FROM NEWTONIAN FORCES TO MEANING REPRESENTATION

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In this contribution I undertake the task of proposing a solution to a significant problem in semantic role theory. The central objective that I wish to pursue in this paper is to apply the proposed solution to meaning representation, yet another problem that mainly features in current computational linguistics.

1. PRESENTING THE PROBLEM

In order to state the problem to be tackled in this paper, I propose to make contact with four texts on English Language and linguistics. The intended contact pertains to their treatment of role theory.

In their influential grammar of the English language Quirk et al (1985: 741) duly remind us that

> analysis of participant roles has not achieved a general consensus, nor has it fully explored all distinctions … [their] description must therefore be considered tentative.

On the other hand, Brown and Miller (1991: 308) justify their description of role theory by "its offering a degree of both generality and particularity [although] it has no easily defended validity … [and] there seems to be no alternative in the current state of knowledge."

While Fromkin et al (2003: 192) prefix their list of roles with a reassurance to the effect that "the list is not complete", Larson and Segal's (1995: 489) considered stance on the nature and number of semantic roles is the most pessimistic, for they write:

> The upshot is that we regard the question of which thematic roles there are and how they are defined as empirical ones, to be resolved in the usual way: by investigations that construct specific theories making detailed and specific predictions. Preliminary theories of this kind have been proposed; however, it is likely that resolving thematic roles precisely will require a great deal of investigation, involving domains beyond linguistics. It is worth remembering that fully 22 centuries elapsed between the first suggestion of the atomic theory of matter, in which all substances were factored into earth, water, air, and fire, and the elaboration of atomic theory by John Dalton, in which a more complete and satisfactory set of atomic constituents was proposed. Finding elementary constituents can evidently be a long-term project.

Admittedly, the development of atomic theory was tortuous; but we need not resign ourselves to a similar state-of-affairs with regard to role theory. Taking my cue from Larson and Segal, consequently, I embark on the quest for semantic roles, in relevant areas beyond linguistics with extraordinary keenness on mechanics.

2. THE FORCE-PREDICATE THEORY

In this paper I employ the term "Newtonian forces" to refer to forces which are captured by means of Newton's Laws of Motion. Furthermore, by "semantic roles" I mean labels such as "agent", "instrument", "affected", "patient" and "experiencer" variously used in current linguistic literature. Although it may be a far-fetched idea to unify physics (or mechanics to be more exact) and theoretical linguistics, the central thesis I am advancing in this paper is that there is a one-to-one correspondence between Newtonian forces and semantic roles. At this point it will be helpful to state Newton's laws of motion:

(1) Newton's First Law of Motion states that if the resultant external force acting on a particle is zero, then it will either remain at rest (if it is already at rest) or it will move at a constant speed in a straight line(if it is already in motion).

(2) Newton's Second Law of Motion states that if the resultant external force acting on a particle is non-zero, then it will move with an acceleration proportional to the mass of the particle and in the direction of the force.

(3) Newton's Third Law of Motion states that if two particles are in contact, then the force exerted on particle 2 by particle 1 is equal and opposite to the force exerted on particle 1 by particle 2.

Letting

$\vec{\mathbf{F}}$	=	resultant external force acting on the particle
$\vec{0}$	=	zero vector
$\vec{\mathbf{v}}$	=	velocity (i.e. speed in a given direction) of the particle
m	=	mass of the particle
$\vec{\mathbf{a}}$	=	acceleration (i.e. change of $\vec{\mathbf{v}}$ in time of the particle

Newton's Laws of Motion can be more compactly stated as follows:

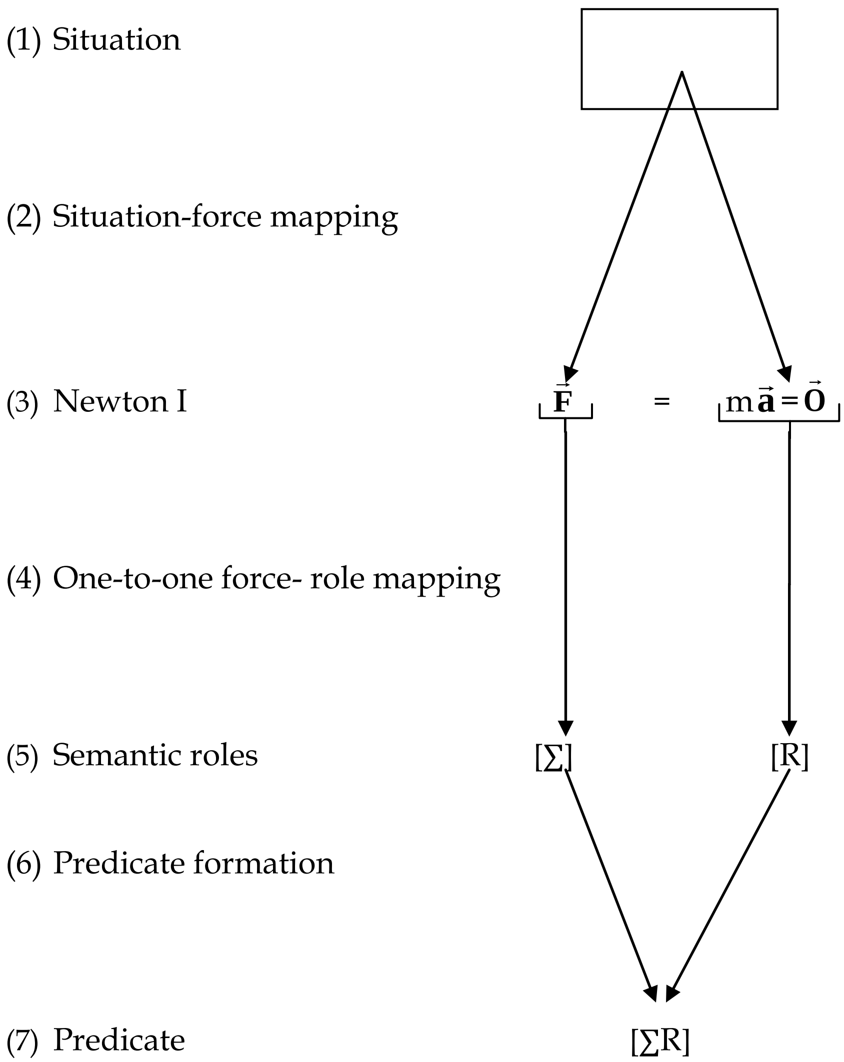
Newton I: If $\vec{\mathbf{F}} = \vec{\mathbf{O}}$, then either $\vec{\mathbf{v}} = \vec{\mathbf{O}}$ or $\vec{\mathbf{v}}$ = constant

Newton II: If $\vec{\mathbf{F}} \neq \vec{\mathbf{O}}$, then $\vec{\mathbf{F}} = m\vec{\mathbf{a}}$

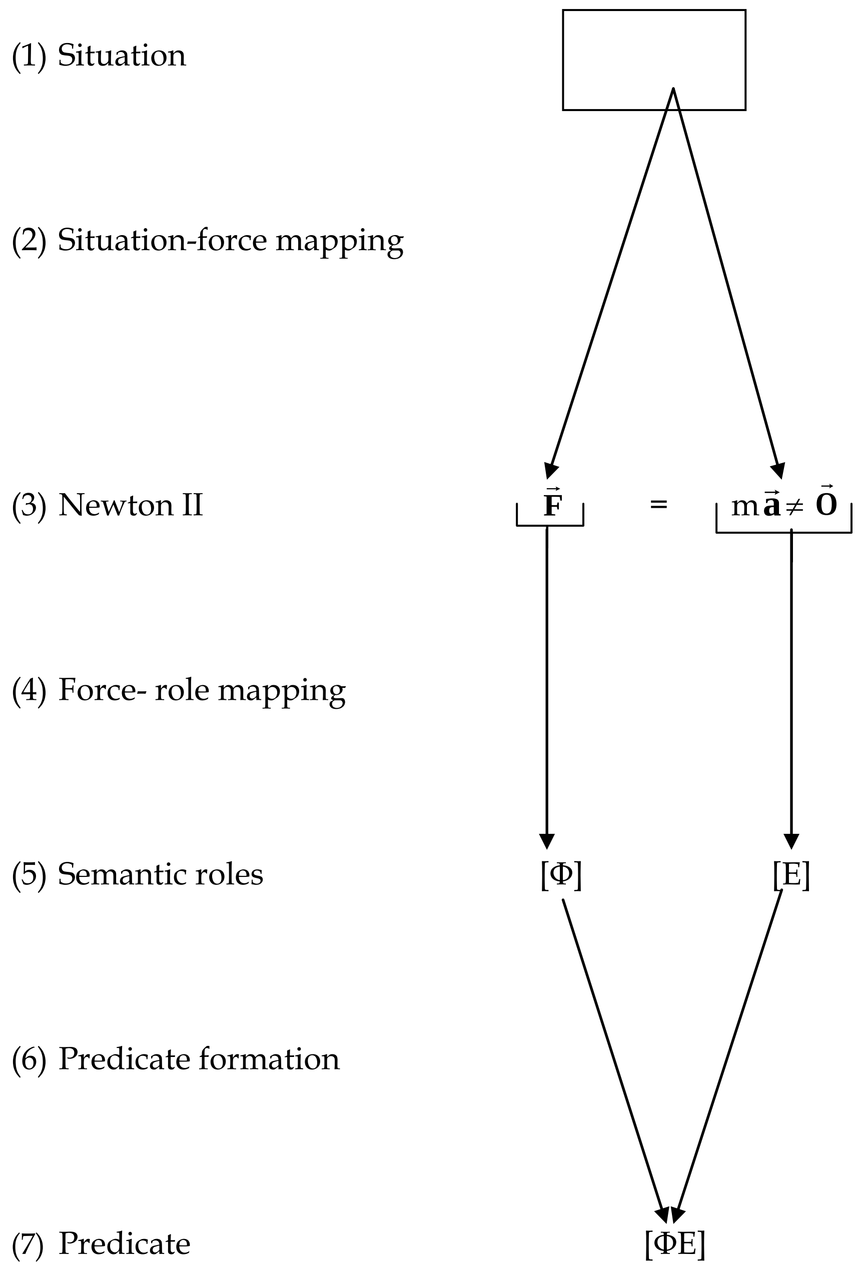
Newton III: If particles 1 and 2 are in contact, then $\vec{\mathbf{F}}_{12} = -\vec{\mathbf{F}}_{21}$.

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.

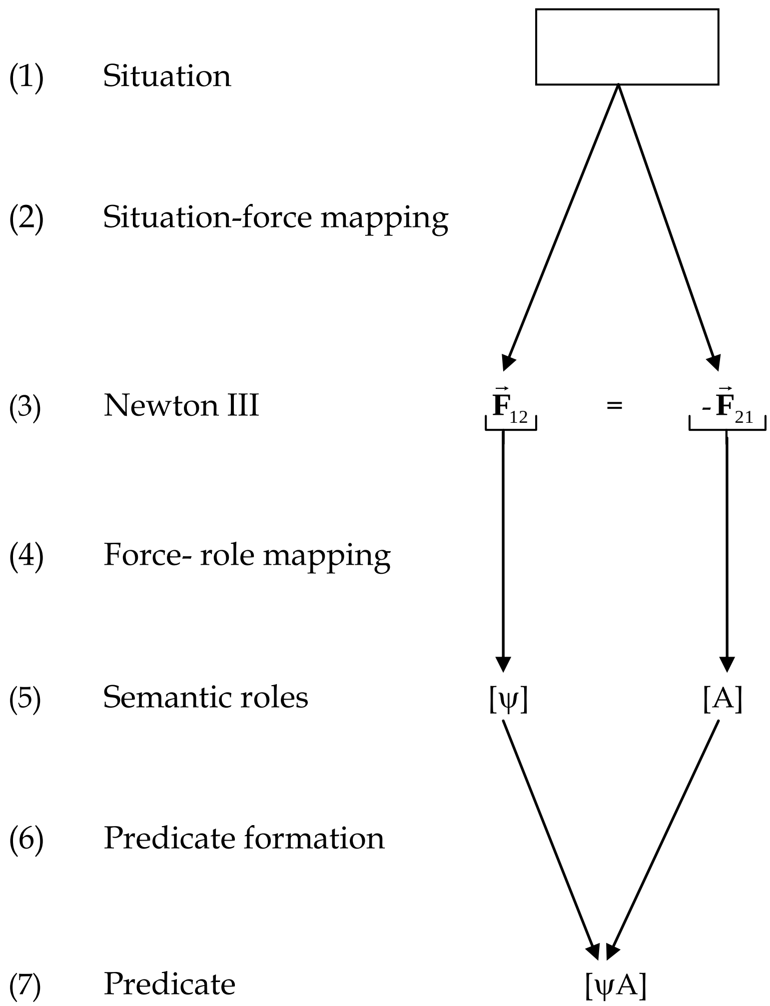
Concretization of the theory follows immediately. First, we consider Newton's first law of motion, or Newton I for short.



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, Newton III is mapped into [ψ] a contactor (which can be dynamic [N] or static [T]) and [A] a contactee.



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

Whether there obtains a mere one-to-one correspondence between Newtonian forces and semantic roles or not, is an issue we shall be addressing later on. For now, we can answer the question posed in the spirit of Larson and Segal (in Sec 1): Is the number of semantic role types precisely determinable; and, if so, which semantic role types are there? There are nine and only nine semantic role types; and six and only six semantic predicate types. To Newton 1 corresponds the role types [B], [Z] and [R]; and the predicate types [BR] and [ZR]. To Newton II corresponds the role types [C], [K], and [E]; and the predicate types [CE] and]KE]. And to Newton III corresponds [N], [T] and [A] as role types; and [NA] and [TA] as predicate types.

If semantic roles do contribute to sentence meaning and computational linguists are very intensely concerned with formalization of sentences, then it would not sound impertinent to originate an instrument of meaning representation. To this end, we present (in Sec 3) a rigorously formal language of the force-predicate theory.

3. MEANING REPRESENTATION

The formal language of the force-predicate theory consists of four parts: undefined terms, unproved assertions, defined terms, and special symbols as set out below.

(1) **Undefined terms**

(a) **semantic entity**: r

(b) **semantic roles**: change bearer [B], nonchange bearer [Z], reference [R], dynamic causer [C], static causer [K], causee/result/effected [E], dynamic contactor/affector [N], static contactor/affector [T], contactee/affected [A]

(c) **semantic domains**:

(i) propositional τ'', sentential σ''

(ii) composite g'', abstract a″, material m″, sex v″, human h″, sign j″, change δ'', zero change ω''

(iii) organism body b″, cognitive c′, perception p″, feeling e″, axiological u″, imaginative i″, communicate k″, psychomotor s″

(iv) form f″, mode w″, direction d″, space ℓ'', time t″, quantity q″, number n″

(v) domain variables: x″ , y″ , z″

(2) **Unproved assertions**

Axiom 1: Semantic role and predicate formation in the human brain-mind is caused by Newtonian forces.

Axiom 2: Different packets of energy are expended in the formation of relative, causative, and contactive predicates.

Axiom 3: Every semantic predicate in either a verbal or a non-verbal language is reducible to a relative, causative, or contactive predicate.

(3) **Defined terms**

(a) An **elementary semantic predicate** is defined as $[\Theta_1\Theta_2]$, where $[\Theta_1]$ and $[\Theta_2]$ are semantic roles such that there are six and only six elementary predicate types: [BR], [ZR]. [CE], [KE], [NA], and [TA].

(b) If π_1 , π_2 and π_3 are elementary predicates, then π is a complex predicate in

(i) $\pi = \pi_1[\pi_2]$

(ii) $\pi = [\pi_1]\ \pi_2$

(iii) $\pi = \pi_1[\pi_2[\pi_3]]$

(iv) $\pi = [[\pi_1][\ \pi_2]]\ \pi_3$

(c) A **proposition** is defined as $r_1(x_1''(y_1''))\ \pi r_2\ (x_2''(y_2))$.

(d) A **canonical sentence** is a **temporalized proposition**.

(e) A **non-canonical sentence** is either

$\Omega[r\ (\sigma'')]$ or $\Omega r_i\ (x_j''(x_k''))\ [\ r(\sigma'')]$,

where Ω is

(i) • a statement operator

(ii) ? a question operator

(iii) —• a directive operator

(iv) ! an exclamation operator

(4) **Special symbols**

(a) **Compositeness** is indicated by a slash:

(i) domain combination : $r\ (g''(x''/y''))$ (forward slash)

(ii) domain separation: $r\ (g''(x''\backslash y''))$(backslash)

(b) **Degree** indicated by vertical bars

(i)	↡	for the lowest degree	e.g.	r (↡x″)
(ii)	↓	for a lower degree	e.g.	r (↓x″)
(iii)	‖	for equality	e.g.	r (‖x″)
(iv)	↑	for a higher degree	e.g.	r (↑x″)

(v) ↟ for the highest degree e.g. r (↟x″)

(c) **Delimiters**

(i) ( ) round brackets for domain delimiting

(ii) [ ] square brackets for role, predicate, proposition, and sentence delimiting

(d) **Negators**

(i) ˥ hook for entity negation

(ii) ⇞ ↟ ∦ ↡ ↓̸ (cf (b) c)

(e) **Numerals**

(i) **Prefixed Arabic numerals** for domain sequence, thus r(1x″) initial, r(2x″) intermediate, r(3x″) final

(ii) **Superscripted Arabic numerals** for domain sequence nuancing, thus

$\ldots, \quad 1^{-4}, \quad 1^{-3}, \quad 1^{-2}, \quad 1^{-1}, \quad 1, \quad 1^{+1}, \quad 1^{+2}, \quad 1^{+3}, \quad 1^{+4}, \quad \ldots$

$\ldots, \quad 2^{-4}, \quad 2^{-3}, \quad 2^{-2}, \quad 2^{-1}, \quad 2, \quad 2^{+1}, \quad 2^{+2}, \quad 2^{+3}, \quad 2^{+4}, \quad \ldots$

$\ldots, \quad 3^{-4}, \quad 3^{-3}, \quad 3^{-2}, \quad 3^{-1}, \quad 3, \quad 3^{+1}, \quad 3^{+2}, \quad 3^{+3}, \quad 3^{+4}, \quad \ldots$

(iii) Subscripted Arabic numerals for entity and domain differentiation

$r_1 \quad r_2 \quad r_3 \quad \ldots \quad \mathbf{x_1''} \quad \mathbf{x_2''} \quad \mathbf{x_3''} \quad \ldots$

(iv) Upper Roman numerals for subdomain differentiation

- Iσ″ statement , IIσ″ question , IIIσ″ directive, IVσ″ exclamation
- Im″ abiotic , IIm″ plant , IIIm″ animal
- Io″ solid , IIo″ liquid , IIIo″ gas
- Iv″ female , IIv″ male , Øv″ sexless
- Ip″ visual perception , IIp″ auditory perception , IIIp″ tactile perception , IVp″ olfactory perception , Vp″ gustatory perception
- Iℓ″ one-dimensional space , IIℓ″ two-dimensional space , IIIℓ“three-dimensional space
- It″ past time , IIt″ present time , IIIt″ future time
- Iδ″ relative change, zδ“ causative change, III δ“ contactive change
- Iω“ relative zero change , IIω “ causative zero change, IIIω “ contactive zero change

(f) **Dotted circle**
⊙x″ for interior location

(g) **Primes**
r′ single prime for entity plurality
x″ double prime for domain

(h) **Domain indifference /neutrality**
Ø″

Now that we have the formal language of the force-predicate theory in place, let us test its power of meaning representation, starting with canonical sentences. A canonical sentence results from temporalization of a proposition, hence [r_1(τ“)ΣRr_2 (t″). Our comparative analytical discussion will be based on example sentences together with their role-theoretical characterizations derived from Brown/Miller (1991) and Huddleston/Pullum (2002), here respectively abbreviated to B/M and H/P. As a preliminary to the confrontation of B/M and H/P with the language of the force-predicate theory, let the following formal definitions of the six predicate types be recorded.

- ❑ $r_1(x_1''(y_1''))BR\ r_2(x_2''(y_2''))$ r_1 in domain x_1'' in y_1'' undergoes a change relative to r_2''in domain x_2'' in domain y_2''.
- ❑ $r_1(x_1''(y_1''))ZR\ r_2(x_2''(y_2''))$ r_1 in domain x_1'' in domain y_1'' persists in a non-change relative to r_2 in domain x_2'' in domain y_2''.
- ❑ $r_1(x_1''(y_1''))CE\ r_2(x_2''(y_2''))$ r_1 in domain x_1'' in domain y_1'' causes r_2 in domain x_2'' in domain y_2'' .
- ❑ $r_1(x_1''(y_1''))KE\ r_2(x_2''(y_2''))$ r_1 in domain x_1'' in domain y_1'' countercauses r_2 in domain x_2'' in domain y_2'' .
- ❑ $r_1(x_1''(y_1''))NA\ r_2(x_2''(y_2''))$ r_1 in domain x_1'' in domain y_1'' makes contact with r_2 in domain x_2''in domain y_2''.
- ❑ $r_1(x_1''(y_1''))TA\ r_2(x_2''(y_2''))$ r_1 in domain x_1'' in domain y_1'' is in contact with r_2 in domain x_2'' in domain y_2''.

(1) **The string** broke. [B/M p.109]
PATIENT
(1a) $r_1(Io'')BRr_2(3f'')$

(2) **Harold** ran **a mile**. [B/M p.109]
AGENT RANGE
(2a) $r_1(h'')BR\ r_2(2g''(n''/\ell''))$

(3) **Susan** went to **Denmark**. [B/M p.309]
AGENT LOCATIVE GOAL
(3a) $r(h'')BR\ r_2(3\ell'')$

(4) **Yasuko** is arriving from **Kyoto**. [B/M p.309]

AGENT LOCATIVE SOURCE

(4a) r_1(h″)BR r_2((1ℓ″)

(5) **Helen** travelled via **Samarkand**. [B/M p.309]

AGENT LOCATIVE PATH

(5a) r_1(h″)BR r_2(2ℓ″)

(6) **She** ran **home**. [H/P p.232]

THEME/AGENT GOAL

r_1(h″)BR r_2(3g″(ℓ″/h″))

(7) **She** went **mad**. [H/P p.232]

THEME GOAL

r_1(h″)BR r_2(3f″(g″(c″/b″)))

(8) **The painting** cost **£5,000**. [B/M p.309]

NEUTRAL RANGE

(8a) r_1(Im″)ZR r_2(g″(n″/u″))

(9) **Celia** is cold/sad. [B/M p.309]

DATIVE

(9a) r_1(h″)ZR r_2(f″)

(10) **The child** is sleeping. [B/M p.309]

NEUTRAL

(10a) r_1(h″)ZR r_2(f″(g″(h″\c″)))

(11) **The town** is **dirty**. [B/M p309]

NEUTRAL ATTRIBUTE

(11a) r_1(g″(ℓ″/h″)) ZRr_2(f″)

(12) **Fiona** is the **convener**. [B/M p.309]
NEUTRAL ROLE
(12a) r_1(h″) ZRr_2(‖f″)

(13) **She** is on **the balcony**. [H/P pp.232-3]
THEME SPATIAL LOCATION
(13a) r_1(h″)ZR r_2(ɡ″(ℓ″/Io″))

(14) **The meeting** is at **noon**. [H/P p.233]
THEME TEMPORAL LOCATION
(14a) r_1(a″)ZR r_2(t″)

(15) **She** was singing. [B/M p.309]
AGENT
(15a) r_1(h″)CE r_2(a″(ɡ″(k″/u″)))

(16) **The dog** is digging **a hole.** [B/M p.309]
AGENT RESULT
(16a) r_1(IIIm″)CE r_2(ɡ″(ℓ″\Io″))

(17) **Kim** wrote **the letter**. [H/P p.227]
AGENT FACTITIVE
(17a) r_1(h″)CE r_2(ɡ″(Io″/a″))

(18) **Kim** heard **an explosion**. [H/P p.227]
EXPERIENCER STIMULUS
(18a) r_1(h″(IIp″))NAr_2(a″)

(19) **They** kissed **us**. [H/P p.231]
AGENT PATIENT
(19a) r_1′(h″)NAr_2‘(h″)

(20) **They** listened to **him**. [H/P p.231]
AGENT NON-PATIENT
(20a) r_1'(h"(↑IIp"))NAr_2(h")

(21) **We** heard **a bang**. [H/P p.231]
EXPERIENCER STIMULUS
(21a) r_1'(h"(IIp"))NAr_2(a")

(22) **Miranda** knew **all the answers**. [B/Mp.309]
DATIVE NEUTRAL
(22a) r_1(h"(c"))TA r_2'(a")

(23) **Harriet** owns **a cat**. [B/M p.309]
DATIVE NEUTRAL
(23a) r_1(h")TAr_2(IIIm")

(24) **They** liked **me**. [H/P p.231]
AGENT NON-PATIENT
(24a) r_1'(h"(e"))TAr_2(h")

(25) **They** remember **us**. [H/P p.231]
AGENT NON-PATIENT
(25a) r_1'(h"(c"))TA r_2'(h")

(26) **He** hates **me**. [H/P p.231]
EXPERIENCER STIMULUS
(26a) r_1'(h"(e"))TAr_2(h")

(27) **They** believe **me**. [H/P p.231]
EXPERIENCER STIMULUS
(27a) r_1'(h"(c"))TA r_2(h")

(28) **We** know **the reason**. [H/P p.231]
EXPERIENCER STIMULUS

(28a) $r_1'(h''(c''))TA\ r\ (a'')$

(29) **John** sharpened **the knife**. [B/M p.309]
AGENT PATIENT

(29a) $r_1(h'')CE[r_2(Io'')BRr_3(3f'')]$

(30) **She** gave **the book** to **Bill.** [B/M p.309]
AGENT PATIENT GOAL
$r_1(h'')CE[r_2(Io'')BRr_3(3h'')]$

(31) **I** got **the cassette** from **David**. [B/M p.309]
AGENT PATIENT SOURCE

(31′) **David** gave **the cassette** to **me**.
CAUSER CHANGE BEARER REFERENCE

(31a) $r_1(h'')CE[r_2(Io'')BRr_3(3h'')]$

(32) **The show** delighted **us**. [H/P p.234]
STIMULUS EXPERIENCER

(32a) $r_1(a'')CE[r_2'(h'')BRr_3(3f''(e''))]$

(33) **The knife** cut **the lace**. [H/P p.231]
INSTRUMENT/CAUSER PATIENT

(33a) $r_2(Io'')CE[r_3(Io'')BRr_4(3f'')]$

(34) **The rain** ruined **the crop**. [H/P p.230]
CAUSER PATIENT

(34a) $r_1(g''(Io''/\ell''/t''))CE[r_2(g''(IIm''/\ell''/t''))BRr_3(3f'')]$

(35) **The thought of being alone** scares **me**. [H/P p.231]
STIMULUS EXPERIENCER

(35a) $r_1(a'')CE[r_2'(h'')BRr_3(3f'')]$

(36) **Kim** gave **the key** to **Pat**. [H/P p.233]

SOURCE/AGENT THEME GOAL/RECIPIENT

(36a) r_1(h")CE[r_2(Io")BRr_3(3h")]

(37) **Kim** shot **the intruder**. [H/P p.227]
AGENT PATIENT

(37a) r_1(h")CE[r_2(Io")CE[r_3(h")BRr_4(f")]]

(38) **I** cut **the lace** with **the knife**. [H/P p.231]
AGENT PATIENT INSTRUMENT

(38a) r_1(h")CE[r_2(Io")CE[r_3(Io")BRr_4(3f")]]

(39) **They** hit **me**. [H/P p.231]
AGENT PATIENT

(39a) r_1′(h")CE[r_2(Io")NAr_3(h")]

(40) **They** did cruel things to him. [H/P p.231]
AGENT PATIENT

(40a) r_1′(h")CE[r_2′(a")NAr_3(h")]

(41) **The light** went from **red** to **green**. [H/P p.233]
THEME SOURCE GOAL

(41a) r_1(a")BR[r_2(1f")]BRr_3(3f")

(42) **She** ran from **the post office** via **the railway station** to **the bus-station**
THEME/AGENT SOURCE PATH GOAL [H/P p.233]

(42a) [[r_1(h")BRr_2(1g"(h"/ℓ"))]BRr_3(2g"(h"/ℓ"))]BRr_4(3ℓ")

(43) **I** contacted **Jane** via **her sister**. [B/M p 309]
AGENT PATIENT PATH

(43a) [r_1(h")NAr_2(h")]BRr_3(2h")

(44) **I** will open **the door** for **you**. [H/P p.233]
AGENT THEME BENEFICIARY

(44a) $[r_1(h'')CE[r_2(Im'')BRr_3(f'')]]BRr_4(h'')$

In terms of predicate embedding our corpus evidences zero embedding (1)- (28), right-had embedding (29)-(40), left-hand embedding (41)-(43), and mixed embedding (44). Paying closer attention to the predicates themselves, we establish that the corpus attests to them as follows:

[BR] (1)- (7)	[ZR] (8)-(14)	[CE] (15)-(17)
[NA] (18)-(21)	[TA] (22)-(28)	[CE[BR] (29)- (36)
[CE[CE[BR]] (37-(38)	CE[NA] (39)-(40)	[BR]BR (41)
[[BR]BR]BR (42)	[NA]BR (43	[CE[BR]]BR (44)

Noteworthy is the absence of [KE] and [KE[ZR], although the latter is readily exemplifiable as in (45).

(45) **The government** is detaining **him** on **a remote island**.

(45a) $r_1(g''(h''/a''/\ell''))KE[r_2((h'')ZRr_3(g''(\ell''/m''))]$

Still more noteworthy is the canonizing pre-treatment of the example sentence in (31). Until now we have been formalizing canonical statements. Using the sentence in (46), we would like to show how non-canonical sentences are formalized in the language of the force-predicate theory.

(46) **Kofi** gave **an old watch** to **Kwame**.

(46a) $[r_1(h'')CE[r_2(Io'')\ BRr_3(3h'')]] \equiv r_4(\tau'')$

(46b) $[r_4(\tau'')BRr_5(It'')] \equiv r(\sigma'')$

For the proposition in (46a) there is a related family of canonical statements in (46b) resulting from the temporalization.

(47) It was the case that **Kofi** gave **an old watch** to **Kwame**.
(47a) • [r(σ″)]

(48) It was **Kofi** who gave **an old watch** to **Kwame**.
(48a) • r_1(h″)[r(σ″)]

(49) **An old watch** was given to **Kwame** by **Kofi**.
(49a) • r_2(Im″)[r(σ″)]

(50) To **Kwame**, **Kofi** gave **an old watch**.
(50a) • r_3(3h″)[r(σ″)]

(51) Did **Kofi** give **an old watch** to **Kwame**?
(51a) ?[r(σ″)]

(52) To **whom** did **Kofi** give **an old watch**?
(52a) ?r_3(3x″)[r(σ″)]

(53)	**Who**	got	**an old watch**	from	**Kofi**?
	REFERENCE		CHANGE BEARER		CAUSER

(53a) ?r(3x″)[r(σ″)]

(54) **What** did **Kofi** give to **Kwame**?
(54a) ?r(x″)[r(σ″)]

(55) Was **an old watch** given to **Kwame** by **Kofi**?
(55a) ?r(Io″)[r(σ″)]

(56) Give **Kwame an old watch**.

(56′) **Kofi**, give **Kwame** **an old watch**.
CAUSER REFRENCE CHANGE BEARER

(56a) $—\bullet r_1(h'')[r(\sigma'')]$

(57) Let **Kofi** give **an old watch** to **Kwame**.

(57a) $—\bullet r_1(h'')[r(\sigma'')]$

(58) To **Kwame** , give an **old watch**.

(58′) **Kofi** , to **Kwame** , give **an old watch**.

(58a) $—\bullet r_1(h'')r_3(3h'')\ [r(\sigma'')]$

(59) How **Kofi** gave **an old watch** to **Kwame**!

(59a) $![r(\sigma'')]$

(60) What **an old watch Kofi** gave to **Kwame**!

(60a) $!r_2(Io'')\ [r(\sigma'')]$

In this Section we have constructed a formal language and then used it to formalize statements, questions, directives, and exclamations. Throughout the representation of meaning we have strictly adhered to the definitions of predicate types [BR], [ZR], [CE] , [KE] , [NA] , and [TA]. But right-hand and left-hand predicate embedding (in (29) - (60)) leads to more complex predicate types. In the next Sections we present a linguistic analogue of the Periodic Table of Chemical Elements.

4. PERIODIC TABLE OF SEMANTIC PREDICATES

In the Periodic Table of semantic Predicates, group membership accords with the sequence [ΣR] –[ΦE] – [ψA]. Period membership not only conforms to right-hand followed by left-hand predicate embedding but also the sequence [ΣR]-[ΦE] –[ψA].

THE PERIODIC TABLE OF SEMANTIC PREDICATES						
	Group I	Group II	Group III	Group IV	Group V	Group VI
Period 1	1[ΣR]	2[ΦE]	3[ψA]			
Period 2	4ΣR[ΣR]	5ΣR[ΦE]	6ΣR[ψA]	7[ΣR]ΣR	8[ΣR]ΦE	9[ΣR]ψA
Period 3	10ΦE[ΣR]	11ΦE[ΦE]	12ΦE[ψA]	13[ΦE]ΣR	14[ΦE]ΦE	15[ΦE]ψA
Period 4	16ψA[ΣR]	17ψA[ΦE]	18ψA[ψA]	19 [ψA]ΣR	20[ψA]ΦE	21[ψA]ψA
Period 5	22ΣR[ΣR[ΣR]]	23ΣR[ΣR[ΦE]]	24ΣR[ΣR[ψA]]	25[[ΣR]ΣR]ΣR	26[[ΣR]ΣR]ΦE	27[[ΣR]ΣR]ψA
Period 6	28 ΦE[ΣR[ΣR]]	29 ΦE[ΣR[ΦE]]	30 ΦE[ΣR[ψA]]	31[[ΦE]ΣR]ΣR	32[[ΦE]ΣR]ΦE	33[[ΦE]ΣR]ψA
Period 7	34ψA[ΣR[ΣR]]	35ψA[ΣR[ΦE]]	36ψA[ΣR[[ψA]]	37[[ψA]ΣR]ΣR	38[[ψA]ΣR]ΦE	39[[ψA]ΣR]ψA
Period 8	40ΣR[ΦE[ΣR]]	41ΣR[ΦE[ΦE]]	42ΣR[ΦE[ψA]]	43[[ΣR]ΦE]ΣR	44[[ΣR]ΦE]ΦE	45[[ΣR]ΦE]ψA
Period 9	46ΦE[ΦE[ΣR]]	47ΦE[ΦE[ΦE]]	48ΦE[ΦE[ψA]]	49[[ΦE]ΦE]ΣR	50[[ΦE]ΦE]ΦE	51[[ΦE]ΦE]ψA
Period 10	52ψA[ΦE[ΣR]]	53ψA[ΦE[ΦE]]	54ψA[ΦE[ψA]]	55[[ψA]ΦE]ΣR	56[[ψA]ΦE]ΦE	57[[ψA]ΦE]ψA
Period 11	58ΣR[ψA[ΣR]]	59ΣR[ψA[ΦE]]	60ΣR[ψA[[ψA]]	61[[ΣR]ψA]ΣR	62[[ΣR]ψA]ΦE	63[[ΣR]ψA]ψA
Period 12	64ΦE[ψA[ΣR]]	65ΦE[ψA[ΦE]]	66ΦE[ψA[ψA]]	67[[ΦE]ψA]ΣR	68[[ΦE]ψA]ΦE	69[[ΦE]ψA]ψA
Period 13	70ψA[ψA[ΣR]]	71ψA[ψA[ΦE]]	72ψA[ψA[ψA]]	73[[ψA]ψA]ΣR	74[[ψA]ψA]ΦE	75[[ψA]ψA]ψA

5. CONCLUSION

From the foregoing in Sections 3 and 4, we would like to draw very general rules of meaning representation. If we let

$$\mathbb{S} = \{f'', w'', d'', \ell'', t'', q'', n'', j''\}$$

$$\mathbb{E} = \{g'', a'', h'', m'', \tau'', \sigma'', \delta'', \omega''\}$$

$$\mathbb{H} = \{v'', u'', b'', i'', s'', p'', e'', c'', k''\}$$

and $\pi = [\Sigma R], [\Phi E], [\psi A]$

the rules can be formulated as follows:

(1) $r_1(x'')\ \mathrm{ZR}\ r_2(y'')$ with $x'' \in \mathbb{S}$, $y'' \in \mathbb{S}$

(2) $r_1(x'')\ \pi\ r_2(y'')$ with $x'' \in \mathbb{S}$, $y'' \in \mathbb{E}$

(3) $r_1(x'')\ \pi\ r_2(y'')$ with $x'' \in \mathbb{S}$, $y'' \in \mathbb{H}$

(4) $r_1(x'')\ \pi\ r_2(y'')$ with $x'' \in \mathbb{E}$, $y'' \in \mathbb{S}$

(5) $r_1(x'')\ \pi\ r_2(y'')$ with $x'' \in \mathbb{E}$, $y'' \in \mathbb{E}$

(6) $r_1(x'')\ \pi\ r_2(h''(y''))$ with $x'' \in \mathbb{E}$, $y'' \in \mathbb{H}$

(7) $r_1(h''(x''))\ \pi\ r_2(y'')$ with $x'' \in \mathbb{H}$, $y'' \in \mathbb{S}$

(8) $r_1(h''(x''))\ \pi r_2(y'')$ with $x'' \in \mathbb{H}$, $y'' \in \mathbb{E}$

(9) $r_1(h''(x''))\ \pi r_2(h''(y''))$ with $x'' \in \mathbb{H}$, $y'' \in \mathbb{H}$

These nine purportedly universal rules of meaning representation in conjunction with the periodic table of seventy five semantic predicates seem to logically , causally , or at least serendipitously , constitute an enticing prospect of being able to formalize semantic and pragmatic meaning shared by any given pair of source and target languages. It is extremely improbable that there is a natural language with at least a predicate that will be neither relative, causative, nor contactive.

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