SEMANTIC REPRESENTATION IN THE LANGUAGE OF FORCE-PREDICATE THEORY

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1. INTRODUCTION

The idea leading to this paper is, on the one hand derived from the computational linguist's preoccupation with semantic representation of natural language input; and, on the other hand, from a research project conceived by Dr Peter Nabende, Dr John Ngubiri, and the author with a view of bringing the problem of semantic representation in computational semantics yet closer to its solution.

Whether the formal language of force-predicate theory* (LFPT) is a viable alternative to the first-order predicate calculus (FOPC) in the representation of meaning is the question to be resolved in this paper. Let us now proceed to a concisely revised presentation of the force-predicate theory itself and the formal language built on it.

2. THE FORCE PREDICATE THEORY

The force-predicate theory stipulates that at the beginning of semantic representation the brain maps situations one-to-one into Newton's laws of motion. Then another one-to-one mapping from Newton's laws into semantic roles follows. Finally, semantic roles combine to form predicates.

Using internationally standardized notation, Newton's laws of motion can be stated as follows:

(a) Newton's first law of motion: $\vec{\mathbf{F}} = m\vec{\mathbf{a}} = \vec{\mathbf{0}}$

* "**Force-predicate theory**" is a more apt substitute tag for "**situatodomainal role theory**" that the author employed in his paper entitled " From Newton's Laws of Motion to the Periodic Table of Semantic Predicates", accessible at www.luganda.com. Moreover , the reader is forewarned of a substantial effort made in the present paper to standardize both terminology and notation; and to carry out corrections that have over time ensued from further ruminations on the theory.

(b) Newton's second law of motion: $\vec{\mathbf{F}} = m\vec{\mathbf{a}} \neq \vec{\mathbf{O}}$

(c) Newton's third law of motion: $\vec{\mathbf{F}}_{12} = -\vec{\mathbf{F}}_{21}$

Concretization of the theory follows immediately. First, we consider Newton's first law of motion, or Newton I for short.

(1) Situation

(2) Situation-force mapping

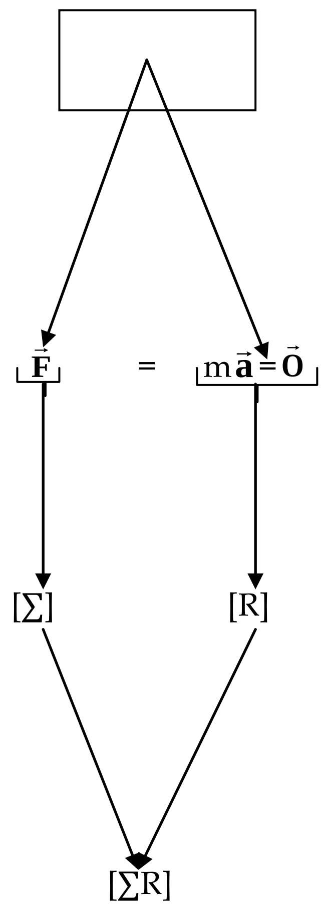
(3) Newton I

(4) One-to-one force- role mapping

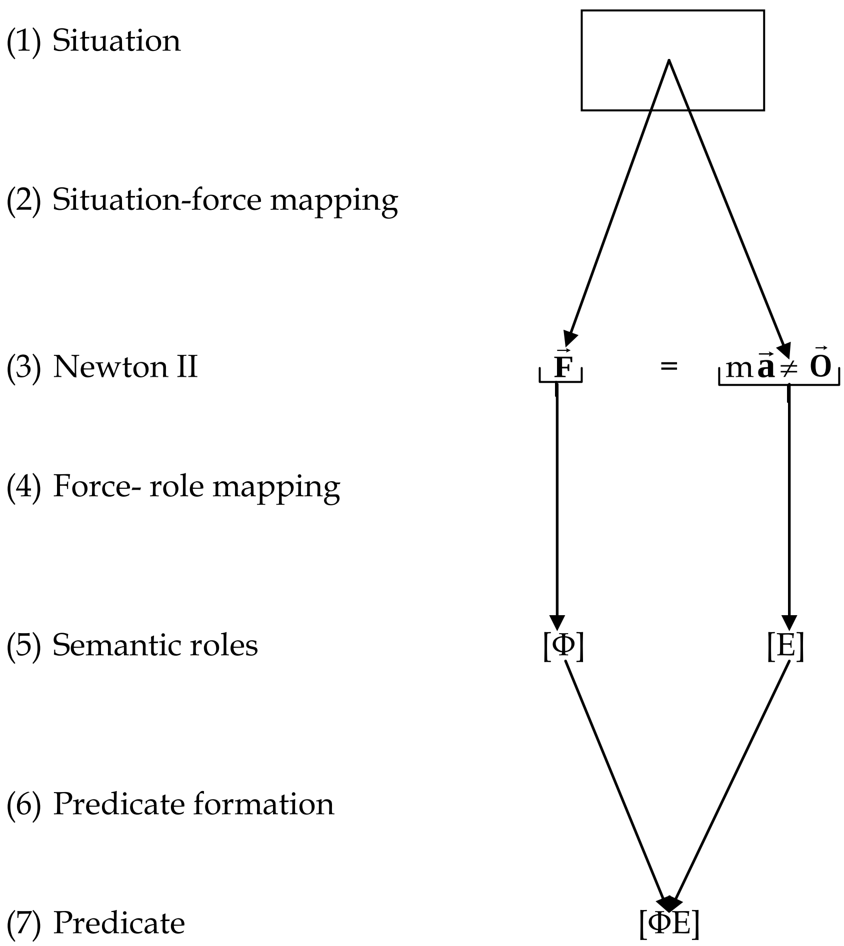
(5) Semantic roles

(6) Predicate formation

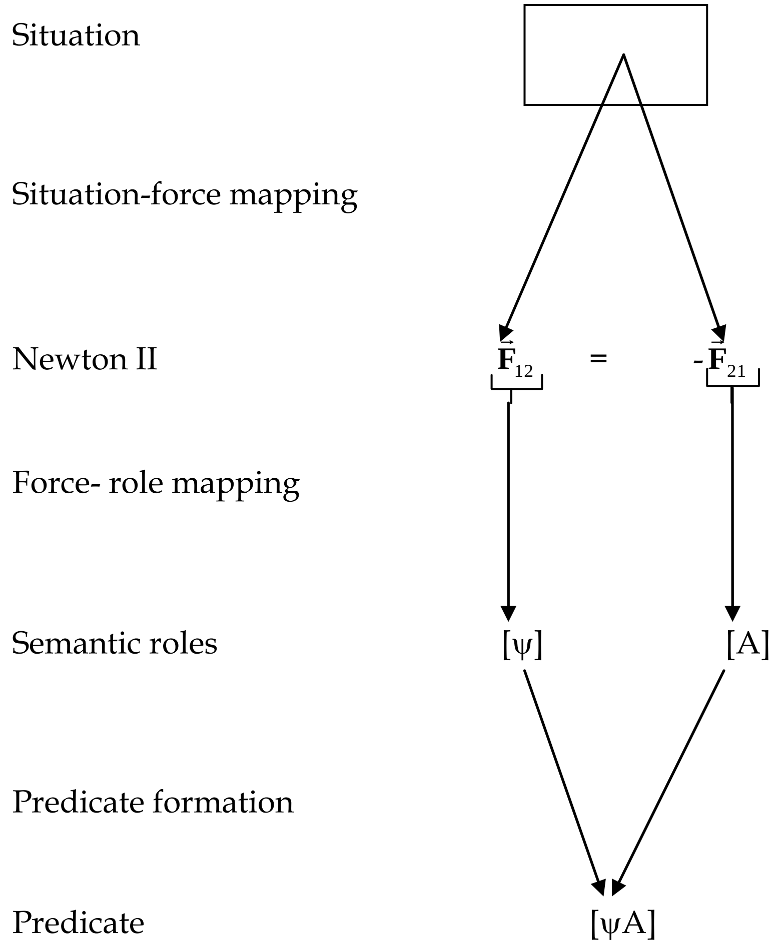
(7) Predicate



If the situation (represented by the box) is that of relative motion or rest, then the first mapping leads to Newton I. Then the force-role mapping leads to semantic roles [Σ] and [R], where [Σ] is the change-bearer [B] or nonchange-bearer [Z] and [R] is a reference. The semantic roles [∑] and [R] combine to form the relative predicate [∑R]. Secondly, for Newton II we correctly expect a different pair of semantic roles.



Unlike Newton I which is obeyed by uniform motion or rest, Newton II concerns accelerated motion. [Φ] is a dynamic causer [C] or a static causer [K] , and [E] is a causee. [Φ] and [E] combine to form the causative predicate [ΦE]. Finally and thirdly, Newton III is mapped into [ψ] a contactor (which can be dynamic [N] or state [T]) and [A] a contactee.



[ψ] and [A] combine to form the contactive predicate [ψA].

3. THE LANGUAGE OF FORCE PREDICATE THEORY

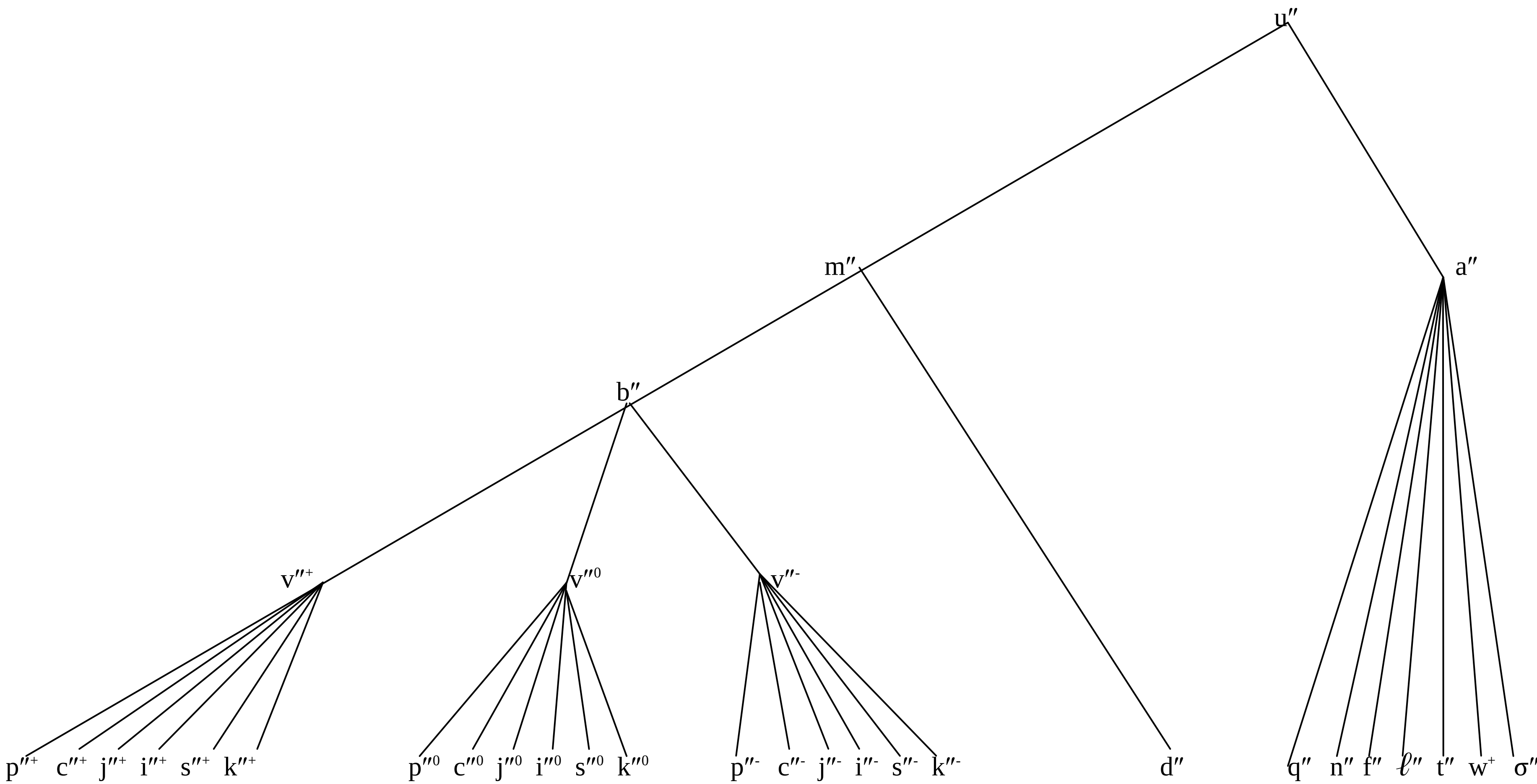
The language of force-predicate theory is an extension of that of first –order predicate calculus as set out in (1) – (10) below.

(1) **Semantic role types:** [B], [Z], [R]; [C], [K], [E]; [N] ,[T], [A]

(2) Predicate types : [∑R] , [ΦE], [ψA]

(3) Entities : entity e, human h , and thing r; e= h, r

(4) Semantic domains:


u″
m″
a″
b″
v″+
v″0
v″-
p″+ c″+ j″+ i″+ s″+ k″+
p″0 c″0 j″0 i″0 s″0 k″0
p″- c″- j″- i″- s″- k″-
d″
q″ n″ f″ ℓ″ t″ w+ σ″

u''	=	universal	m''	=	material	a''	=	nonmaterial
b''	=	life-bearing	d''	=	nonlife-bearing	f''	=	formal
σ''	=	sentential	w''	=	propositional	q''	=	contentual
n''	=	numerical	ℓ''	=	spatial	t''	=	temporal or situational
v''^{+}	=	volitional	v''^{0}	=	nonvolitional	v''^{-}	=	countervolitional

p''^{+}	=	perceptual –volitional	c''^{+}	=	cognitive – volitional
j''^{+}	=	evaluative –volitional	i''^{+}	=	suppositive – volitional
s''^{+}	=	linguistic – volitional	k''^{+}	=	psychophysical – nonvolitional
p''^{0}	=	perceptual – nonvolitional	c''^{0}	=	cognitive – nonvolitional
j''^{0}	=	evaluative – nonvolitional	i''^{0}	=	suppositive – nonvolitional
s''^{0}	=	linguistic – nonvolitional	k''^{0}	=	psychophysical – nonvolitional
p''^{-}	=	perceptual – countervolitional	c''^{-}	=	cognitive – countervolitional
j''^{-}	=	evaluative – countervolitional	i''^{-}	=	suppositive - countervolitional
s''^{-}	=	linguistic – countervolitional	k''^{-}	=	psychophysical –countervolitional

(5) Tense: U = utterance time, R = reference time, S = situation time

(6) Sentence type operators:

statement operator	″ • ″
question operator	″ ? ″
directive operator	″–•″
exclamation operator	″ ! ″

(7) Proposition: $r^{0}(w'') = [\theta_1 e_1(g_1'')\theta_2 e_2(g_2'')]$ or

$r^{+}(w'') = [\theta_1 e_1(g_1'')\theta_2 e_2(g_2'')]<\tau(\mathbb{U},\mathbb{R},\mathbb{S})>$.

where $r^{0}(w'')$ or $r^{+}(w'')$ is a proposition (i.e. thing r in domain w'')

θ_1,θ_2 are roles of the predicate $[\theta_1\theta_2]$

e_1,e_2 are entities

$(g_1''g_2'')$ are domains

$e_1(g_1'')$, $(e_2(g_2'')$ are entities e_1,e_2 in domains $g_1''g_2''$

$\tau(\mathbb{U},\mathbb{R},\mathbb{S})$ is a tense formula in terms of $\mathbb{U},\mathbb{R},\mathbb{S}$.

(8) Sentence type: If $r^0(w'')$ is an untensed proposition, $r^+(w'')$ is a tensed proposition such that $r^+(w'') \equiv [r^0(w'') < \tau(\mathbb{U},\mathbb{R},\mathbb{S}) >]$, then $r(\sigma'')$ is a sentence type such that

$$r(\sigma'') \equiv \Omega e(g'')\{r^+(w'')\}$$

where Ω is a sentence type operator.

(9) Re-subtypes:

R_{so} = Source R_{go} = Goal R_{po} = Part -of R_{hp} = Has –part
R_{mo} = Member –of R_{hw} = Has-member R_{hr} = Hypernym -of
R_{ho} = Hyponym -of

R_{in} = Ingressive	R_{eg} = Egressive	R_{eg} = Direction
R_{bn} = Beneficiary	R_{cm} = Comitative	R_{pt} = Parallel
R_{df} = Different -from	R_{sm} = Same-as	R_{op} = Opposite -of
$R_{\ell t}$ = Less –than	R_{mt} = More –than	R_{eq} = Equal -to
R_{pr} = Predecessor –of	$R_{f\ell}$ = Follow -of	R_{nt} = Neutral -to
R_{rg} = Range	R_{ps} = Position	R_{rt} = Rate

(10) The periodic table of predicates:

	Group I	Group II	Group III
Period 1	1[ΣR]	2[ΦE]	3[ψA]
Period 2	4 Σ[$\mathcal{T}'$]R	5 Φ[$\mathcal{T}'$]E	6 ψ[$\mathcal{T}'$] A
Period 3	7 ΣR[$\mathcal{T}$]	8 ΦE[$\mathcal{T}$]	9 ψA[$\mathcal{T}'$]
Period 4	10 Σ[$\mathcal{T}$]R[$\mathcal{T}$]	11 Φ[$\mathcal{T}$]E[$\mathcal{T}$]	12 ψ[$\mathcal{T}$]A[$\mathcal{T}$]
Period 5	13Σ[Ω]R	14 Φ[Ω]E	15ψ[Ω]A
Period 6	16 ΣR[Ω]	17 ΦE[Ω]	18 ψA[Ω]
Period 7	19Σ[Ω] R[Ω]	20 Φ[Ω]E[Ω]	21ψ[Ω]A[Ω]
Period 8	22Σ[Λ]R	23 Φ[Λ]E	24ψ[Λ]A
Period 9	25 ΣR[Λ]	26 ΦE [Λ]	27 ψA[Λ]
Period 10	28 Σ[Λ] R[Λ]	29 Φ[Λ]E[Λ]	30 ψ[Λ]A[Λ]

$\mathcal{T}$	=	$1\,[\Sigma R]$,	$2\,[\Phi E]$,	$3[\psi A]$
Ω	=	$4\Sigma[\mathcal{T}]R$,	$5\,\Phi[\mathcal{T}]E$,	$6\,\psi[\mathcal{T}]\,A$
		$7\,\Sigma R[\mathcal{T}]$,	$8\,\Phi E[\mathcal{T}]$,	$9\,\psi A[\mathcal{T}]$
		$10\ \Sigma[\mathcal{T}]R[\mathcal{T}]$,	$11\,\Phi[\mathcal{T}]E[\mathcal{T}]$,	$12\,\psi[\mathcal{T}]A[\mathcal{T}]$
Λ	=	$13\Sigma[\Omega]R$,	$14\,\Phi[\Omega]E$,	$15\psi[\Omega]A$
		$16\,\Sigma R[\Omega]$,	$17\,\Phi E[\Omega]$,	$18\,\psi A[\Omega]$
		$19\Sigma[\Omega]\,R[\Omega]$,	$20\,\Phi[\Omega]E[\Omega]$,	$21\psi[\Omega]A[\Omega]$

4. FORMALIZING PROPOSITIONS

4.1. How to generally read open LFPT propositional formulae

If $e(g'')$ is read as "e which is in domain g''"
or simply as "e in g''", then open LFPT propositional formulae are read as follows:

(1) $Be_1\,(g_1'')\,Re_2(g_2'')$: $e_1(g_1'')$ **changes relative to** $e_2(g_2'')$

(2) $Ze_1(g_1'')Re_2(g_2'')$: $e_1(g_1'')$ **persists relative to** $e_2(g_2'')$

(3) $Ce_1(g_1'')Ee_2(g_2'')$: $e_1(g_1'')$ **causes** $e_2(g_2'')$

(4) $Ke_1(g_1'')Ee_2(g_2'')$: $e_1(g_1'')$ **countercauses** $e_2(g_2'')$

(5) $Ne_1(g_1'')Ae_2(g_2'')$: $e_1(g'')$ **dynamically contacts** $e_2(g_2'')$

(6) $Te_1(g_1'')Ae_2(g_2'')$: $e_1(g_1'')$ **statically contacts** $e_2(g_2'')$

4.2. Propositions from Quirk et al (1985:754)

[1i] She is happy.
[1ii] $Zh_0\,(b'')\,R\,h_0(f'')$*

* The zero subscript denotes a constant entity.

[2i] He turned traitor.
[2ii] Bh_0 (b″)R h_0 (f″)

[3i] The Sahara is hot.
[3ii] Zr_0 (ℓ″) Rr_0 (f″)

[4i] Last night was warm.
[4ii] Zr_0 (t″) R r_0(f″)

[5i] The show was interesting.
[5ii] Zr_0 (t″) R r_0(f″)

[6i] It is windy.
[6ii] Br_0 (t″) Rr_0 (f″)

[7i] He was at school.
[7ii] Zh_0 (v″) R_{ps} r (ℓ″)

[8i] She get into the car.
[8ii] Bh_0 (k″) R_{in} r_0 (ℓ″)

[9i] He is lying on the floor.
[9ii] Zh_0 (v″) R_{ps} r_0 (ℓ″)

[10i] The meeting is at eight.
[10ii] Zr_{01} (t″) Rr_{02} (t″)

[11i] He was working.
[11ii] Ch_0 (v″) E[Br(u″)Rr(f″)]

[12i] She is standing.
[12ii] Zh_0 (v″) R_{ps} r(ℓ″)

[13i] The curtains disappeared.
[13ii] Br′(d″) R_{so} r (ℓ″)*

[14i] The wind is blowing.

* The superscripted single prime denotes plurality.

[14ii] Br(t″) Rr(f″)

[15i] It is raining.
[15ii] Br(t″) Rr(f″)

[16i] He threw the ball.
[16ii] Ch_0 (k″) E[Br_0 (d″)Rr(ℓ″)]

[17i] Lightning struck the house.
[17ii] Nr(t″) A r (d″)

[18i] He is holding a knife.
[18ii] Kh_0 (k″) E[Zr_1 (d″) R r_2(ℓ″)]

[19i] The stone broke the window.
[19ii] Cr_{01} (d″) E[Br_{02} (d″) R r_{02}(f″)]

[20i] She has a car.
[20ii] Th_0 (v″) Ar(d″)

[21i] We paid the bus driver.
[21ii] Ch'_0 (v″) E[Br(u″)R_{go} h_0(v″)]

[22i] The will benefits all.
[22ii] Zr_0 (s″) R_{bn} h'_0(v″)]

[23i] They climbed the mountain.
[23ii] Bh'_0(k″) R_{rg} r_0(ℓ″)

[24i] The bus seats thirty.
[24ii] Zh'(v″) R_{in} r_0(ℓ″)

[25i] They fought a clean fight.
[25ii] B[Nh'_0(v″) A h'(v″)] R_{rg} r(f″)

[26i] I wrote a letter.
[26ii] Ch_0(k″) E[Br(a″) Rr(f″)]

[27i] They had an argument.

[27ii] $Ch'_{0}(v'')\ E\ r(\sigma'')$

[28i] He nodded his head.

[28ii] $Ch_{0}(k'')\ E[Zr_{0}\ (b'')\ R_{po}\ h_{0}(v''^{-})]Rr(\ell'')]$

[29i] He declared that she was the winner.

[29ii] $Ch_{0}(s'')\ E\ r\ (\sigma'')$

[30i] The sun turned it yellow.

[30ii] $Cr_{0}(d'')\ E[Br_{0}(m'')\ R\ r_{0}\ (f'')]$

[31i] The revolver made him afraid.

[31ii] $Cr_{0}(d'')\ E[Bh_{0}\ (v''^{-})\ R\ h_{0}\ (f'')]$

[32i] I found that it was strange.

[32ii] $Nh_{0}(j''^{-})\ A[Zr_{0}\ (u'')\ Rr_{0}\ (f'')]$

[33i] He placed it on the shell.

[33ii] $Ch_{0}(k'')\ E[Br_{01}\ (m'')\ R_{go}\ r_{02}\ (\ell'')]$

[34i] The storm drove the ship ashore.

[34ii] $Cr(t'')\ E[Br_{01}\ (d'')\ Rr_{02}\ (\ell'')]$

[35i] A car knocked it down.

[35ii] $Cr_{1}(d'')\ E[Br_{0}\ (m'')\ Rr_{2}\ (\ell'')]$

[36i] I prefer them on toast.

[36ii] $Th_{0}(j'')\ A[Zr'_{0}\ (d'')\ Rr\ (\ell'')]$

[37i] I brought her a gift.

[37ii] $B[Nh_{0}(v'')\ A\ r(m'')]\ R_{bn}h_{02}\ (v'')$

[38i] She gave the door a kick.

[38ii] $Nh_{0}(k'')\ A\ r\ (d'')$

[39i] She knitted me a sweater.

[39ii] $B[Ch_{01}(k'') Er(d'') R_{bn} h_{02} (v'')]$

5. FORMALIZING SENTENCE TYPES

The sentences in [1] –[3] all taken from Jurafsky & Martin will provide a basis for demonstration of how to formalize sentence types in LFPT.

[1i] John opened the door.
[1ii] John opened the door with the key.
[1iii] The key opened the door.
[1iv] The door was opened by John.

[2] The waiter brought Mary the check.

[3] I believe that Mary ate British food.

It will easily be noted that while sentences in [1] and [2] are unembedded, [3] results from embedding.

The method to be used in the semantic representation of sentence types in LFPT is tripartitely statable as follows:

(a) determination of the untensed proposition i.e. $r^0 (w'')$
(b) determination of the tensed proposition i.e. $r^+ (w'') \equiv r^0 (w'') < \tau(\mathbb{U},\mathbb{R},\mathbb{S}) >$
(c) semantic representation of the sentence type i.e. $r (\sigma'') \equiv \Omega e(g'')\{ r^+ (w'')\}$

Since the semantic representation of untensed propositions was treated in Section 4.2, our attention should now be directed to the tense formula $\tau(\mathbb{U},\mathbb{R},\mathbb{S})$ in order to pave the way for sentence formalization. The tense formula encompasses three temporal zones: past, present, and future (marked with minus, zero, and plus superscript respectively).

(1a) Ali wrote. $R^- = S^- < U^0$
(1b) Ali writes. $U^0 = R^0 = S^0$
(1c) Ali will write. $U^0 < R^+ = S^+$

(2a)	Ali was writing.	$\Delta R^- = \Delta S^- < U^0$
(2b)	Ali is writing .	$U^0 \in \Delta R^0 = \Delta S^0$
(2c)	Ali will be writing.	$U^0 < \Delta R^+ = \Delta S^+$
(3a)	Ali had written.	$S^- < R^- < U^0$
(3b)	Ali has written.	$S^0 < R^0 = U^0$
(3c)	Ali will have written.	$U^0 < S^+ < R^+$
(4a)	Ali had been writing.	$\Delta S^- < R^- < U^0$
(4b)	Ali has been writing.	$\Delta S^0 < R^0 = U^0$
(4c)	Ali will have been writing.	$U^0 < \Delta S^+ < R^+$
(5a)	Ali was going to write.	$R^- < S^- < U^0$
(5b)	Ali is going to write.	$U^0 < R^0 < S^0$
(5c)	Ali will be going to write.	$U^0 < R^+ < S^+$

Now we turn to the sentences in [1] –[3] fully cognizant of the methods of semantic representation enunciated above.

[4i]	John opened the door.		
[4ii]	$r^0(w'')$	$\equiv$	$[Ch_0(k'')\ E[Br_0(d'')\ Rr_0(f'')]]$
[4iii]	$r^+(w'')$	$\equiv$	$[r^0(w'') < R^- = S^- < U^0 >]$
[4iv]	$r(\sigma'')$	$\equiv$	$\bullet r_{01}(d'')\ \{ r^+(w'')\}$
[5i]	John opened the door with the key.		
[5ii]	$r^0(w'')$	$\equiv$	$[Ch_0(k'')\ E[Cr_{01}(d'')\ E[B\ r_{02}(d'')Rr_{02}(f'')]]]$
[5iii]	$[r^0(w'')< R^- = S^- < U^0 >]$		
[5iv]	$r(\sigma'')$	$\equiv$	$\bullet h_0(k'')\ \{ r^+(w'')\}$
[6i]	The key opened the door.		
[6ii]	$r^0(w'')$	$\equiv$	$[Cr_{01}(d'')\ E[Br_{02}(d'')\ Rr_{02}(f'')]]$
[6iii]	$r^+(w'')$	$\equiv$	$[r^0(w'') < R^- = S^- < U^0>]$
[6iv]	$r(\sigma'')$	$\equiv$	$\bullet h_0(k'')\ \{ r^+(w'')\}$
[7i]	The door was opened by John.		
[7ii]	$r^0(w'')$	$\equiv$	$[Ch_0(k'')\ E[Br_0(d'')\ Rr_0(f'')]]$
[7iii]	$r^+(w'')$	$\equiv$	$[r^0(w'') < R^- = S^- < U^0>]$
[7iv]	$r(\sigma'')$	$\equiv$	$\bullet r_{01}(d'')\ \{ r^+(w'')\}$

[8i] The waiter brought Mary the check.
[8ii] $r^0(w'') \equiv [Ch_{01}(v'')\ E[Br_0(a'')\ R_{go}\ h_{02}(b'')]]$
[8iii] $r^+(w'') \equiv [r^0(w'') < R^- = S^- < U^0>]$
[8iv] $r(\sigma'') \equiv \bullet h_{01}(v'')\ \{ r^+(w'')\}$

[9i] Mary ate British food.
[9ii] $r_1^0(w'') \equiv Ch_{01}(v'')\ E[Br(d'')\ R_{in}\ h_{01}(\ell'')]$
[9iii] $r_1^+(w'') \equiv [r_1^0(w'') < R^- = S^- < U^0>]$
[9iv] $r_1(\sigma'') \equiv \bullet h_{01}(v'')\ \{ r_1^+(w'')\}$

[10i] I believe that Mary ate British food.
[10ii] $r_2^0(w'') \equiv Th_{02}(c'')\ Ar_1(\sigma'')$
[10iii] $r_2^+(w'') \equiv [r_2^0(w'') < U^0 = R^0 = S^0 >$
[10iv] $r_2(\sigma'') \equiv \bullet h_{02}(c'')\ \{ r_2^+(w'')\}$

[11i] What John opened with the key was the door. (Cf [5i])
[11ii] (See [5ii])
[11iii] (See [5iii])
[11iv] $r(\sigma'') \equiv \bullet r_{02}(d'')\ \{ r^+(w'')\}$

[12i] What opened the door? (Cf [6i])
[12ii] (See [6ii])
[12iii] (See [6iii])
[12iv] $r(\sigma'') \equiv ?r(d'')\ \{ r^+(w'')\}$

[13ia] John, open the door.
[13ib] $r(\sigma'') \equiv -\bullet h_0(k'')\ \{ [[Ch_0(k'')\ E[Br_0(d'')\ Rr_0(f'')]]<U^0 =R^0 =S^0>]\}$

[14ia] How John opened the door! (Cf [4i])
[14ib] $r(\sigma'') \equiv !\ h_0(k'')\ \{ [Ch_0(k'')\ E[Br_0(d'')\ Rr_0(f'')]]< R^- = S^- = U^0 >\}$

[15i] Who brought Mary the check? (Cf [4i])
[15ii] (See [8ii])
[15iii] (See [8iii])
[15iv] $r(\sigma'') \equiv ?\ h_1(v'')\ \{ r^+(w'')\}$

[16i] Whom did the waiter bring the check? (Cf [8i])
[16ii] (See [8ii])
[16iii] (See [8iii])

[16iv] $r(\sigma'') \equiv ?\, h_2(b'')\ \{ r^+(w'')\}$

[17i] Who do I believe ate British food? (Cf [10i]))
[17ii] (See [10ii])
[17iii] (See [10iii])
[17iv] $r_2(\sigma'') \equiv ?h_1(v'')\ \{ [Th_{02}(c'')\ A\ r_1(\sigma'')]<U^0 = R^0 = S^0>\}$

[18i] Who was going to open the door? (Cf{4i])
[18ii] (See [4ii])
[18iii] $r^+(w'') \equiv [r^0(w'') < R^- < S^- < U^0>]$
[18iv] $r(\sigma'') \equiv ?h(k'')\ \{ r^+(w'')\}$

[19i] Has John opened the door? (Cf[4i])
[19ii] (See [4ii])
[19iii] $r^+(w'') \equiv [r^0(w'') <S^0 < R^0 = U^0>]$
[19iv] $r(\sigma'') \equiv ?h_0(k'')\ \{ r^+(w'')\}$

[20i] What John did was to open the door. (Cf[4i])
[20ii] (See [4ii])
[20iii] (See [4iii])
[20iv] $r(\sigma'') \equiv \bullet\ r(t'')\ \{ r^+(w'')\}$

6. CONCLUSIONS

Throughout the present paper the author has studiously eschewed direct criticism of any computational linguist's work on the issue of meaning representation. But an exceptional occasion presents itself when we stumble on so-called primitive predicates as listed in Jurafsky & Martin (2000:621). It will be recalled that the force-predicate theory characterized in Sec 2 posits three predicate types, namely relative, causative, and contactive predicates. Section 3 is concluded with the periodic table of predicates in which [∑R] , [ΦE] , [ΨA] feature as the primitive building blocks for the entire table. It is, therefore, appropriate to initiate a conclusion to this paper by reducing "the eleven [*sic*] primitive predicates … used to represent all predicate-like expressions" (ibid.) to the three predicate types that correspond to Newton I, II, and III. But because Jurafsky & Martin offer only one example (Cf {8i]-[8iv] in Sec 5), we shall, in what follows, base our formalization on the verbatim definitions of the "primitive predicates" listed (ibid.).

(1i) "ATRANS The abstract transfer of possession control from one entity to another."
(1iia) Ch_1 (v″) E[Nh_2 (v″) Ae (a″)]
(1iib) CE[NA]

(2i) "PTRANS The physical transfer of an object from one location to another."
(2iia) Ch (v″) E[Be_1 (m″) R_{rg} [Ze_2 (ℓ″) $R_{\ell t}$ e_3 (ℓ″)]]
(2iib) CE[BR[ZR]]

(3i) "MTRANS The transfer of mental concepts between entities or within an entity."
(3iia) Ce_0 (v″) E[Be_1 (a″) R_{go} e (v″)]
(3iib) CE[BR]

(4i) "MBUILD The creation of new information within an entity."
(4iia) Ce_0 (v″) E[Be_2 (a″) R_{po} e_1 (v″)]
(4iib) CE[BR]

(5i) "PROPEL The application of physical force to move an object."
(5iia) Ce_1 (b″) E[Cr(t″)E[Be_2 (m″)R_{rg} e_3 (ℓ″)]]
(5iib) CE[CE[BR]]

(6i) "MOVE The integral movement of a body part by an animal."
(6iia) Cr(b″) E[B[Ze(b″) R_{po} r(b″)]R_{rg} e (ℓ″)]
(6iib) CE[B[ZR]R]

(7iia) " INGEST The taking in of a substance by an animal."
(7iib) Cr(b″) E[Be(m″) R_{in} r (ℓ″)]
(7iib) CE[BR]

(8i) "EXPEL The expulsion of something from an animal."
(8iia) Cr(b″) E[Be(m″) R_{eg} r (ℓ″)]
(8iib) CE[BR]

(9i) " SPEAK The action of producing a sound."

(9iia) Ch(b″)E [Br(t″) Rr(f″)]
(9iib) CE[BR]

(10i) "ATTEND The action of focusing a sense organ."
(10iia) Ce_1 (v″) E[N[Z e_2(b″) R_{po} e_1(b″)]Ae_3 (u″)]
(10iib) CE[N[ZR]A]

If we assimilate our results in (1ii)- (10ii) to the periodic table of predicates in Section 3, the following facts emerge:

(a) definitions (1i), (3i), (4i), (7i), (8i), and (9i) instantiate predicate 8ΦE[$\mathcal{T}$]
(b) definitions (2i), (5i), (6i), and (10i) instantiate predicate 17 ΦE[Ω].

Since [$\mathcal{T}$] = 1[∑R] , 2[ΦE] , 3[ΨA]; 8ΦE[$\mathcal{T}$] is an instantiation of Ω; and 17 ΦE[Ω] is an instantiation of [Λ] , all the definitions (1i) - (10i) are manifestly reducible to 1[∑R] , 2[ΦE] , and 3[ΨA], hence to the primitive predicates as postulated by force-predicate theory.

Let the highlights of the paper be recapitulated here below:

(a) buttressing the introduction of the force-predicate theory into the arena of linguistic discourse littered with sanctimonious theories and models on the essence of language
(b) boldly fixing the number of semantic rules to nine, and the number of predicate types to three
(c) developing a meaning representation language which integratively captures time, aspectuality , and modality by consecutive moves from the extralinguistic situation r(t″) , untensed proposition r^0 (w″), tensed proposition r^+ (w″) up to sentence type

$$r(\sigma'') \equiv \Omega e(g'') \{ r^+ (w'')\}$$

(d) presenting a revised version of the periodic table of predicates which has not only predictable but also foreseeable, implications for computational semantics, pragmatics, syntax, morphology, and lexicology.

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