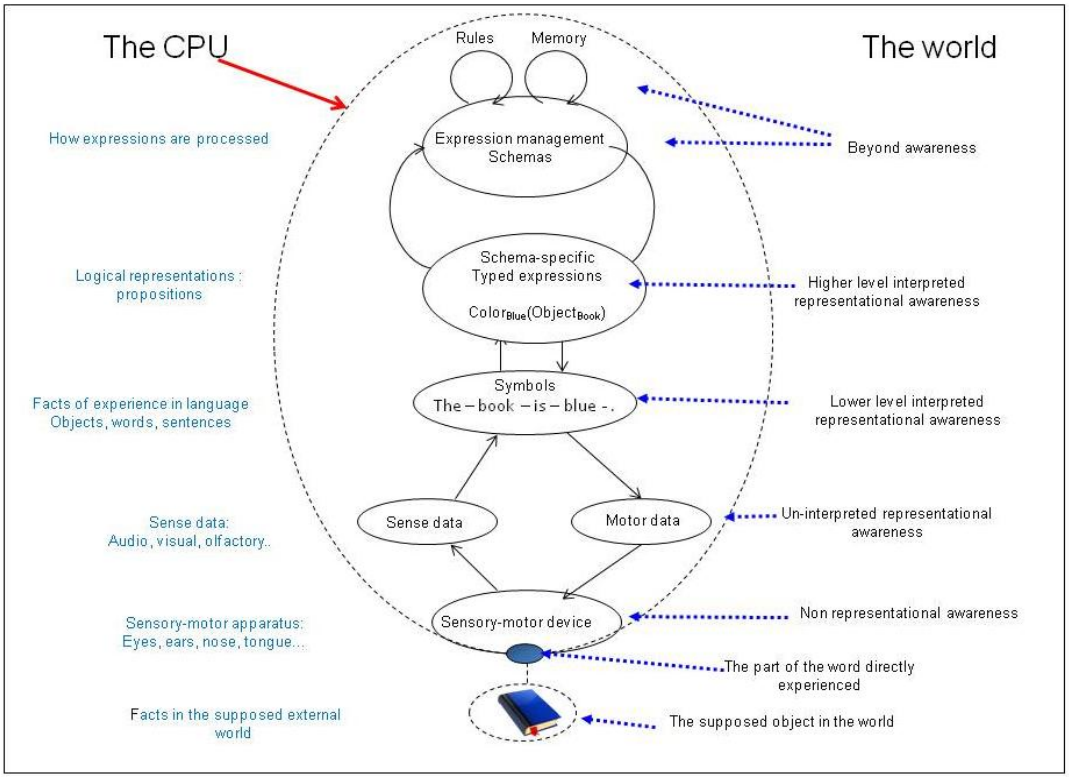
Consider fourth, the distinction within logical understanding between the typed expressions of which we are aware and the expression management machinery of which we are not aware. It's not enough to account for the mapping from words to an internal logical form. Something, even though it lies beyond our individual awarenesses, must also be responsible for the processing of expressions of which we are aware: answering questions, testing assertions, asking questions and issuing commands.

Consider fifth the distinction within expression management processing between executable expressions input, executing expressions thruput, and execution results output. Having moved logic to a cognitive processing paradigm, it is important to explicitly account for the entity's processing-based interaction with the so-called external world via its internal representations of same.

And finally, consider within the space of executing expressions, the distinction between definition or rule-based-paths, memory-based paths and experience-based-paths. These represent the different ways that any input expression can be processed. For example, if the input expression is a question (e.g., what color is the book?), the question could be answered with the assertion 'The book is blue.' by applying a rule or appealing to a definition that says that says 'all books are blue' or by remembering that you were told the book is blue or by walking over to the library and looking for yourself at the book. These too are a really important collection of distinctions. Without them there would be no way to distinguish different kinds of truth or truth testing procedures.

Here now is a visual depiction or 'New Paradigm Map' of all levels of language and associated awareness and showing the same example that was visually depicted in diagram one. The critter or cognitive processing unit or 'CPU' is encased in a dotted line. Immediately you can see the ambiguity in the canonical view of facts, states of affairs, or the world. Is the book the supposed object in our supposed external world? Or is it a particular fact of experience in language? Philosophically, the intent might be to locate objects in the supposed external world, but computationally they must exist as facts in language experience if assertions are ever to be tested.

A multi level model of awareness



Sense data is a representation of the part of the world directly experienced through the CPU's non-representational awareness. Sense data provides raw information that requires further interpretation, such as the visual bits, which through subsequent analysis, we interpret as verbal or non-verbal objects. And it provides sensations that are directly experienced without interpretation such as strong odors, bright lights, high heat etc.. Sense data is typically finer grained and refreshes more quickly than can be interpreted by the lower level interpretation layer, else we would see the grain in our visual field.

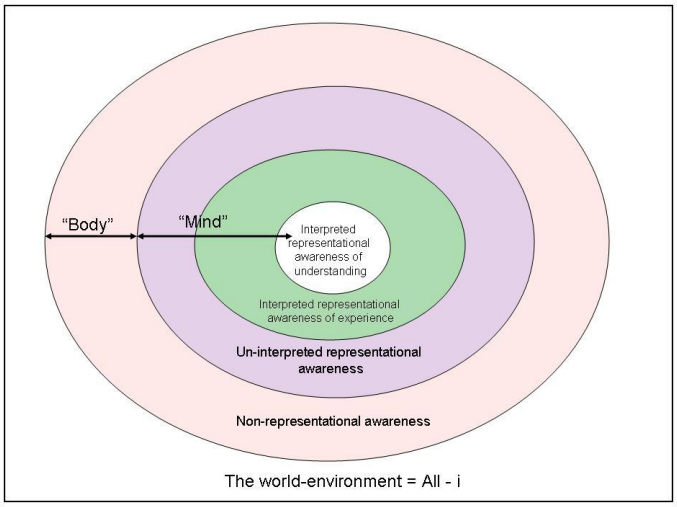
Symbols, lower level interpreted awareness or what Russell might have called the facts of experience are themselves representations of sense data. And schema specific typed expressions are again representations of the facts of experience in language. So the process of linking what in the classical, naïve, view is a direct relationship between assertion and object requires at least four nested levels of a language-based representation of the world:

- Level one treats the supposed external world as the world and produces non-representational language representations of the specific parts of the supposed external world that are directly experienced as output.
- Level two treats the output of level one - or non-representational language representations of the supposed external world- as the world, and produces un-interpreted language representations qua sense data as a result.
- Level three treats the output of level two – un-interpreted language representations qua sense data- as the world and produces lower level interpreted language representations as output.

- Level four treats the output of level three – a number of lower level interpreted language representations as the world and produces a small number of higher level interpreted language representations as output.

So the distinction between language and the world is functional. The same information that is the representational language output of one level's process functions as the world-to-be-represented in another. The ensemble of nested representations can also be viewed as an alternate way of looking at what's typically called the mind-body distinction. Though the cognitive processing paradigm has no need to make such a distinction, to the degree that one wants to, the nested layers of representation, as illustrated below, make for a more robust, more nuanced, and more computable set of distinctions.

A new view of the mind-body distinction



1.2 Linking canonical discussion to the new paradigm map

We now link the major topics in Classical (and non-Classical) logic to the new paradigm map.

- The question of ontological commitments can play out either at the level of facts in the supposed external world or at the level of facts of experience in language.
- Well formedness plays out in the rules that govern types, schemas and expressions (shown here only as connected to schemas).
- The Liar paradox is resolved within the rules that govern the mapping of symbols into typed expressions
- Wittgenstein's notion of Grammatical form corresponds to well formedness for schemas
- Surface grammar plays out at the symbol level and in its mapping to typed expressions – but not in the typed expressions themselves
- Atomic propositions loose their paradoxical appearance when understood as instances of well formed schemas

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- Equivalence and substitution criteria follow from the general definition of a type as do primitive operators
- Truth and believability follow from the mapping of logical assertions to their physical representations, and from the various paths by which an expression may be processed (passing thru rules, memory or experience
- Reference plays in the same field as questions of ontological commitments: facts in the supposed external world or facts in language experience
- Sense stems from the type and schema definitions to which the word AS symbol was mapped
- The analytic / synthetic distinction traces is explained in terms of the path by which an assertion was produced.

In addition there are also topics that assume Logic includes additional types beyond Boolean and Categorical

- Part/whole relations or mereology
- Temporal and spatial logic
- Modality
- Defining whole numbers, Rationals, Irrationals and infinite sets

