

Why Log Truck Drivers Rise Earlier Than Students of Zen

In the high seat, before-dawn dark,
Polished hubs gleam
And the shiny diesel stack
Warms and flutters
Up the Tyler Road grade
To the logging on Poorman creek.
Thirty miles of dust.

There is no other life.

-**Gary Snyder**, *Turtle Island*
New Directions Publishing
New York
1974



An Interpretation of Sheldon Klein's Four Valued Analogical Transformational Operator

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Abstract

This paper presents a machine implemented¹ encoding of a versatile analogical four-valued n-adic control logic designed for parallelized expert systems as suggested in the works of Klein. The logic allows for a benign dynamic analogical encoding of both syntactic and semantic information into a common notation, the testing of N conditionals in theoretic time $O(C)$, while maintaining the linear growth of information as stressed by Klein. The computer model, a novel formalism of the analytic techniques of Harris, Herdan, Kleene and Levi-Strauss is specifically tailored for natural language processing but may be viewed as a general theorem prover for its applicability in other areas of computer science. Similar logical formulations using the Klein-4 group in meta-mathematical considerations made independently by both Dubarle and Belnap will be briefly discussed.

Introduction

After graduating from the University of Wisconsin, Sheldon Klein was kind and gracious enough to extend me an invitation for a Cambridge style tutorial in any science of my choice, an educational opportunity that I will be forever grateful for. The following monograph arose from our discussions on the nature and design of experimental tests for linguistic science. While our views on linguistic empiricism differed slightly, Klein preferring the logical positivism of Wittgenstein while I sided with Yngve, as a programmer I always had the utmost respect for the simplistic elegance of Klein's system designs and the unique ways he stressed his simulations in designing computer applications for the social sciences. Even now I still feel that one of the most creative and beneficial aspects of computers lies in their ability for Monte Carlo Simulation of which Klein's research is a stellar example. In this formulation I specifically desire to remove any empirical objections there might be for the use of Klein's model as a tool for linguistic anthropology. The intuitionism of Kleene [Kleene 65] was selected as the constructive base of the logic since I feel his one-place number-theoretic function variables for Brouwer's "choice sequences" is the most amenable for this type of constructive analysis. In the course of reviewing the different philosophical and logical literature for this paper, I became more aware of the historical arguments in this branch of logic and also claim a intuitionistic mathematical mechanization for Aristotle's *Syllogistic*. The presentation by Kleene can be intimidating to those outside the field of logic but since considerable effort was put into broadening his approach to include the constructivism of the Russian School of Functional Analysis, I will also be referring to Markov's colloquial work on algorithms and string rewriting systems [Markov 71] for its generally accessibility. It should be noted that the logical models of Klein were designed independently of Kleene and I do encourage people to try other frameworks if they prefer.

¹ Disclosed embodiments in this paper are patent pending.

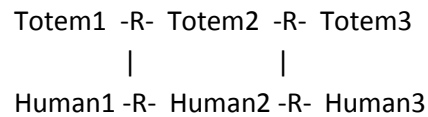
History

The combinatorics involved in the processing time associated with the analysis of natural language on computers has occupied and stymied researchers in the field of computational linguistics and artificial intelligence since the debut of the field. This explosion of computer resources, generally unknown to people outside this specialty, becomes readily apparent when attempting to scale any system to the lexicon with the size and interconnectedness possessed by adult speakers. In fact, word recognition rates of any real world test of computers that attempt to analyze natural spoken language with its full metaphoric load, referred to as "continuous speaker independent speech recognition" has literally been stagnant for decades despite the increases in processor speeds that have occurred and in spite of the statistical evidence that can be given for viewing natural language as an efficient encoding system [Herdan 65] which would seem to suggest the existence for an optimal encoding. The notion that these problems are being encountered by language researchers from a loss of information due to their removal and study of human communication outside of its proper socio-cultural context, still a minority view in linguistics, was advanced by both Klein and Yngve. The primary difference between the viewpoints being that Klein argued that the problems were due primary to a loss of information from the visual domain and never explicitly rejected phonetic discrimination (binary encoding) as Yngve. To try and recover this loss of information in linguistic models was the major impetus for Klein's interest in structural anthropology, an effort to bring symbolic cultural artifacts and their information into his analyses. One of Klein's major theses is that humans bring in global constraints from their shared societal structures in limiting the growth researchers see on computers. The collection of empirical evidence for the linear structuring of the totemic systems of Levi-Strauss was a major feature of Klein's work and the interested reader should consult his papers [Klein 83] on the subject as the rest of this paper will be mainly focused on his computerized models of phrase structure [Harris 52 p. 325], which Klein argued for as an efficient analytic technique to optimize resources for finite state automaton. A similar view of phrase structure was explained by Yngve when discussing the arguments given by others for its necessity, "the extra power of a transformational grammar are found in language just to keep it within the bounds of a finite-state device while allowing maximum use of the innately given limited temporary memory to optimize the use of the available innately given permanent memory" [Yngve 95 p.62].

Structuralism

Structuralism as an academic discipline covers an assortment of different fields, with different empirical goals and assumptions. French Structuralism alone, Prof. Levi-Strauss being the most prominent, is quite voluminous and can only be briefly touched on for such a short paper. Part of Levi-Strauss's fame was for resolving the classical anthropological question of totemism with his publication of *Totemism Aujourd'hui* and *Le Pensee Sauvage*. In the two, Levi-Strauss reduces totemism found in primitive society to more general classificatory schemes that are commonly found in all societies using his style of functional analysis and analogical feature bundles. The following diagram (**Figure 1**) is often used to illustrate Levi-Strauss's reduction and is sufficient in showing the general aspects of structural anthropology relevant for this particular derivation. It highlights how the relations found between different totemic groups for a culture can be discovered in its symbolic culture and attributed to different relations between human groupings of that culture. That only the relation between the

groupings that are to be mapped and are passed on culturally is a subtle but very important point, corresponding to Saussure's signe/signifée dichotomy in linguistics.



(Figure 1)

Klein's contribution to French Structuralism was the invention of using of the strong equivalence operator and bit vectors, in conjunction with his work on semantic networks, to model these analogical relations. The random generation of Proppian tales, which he did at the behest of Levi-Strauss [Klein 76] was an avenue of research continuously developed by Klein who was pursuing the implementation of Russian fairy tales in virtual reality at the time of his passing. A demonstration of the model by me correcting the name type conventions and missing actions, made possible with the translation of Propp's PhD thesis[Propp 82], that were brought to the attention of Klein by Russian folklorists is forthcoming. The transformations used in reasoning about these feature bundles loosely obey the following formula for analogies posed by Levi-Strauss in *L'Anthropologie Structurale*. Here the symbols f_x and f_y should be viewed as (possibly randomized) normal algorithms [Markov 71 p. 111].

$$f_x(a) : f_y(b) :: f_x(b) : f_y^{-1}(a)$$

(Figure 2)

The notation invented by Klein is quite economical from a computational standpoint with the computer manipulating strings of bits, which allow for the linear scaling of information in his models. Klein does distinguish between two different types of transformations that Levi-Strauss uses which are modeled with singular and binary features respectively. Singular features are used for seriation and for the forming of analogical relations for surrealistic imagery. Singular features also allow for the addition of new information into the system without any a priori bias which then can be verified and put into binary opposition by an informant (oracle). Binary features are the primary method used in modeling the majority of analogies and social mappings in structural anthropology. The use of which has an effect of halving the search time, a point of Levi-Strauss's that should be emphasized. This reduction is the primary reason given by Levi-Strauss for their preference and predominance in human societies, a point that is confirmed by ethnography. **Figure 2** does suffer from one important flaw, namely that underlying this important relationship is the geometric Klein-4 group (Vierer-gruppe), which only first appears, quite briefly, in Levi-Strauss's *L'Origine de Maniere de Table*. The mathematical group, created by Grassman but named after the famous mathematician Prof. Felix Klein, was considered as a primary logical group by many in French Structuralism. The only connection in the works of Klein between his encoding and that of the Vierer-gruppe is the following diagram shown beside a Boolean representation of the Klein-4 group which also appears in his papers.

Boolean Klein-4 Group					Four Valued ATO				
<u>==</u>	<u>00</u>	<u>01</u>	<u>10</u>	<u>11</u>	*	0	1	.	.0
00	11	10	01	00	0	1	0	.0	.
01	10	11	00	01	1	0	1	.	.0
10	01	00	11	10	.	.0	.	1	0
11	00	01	10	11	.0	.	.0	0	1

(Figure 3)

Logic

Klein's writings [Klein 77] on multi-valued logics are quite brief, consisting of just a few sentences and the preceding diagram on the right. He does supply the values {false, true, undefined} for his own particular notation of {0, 1, "."} but provides no information for the fourth value {"0"}. After introducing his notation Klein quickly breaks his examples down into a three valued Kleene logic [Kleene 52 p. 332] which was more commonly known and accepted at the time of his writings. It is my primary thesis that Klein intended the Vierer-gruppe to serve as the basis of a four-valued analogical encoding of Levi-Strauss's works to reason about the analogical relationships in the predicate calculus among the nodes in his dynamic semantic network. To derive the other logical connectives it's not important to know their semantic meaning at this time but only a simple matter of knowing that every element has a inverse relation in the Vierer-gruppe (Boolean reversibility) [Klein 02 p. 19]. This knowledge with the law of double negation ($A \rightarrow \neg \neg A$) [Kleene 52 p. 122] provides the truth table for the logical **NOT** operator. Working backwards from the formula for strong equivalence allows the derivation for the logical **AND** and logical **OR** connectives, which when checked by truth table preserve the four main axioms of propositional mathematics and Aristotle's definition of inference (proven by truth table) [Reichenbach 47 p. 19 p. 25] [Borkowski 70 p.315].

Formula for the Strong Equivalence Operator

$$(\neg a \wedge \neg b) \vee (a \wedge b)$$

<u>¬</u>	<u>∧</u>	<u>∨</u>
F T	F F T U D	F F T U D
T F	T F T U D	T T T T T
U D	U F U U F	U U T U T
D U	D F D F D	D D T D T

Axioms of the Propositional Calculus

$$1. a \vee a \rightarrow a \quad 2. a \rightarrow a \vee b \quad 3. a \vee b \rightarrow b \vee a \quad 4. (a \rightarrow b) \rightarrow (c \vee a \rightarrow c \vee b)$$

Precedence of the operators being \neg , \wedge , \vee , \rightarrow

(Figure 4)

Kleene labels his third value undefined and assuming negation forces the opposite semantic property for the symbol {"0"}, I reviewed Kleene's recursive formulization of Lukasiewicz's 3 - valued and ∞ - valued logics for mathematical determinism. Kleene was able to mechanize the work of Lukasiewicz with his theory of recursive functions by using a queer amalgamation of defined [Kleene 65 p. 91] and undefined (value immaterial) [Kleene 52 p. 335] which Kleene places as a value into his meta-mathematics² but not quite on par with the other classical values {true, false} in his theories [Kleene 52 p. 333]. Markov also uses a concept similar to Kleene's "value immaterial" with his notion of "not applicable" [Markov 71 p. 118] and Yngve as well when discussing properties for linkages in his theory of people, "property is undefined or undetermined" [Yngve 95 p.144]. The introduction of the Vierer-Gruppe to the meta-mathematics allows both undefined and defined to be raised into equal prominence beside the other classical values for modeling mathematical determinism, thus allowing for the possibility of an algorithm "for deciding , given x , whether $Q(x)$ is defined or not (e.g. there is none when $Q(x)$ is $\mu y T_1(x,x,y)=0$)" [Kleene 52 p. 333], allowing for a valid constructive Aristotelian law of the excluded fifth for the logic while maintaining a "tertium non datur" on the decision procedures. To be concise I will refer to Kleene's undefined and defined as (mathematically) undetermined and (mathematically) determined respectively. The raising of these two values requires almost no changes to the presentation or functioning of the lambda calculus in Kleene's classical or intuitionistic logics [Kleene 52, Kleene 65] with only minor changes to Kleene's reasoning on multi-valued logics for future propositions, which may be speculated for recursive step= $n+1$ but then must be converted by negation to value immaterial for step= $n+2$ for modeling indeterminacy[Borkowski 71 p. 110 p. 175]. Kleene in defining the λ -prefix uses the notion of functional equivalence where $u = v$ is understood to be an abbreviation for $\forall x (u(x) = v(x))$ where x is any variable not occurring free in u or v [Kleene 65 p. 15]. The benefit of this n-adic encodings(semantic features) comes primarily in efficiency for computer implementations, by providing this needed extra information directly to the underlying representation for the treatment of the terms and functors (subject and verb) as equal. In (class)conditional testing for the λ -definition of recursive functions and passing of phrasal re-write rules, done in theoretic time $O(C)$, undetermined(value immaterial) should be viewed as a category into which any propositions may fall {true, false, undetermined, determined} implying a complete lack of knowledge or ambivalence to the proposition and a complete absence of any binding to a primitive function. Determined(unknown) should be viewed as a category into which propositions may be placed where there is a lack of information as to what specific value a proposition may be between the two values {true, false} while maintaining the exclusivity of the classic truth values and is also used to indicate the binding of partial function to a recursive function as well. In the passing of rules it may be viewed as only allowing the

² meta-mathematics here refers to the definition of meta-mathematics by Kleene, not the one used and introduced into linguistics by Carnap and others. [Kleene 52 p. 63] This use, widely used in argumentations about the mind as a machine, was also abhorred by Markov [Markov 71 p.441] and Yngve [Yngve 95 p.39 p.76]

truth values {true, false} to pass through to the propositions, disallowing the possibility of the proposition assuming the values {undetermined, determined}. Linguistically the truth values may be more commonly viewed as the properties {can't have, must have, don't care(no need to test), data }. Data in this sense is important for ensuring the existence of the fleeting properties that may be associated with the stack of **OR** features used for inheritance and associated with the re-write rules in categorial grammars. Data is also a nice interpretation for the role the natural numbers may take in the encoding for n-adic logics when implementing self-referencing programs [Turing 37 p. 253], designed by Klein to meet the specific objections of E. Mark Gold for modeling phrase grammars, possibly more powerful than context free [Klein 02 p. 19], for the implementation of computerized natural language query engines [Herdan 65 p. 123][Gold 65][Gold 67]. To adjust the notation of Klein, the model itself theoretically similar to Lamb's stratificational grammar in linguistics, to the constructivism of Kleene, one only has to rename his base semantic units of object and relations to the more common mathematical names of terms and functors, his two-tuple to primitive recursive functions, his triple to general recursive functions, and secondary triples to partial functions. In the terminology of Markov, words may be substituted for object and relations, normal algorithms for the term triple and letters for the notion of class. This completes the process for the mechanization of Aristotelian inference introduced into western philosophy over eight hundred years ago by the Spanish philosopher Raymundus Lullius (Ramon Lull) [Kolmogorov 96 p. 2] although this interpretation is dependent on the reading of *Syllogistic* that has been transmitted to historians through the works of both Sextus Empiricus and Muhammad ibn Musa al-Khwarizmi with the interpretation of metaphor used by Klein being more contemporary than that of the *Poetics* [Black 62]. I do feel it just to rename the term realizability (computability) [Turing 37 p. 263] to Grassman realizability in honor of the man whose mathematical creation lies at the core and representation of the logic.

"La langue est une illusion"

At this point it's necessary to discuss the differing views of empiricism in linguistics and machine translation and the senseless divisions that exist before introducing the literary stylo-statistical work of Klein. Following that will be a brief introduction to statistical methods for linguistic science. It's also at this point where the differences between the empirical philosophies of Yngve and Klein, mentioned earlier, emerge. Yngve, creator of the first non-numerical programming language and first president for the Association for Computational Linguistics (ACL), abandoned the notion of phonetic discrimination which he viewed as a philosophical remnant of the semiotic-grammatical tradition of the Stoics [Yngve 95 p. 17] for causing language scientists to engage in meaningless grammatical arguments and discussions that focus on their formal models which fail quite spectacularly in any real world test, instead of the real phenomenon of human communication, which is people . This critique, apt for much of the field, is less applicable to the work of Klein who always placed people and real world observation³ of their behavior at the heart of his theories. Yngve commonly referred to much of linguistic and the cognitive science as the "theory of trees" and placed much of the modern research in machine translation into the category of engineering proper with little or no scientific value. A major reason for this predicament has been the utter dismissal of statistical techniques by linguists blindly defending the

³ Yngve includes observation in his definition of experiment following the example of Richard Feynman [Yngve 95 p. 104].

dogma of their cult leaders, fearful of scientific reduction [Yngve 96 p. 327], to the point where simply knowing how to properly compute the grammatical norm isn't taught leaving their pupils blind to essential mathematical methods needed for their science. People in this first camp tend to disregard the argument that while the idiolect can be directly observed and whose existence cannot be questioned any inference about human communication above this level has to be a statistical inference by nature. In the other camp are people generally from the physical sciences, along with traditional statisticians, who choose natural language as an area to apply their statistical ideas and methods developed for disparate sciences, never bothering to check if their statistical assumptions actually correlate with reality or even to check if someone might have tried their particular approach before. These engineers and mathematicians refuse to admit any limitations of their approach, "information theory is of very little use when applied to anything but the smallest linguistics units" [Herdan 62 p. 179], or even acknowledge the simple fact that there is no observed correlation between speech recognition and processor speeds. Both of these camps tend to be oblivious to one of the most important linguistic discoveries of the last century which is "that the relation between the vocabulary and the occurrence of distribution with regard to word length should turn out to be one between different moments of a statistical variate" [Herdan 62 p. 20].

Gustav Herdan was once properly recognized and credited with connecting Shannon's mathematical theory of communication to the theories of Saussure allowing for a precise statistical treatment of linguistic phenomenon. If one does accept the linguistic principle of phonetic discrimination (quantification of the audio wave form) and along with it the axiom of the independence of sound from meaning ("le signe/ le signifié"), one is hard pressed into not accepting that the laws of information theory, with the redundancy in encoding that can be observed with this principle, applies to human communication. Herdan specifically applied the geometric law of duality to Saussure's "la langue/ la parole" dichotomy, giving rise to the statistical view of language, "la langue", as all observed n-grams plus their probability of occurrence with an utterance, "la parole", as being a statistical sample from that universe. The major thesis of Herdan was that the critical difference between "statistics in the mass" and literary statistics is that "random partitioning must be applied before random sampling on the vocabulary level to properly take account of the transition probabilities between words into account" [Herdan 62 p. 197][Herdan 65 p. vi] when dealing with running texts. The linguist reason behind this difference is Saussure's notion of the "principle linear" of human communication and must be done to properly compute the Normal Law of statistics [Herdan 65 p. 400]. That this is required by information theory is extremely important since "the best code is one which leaves the entropy of the source unchanged." [Herdan 62 p. 127] The correct sampling techniques, created and championed by him, with the specific use of the Bose-Einstein equations was referred to by him as the "Quantum Theory of Language" [Herdan 62 p. 177]. Now it would be a logical error to assume that all language researchers are making such naive sampling errors but I challenge the curious reader to go to the recent proceedings of the ACL or on-line to Oxford, M.I.T, Stanford (the list is non-exhaustive) to browse the publications of the experts in these fields to find a mention of the use of the random partitioning function that is required to properly account for this particular statistical linguistic quirk, or even to find a researcher attempting to deal with the problem of the universe of discourse. One can even note a complete absence of this linguistic discovery and the principles for dealing with it from linguistic textbooks is

scientifically atrocious and speaks volumes about the narrow minded approach taken by most researchers in this discipline.

The computer data structures needed for the modeling of randomized phrase structure, inspired by Yngve's demonstration [Yngve 60], for the coherent random generation, paraphrasing, machine translation, historical change of language and computerized linguistic field worker were written in a variety of papers, spread over different institutions during the early career of Klein, all these ideas were neatly summarized and presented whole by Klein in UWCS Tech Report #163 [Klein 72]. The machine learning techniques for a computerized field worker initially designed by Klein is still a open theoretical area of research in the use of limiting recursive heuristics for formal language theory [Gold 65]. Connections with the neural networks of Kleene using Brouwer's fixed point theorem are straight forward but are an open area of interest as well [Kleene 57 p. 37] [Cromme 91] Herbert Simon did rename part of the work done by Klein to the blackboard system of problem solving after Klein's departure from Carnegie Mellon and has been accidently given academic credit due to Klein [Klein 64] [Klein 65] [Engelmore p. 18], an error that has now been rightfully corrected. To emphasize why even the assumptions of Swedish award winners should be carefully examined in a proper scientific discipline please reference the chapter by Herdan "A Critical Examination Of Simon's Model Of Certain Distribution Functions In Linguistics" [Herdan 62 p. 64 p. 108]. People and historians, interested in the early years of computational linguistics, should consult the Computational Linguistics Bibliography for the years '59-68 published by Systems Development Corporation as part of their non-profit academic charter. [Hays 64][Hays 65][Hays 66][Hays 67][Hays 68][Henisz-Dostert 70].

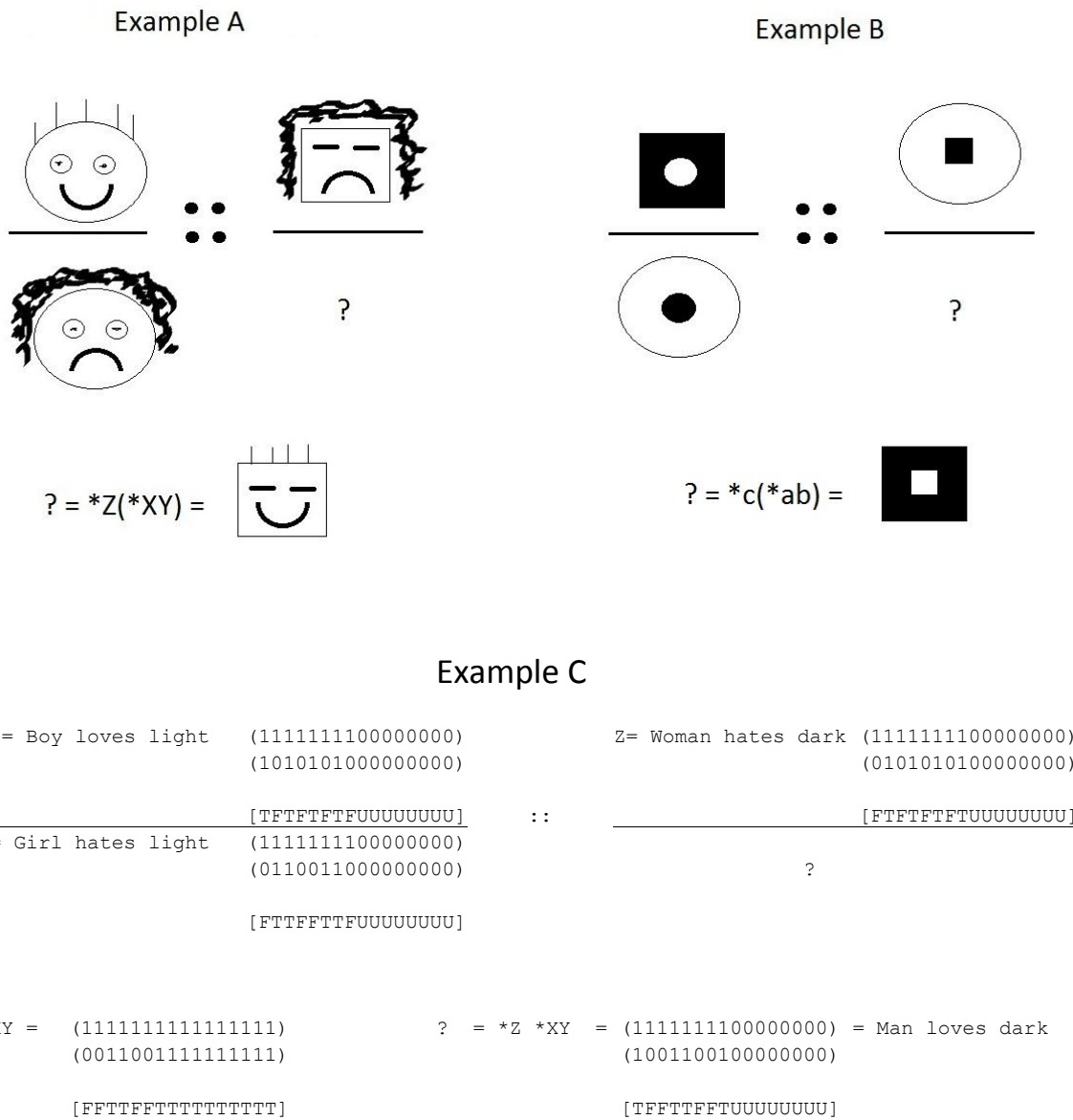
Other Derivatives

The astute logicians may by now have recognized the truth tables above as the ones first published by Belnap [Belnap 77] but was actually first loosely conceived of by Dubarle [Dubarle 89]. Belnap, who opposes the notion of intuitionistic functional equivalence and changes to realizability offered by Kleene [Vesley 63][Belnap 63] [Kleene 65 p.73] and used herein, argues for an arbitrary, religiously biased, a priori ordering of four truth values {false, true, undefined, contradiction} onto a lattice structure and in the process confuses the underlying eternal mathematical concept of the Vierer-gruppe with it's symbolic Boolean representation. Grassman's Vierer-gruppe is a mathematical concept that "extends and intellectualizes the sensual intuitions of geometry into general, logical concepts, and , with regard to abstract generality, is not simply one among the other branches of mathematics, such as algebra, combination theory, and function theory, but rather far surpasses them, in that all fundamental elements are unified under this branch, which thus as it were forms the keystone of the entire structure of mathematics"[Grassman 2000 p. xiii] and its creation was the initial spark for the *geometrical* revolution of physics [Herdan 62 p. 21] that culminated with the birth of Einsteinian physics. Now while I do disagree with Belnap's geometric argumentation and the choice he makes for his fourth value, Belnap should be credited for establishing the consideration of a fourth truth value{True, False} in set theory since almost all modern arguments in mathematics generally digress there. Nor do I wish to question the completeness of the logic up to the first order offered by this school [Pawlak 84][Pagliani 96][Tsoukias 02] who, using an older version of realizability created together by both Kleene and Nelson [Kleene 52 p. 487], have extended Nelson's notion of P-realizability and N-realizability. Nelson's algebra does allow for the introduction of contradiction non-trivially to the logic, a property that one can

envison could be quite useful for computers, and its continued development was a desire of both Kleene and Nelson. Kleene did recognize that the older realizability, not valid for his newer version of intuitionistic number theory, could be attached for intuitionistic analysis [Kleene 65 p. 99] to the present system suggesting a easy transfer of some of the concepts, viewing contradiction as a type of superset to the value mathematically determined, developed by Belnap's followers to the present framework. Shapiro's early work in this area already validates the ability of the semantic network to handle theories of this type [Shapiro 71][Shapiro 76]. Though much like Nelson who states, "Does the system have any practical interest? I should not want to claim much in this direction" [Heyting 59 p. 224], any significant real world applications have yet to be developed.

The memoir by Dubarle published posthumously is more interesting after being properly deciphered and I believe has been incorrectly associated with the work of Belnap by Tsoukias [Tsoukias 02 p.80]. This memoir can only hoped to be understood by using his later book [Dubarle 77], that by itself is quite philosophically impressive, to sort through and clarify points that are muddled with Dubarle using Hegel's dialectics to guide the creation of the "groupe de Klein" and "l'effets profonde" it has on his logic. The basic premise of Dubarle is he rejects the three-valued logic of Lukasiewicz as "l'essai d'une logique a trois valeurs, l'un de ceux qui a ete plusse le plus avant, s'est montre fort decevant", for violating the law of double negation and reversibility arguing that speculative propositions do have a bi-valence to their essential essence. This bi-valence for future events "proposition speculative" was the main issue Dubarle took with the work and views of Lukiswicz [Dubarle 77 p. 266], Lukiswicz arguing that all multi-valued logics between his 3-valued and ∞ - valued are primarily the same with no distinguishing characteristics between them[Borkowski 71p. 333]. To try and invalidate both of these claims was something Dubarle wished to show by trying to prove that the Vierer-gruppe and all the Boolean groups higher than it could serve as a valid base for reasoning about the propositional calculus. Deciphering Dubarle's work can be done by associating his values "reel" and "ideel" , that are related to the Hegelian term "d'Aufhebung" [Dubarle 63 p. 21], with the two values "etre" (mathematically determined) and "rien" (mathematically undetermined) [Dubarle 77 p. 253 p. 259]with the insistence for a "function maximale" [Dubarle 63 p.47] between the four values. Interestingly Dubarle's main thesis, although no evidence was given by him for this conjecture, that all Boolean groups could serve as a base for multi-valued logics was actually proven by Piaget [Piaget 52]in his explanation of how the Vierer-gruppe has the seven essential properties needed for reasoning about the propositional calculus and how to "construct a similar table, with the same seven properties (and several others besides) by means of the 256 tertiary operations, the 65,536 quaternary operations, etc." [Piaget 53 p.35]that would allow any of these Boolean groups to serve as the basis for his operational psychology. That Dubarle was unaware of Piaget's work is remarkable considering Dubarle's desire for a notation to connect the theories of Saussure with his unique interpretation of the semiotics of Peirce for the "nouvelles possibilites d'etendre le concept de representamen au-dela du champ psychomental propre a la notion de signe" [Dubarle 77 p. 140] At this point it's probably best to introduce an semiotic example by Klein which gives a visual representation to these semiotic arguments. The examples in **Figure 5**, which combines two pictorial analogy given by Klein, adding the example on page 3[Klein 02] onto the end of the analogies on pages 4-5. Showing how different knowledge sources with distinct and disparate features needed for their functioning can share a common dynamic symbol table in the system. The

example shows how new features, needed to allow the growth of information in the system, default to undetermined in preexisting analogies, making any new information growth benign. The binary encoding of a truth value for a property to a single specific bit position, starting from left to right, across two different bit arrays needed for modelling the Vierer-gruppe directly and performing Klein's analogical operations is given below with the two arrays being enclosed in parentheses "()", with the corresponding truth value for that position shown directly below that position and enclosed in brackets "[]". Features are mapped from left to right with the values: {male (straight hair), female (curly hair), young (circle), adult (square), love (smile), hate (frown), light (circle eyes), dark (line eyes), outer square, outer circle, outer light, outer dark, inner square, inner circle, inner light, inner dark}. One can picture how the blankness of Turing's tape [Turing 37 p. 232] is constructed into underlying analogies using undetermined to separate knowledge in the n-adic representation.



(Figure 5)

The analogies offered here and elsewhere by Klein may seem simplistic, but this simplicity is actually a common form of semiotic systems which tend to have the inverse relationship of simplicity of form to high semantic density, all concisely explained in the totemic study of the Walpiri by Nunn. Along with the works of Strehlow, it provides an illuminatory introduction to the ethnography involved in semiotic studies[Nunn 86 p. 213][Strehlow 49][Strehlow 71].

Klein did strive to push his analysis of operational psychology to the emergence of modern man from Africa and the technological innovations that accompanied this dispersal. Since modern DNA haploid testing is continually pushing back the date of the Upper-Paleolithic revolution and the preponderance of evidence that modern man was inhabiting costal East Africa, fishing hooks and shell middens being the earliest evidence of modern man, I contend that the focus in archaeology should shift to the creation of the fishing industry since this food gathering strategy is solely unique to Homo-Sapien alone among the great apes [Excoffier 07][Mourre 10]. I conjecture that the recursive cognitive abilities needed to tie a highly efficient knots, like the San Diego Jam knot, that maximize the tensile strength of the line is the correct sensori-motor skill equivalent of Piaget's symbolic group play and may have emerged in humans due to a simple increase in their underlying working memory. Climatic change will make empirical questions like this hard to test from an archaeological approach but to my knowledge the design of cognitive experimental tests along this line of inquiry to try and establish a baseline cognitive skill among Hominidae and specifically genus Pan has not to my knowledge been attempted in primatology. Experimental testing for this domain is no doubt quite subjective but could be quite interesting given the difficulties language reared apes encounter in understanding commands involving predicate participant constructions, suggesting a very limited working memory in almost all modern formulations of grammar[Savage-Rumbaugh 86]. I do hesitate to speculate too much in this direction since the experimental validity of testing hypotheses of this nature was the reason Yngve abandoned his depth hypothesis⁴ and phonetic discrimination.

Constructive Epicurean Mathematics for Hard Science Linguistics

One of the primary aim of this paper was to remove any logical or empirical objection to the encoding for anyone following the linguistic empiricism of Yngve. Yngve does use a similar n-adic notation, introduced from the state theories of physics(solid-state, quantum), to Klein for considering the properties of communication, used explicitly for the storage of the properties used in his computation of the state change function[Yngve 95 p. 149]. The treatment of state information and view of language in this manner is consistent with Herdan's statistical conception of language[Herdan 65 p. 216] and should be strongly considered for those interested in computational linguistics since "Considering current views of grammar and lexicon, we are led to an estimate that the component properties of a communicating individual may number into the many thousands or millions" [Yngve 95 p.144] The usefulness of computer simulation for linguistics, and the other sciences, was a concern of Yngve [Yngve 95 p. 328] so I don't believe he would raise a objection to the use of a multi-valued n-adic representation, consistent

⁴ The depth hypothesis by Yngve is currently being put into many current cognitive theories with the restriction of limiting the phrasal re-write rule to two. The evidence usually given in support for this limitation is generally brought in from experiments in psycho-linguistics. Continuing the American linguistic tradition of renaming theories for blatant intellectual plagiarism also occurring with the relabeling of Harris's precedence operator[Yngve p. 43 p. 51].

with his logical views, that eases the implementation of his state function by optimizing system resources for computations done in parallel [Yngve 95 p. 271] and other problems like the Von Neuman Bottleneck that are encountered on modern architectures. That this storage of information can be captured and analogically encoded in such a simplistic while being consistent with so many different theorists owes to the hard work of Klein in extending his analysis to encompass all different aspects of the linguistic code[Herdan 62 p. 263].

I do recognize that my presentation here may have seemed harsh at times but this is only because the lowering of empirical standards in linguistics does have serious repercussions for other sciences, in particular biology since DNA may be also viewed as a case of information transfer in a noisy channel with the difference being just one of time and scale. Many of the modern techniques used in this relatively new field are routinely "proven" on natural language before being forced unknowingly on biologists, instead of properly presenting correct linguistics methods to biology and letting them decide what methods are the most empirically relevant for their field. The logical and empirical views expressed above by me, are mine alone and do differ from Klein whose own views tended to be more tolerant of classical views of logic and was open to a wide range of differing views for semantic interpretations[Klein 57]. Klein was also not aware of any connection with his research with that of Dubarle and Belnap and the critique of their work is also mine alone. As a scientist I do accept all responsibility for any errors in presenting my interpretation of Klein's work and will gladly reprint any correction or retraction if an error is found. There is one last point I wish to make before I go, concerning the old woman who thinks the world sits on the back of a turtle. Go to your local library, cross-reference the bibliographies in some logic papers, to find out who everyone has to quote for forming the recursive base of their theories. Notice, it's Badgers all the way down. On Wisconsin.

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