

# Vector (Scalar) Field Analysis of Verbal Structures

## Abstract

This paper presents the analysis of basic verbal structures in terms of vector (scalar) space. Applying vector (scalar) methods to description of word meaning and basic syntax structures offers new methodological opportunities to interpret effect of semantic and pragmatic forces at morphology and syntax levels.

Human verbal perception reflecting internal and external features of object and action (event) presents specific complex phenomenon to be described in the framework quantum semantic space.

*Key words:* mental representation, semantic space, scalar, vector field, semantic value, cohesion, transformations, semantic gravity, quantum semantics.

## 1. Introduction

### 1.1. Methodological issues

Human verbal cognition has continuous and non-continuous properties. The study of the properties of isolated word is complementary to the study of word properties in syntax composition. This methodological assumption is an indication of the applicability of wave-particle duality to linguistics. In that's way the field theory is valid for description of a word in stationary (morphology) and dynamic (syntax) aspects. In verbal thinking human thought as an integer of brain energy is realized in semantic quants which at contextual level is associated with pragmatic effect and entropy. Description of brain energy as continuous functions is not coming to contradiction to an idea of discrete semantic units or quants in stationary states. In dynamic states semantic quants behaves as waves. Introducing notion of stationary and dynamic states means to refer to field theory. Spatio-analogical and temporal nature of mental representations can be described on the level of neural representations and on the level of abstract mental representations. (Schultheis, Bertel & Barkowsky, 2014) Semantic space as a kind human mental (cognitive) space is a basis to introduce the geometry of space in linguistics. The geometry of space in cognitive semantics (also neuro semantics) looks like the bridge connecting separate elements, structures and subregions (areas) of semantic space.

30 Idea of cognitive or mental space closely correlated with quantum semantics space which  
31 is represented by network structure of words, syntax constructions. Quantum semantics  
32 space is a framework to unified description of all components and interactions. (Jeffrey M.  
33 Schwartz, Henry P. Stapp, Mario Beauregard. 2005). Strong or weak field effect of  
34 semantic /pragmatic forces must be embedded in terms of quantum semantics relativity.  
35 In human cognitive space mental primitives of verbal thinking created vector spaces with  
36 its components (vectors), operations over the vector (scalar) field.

37 In cognitive space mental primitives are correlates of deep structures (Ch. Chomsky.  
38 1965). Basis of vector space consists of finite or infinite set of vectors. In cognitive space  
39 are notable scalar and vector fields and a non-linearity of mental spaces is an object of  
40 interpretation in terms of tensor space.

41 Stationary value of word and its realization in dynamic state (syntax structures) must be  
42 described by means of the vector scalar method. Words are considered as singularities of  
43 the field. But singularity of word corresponds to a point value as the source of field, for  
44 example, semantic field.

45 Conservation of word's value and its transformation are the product of the field.  
46 Description of a direct and indirect relations between words at a distance are object of  
47 vector-based analysis. Semantic/pragmatic value of word at distance in syntax  
48 composition can be computed in the framework of quantum semantics. Researchers in  
49 psychological and neuro-cognitive linguistics emphasized hypothetical idea that sequence  
50 regularities (word order regularities) reflect the relevance of intrinsic and extrinsic features  
51 of an object to verbal cognition. This is one of reasons to apply the principle of  
52 correspondence to study of verbal cognition in the framework of quantum semantics.  
53 (Werner Heisenberg. 1933, Stephen Hawking. 2011).

54 Scalar field in semantics must describe the potential semantic force and charged  
55 semantic components (as particles), in that's way scalar field is to describe interaction  
56 between words through a scalar. Complex semantic-pragmatic fields in 2-3 dimensions  
57 must be interpreted using second and third rank tensors. Semantic fields must be long-  
58 ranged and short-ranged as scalar fields depending on a scale of syntax structures.  
59 Question is about carriers of semantic field. Vector-based interpretation of referential

60 systems in different languages has theoretical perspectives because principle of  
 61 canonical orientation claims that intrinsic reference frames refers to canonical position  
 62 with respect to perceptual frame of orientation of the located object. (Burigo & Sacchi.  
 63 2013).

64 Question about narrow scope and wide scope reference (non-relative property as a color  
 65 is recognized faster than relative property as a size) presents an interest in terms of  
 66 vector (scalar) field of cognition. According to our consideration, semantic potential  
 67 (value) of a word is a scalar quantity and set of semantic values (potential) must be  
 68 assigned throughout a continuous region of semantic space. Since semantic value  
 69 (potential valency) is a scalar quantity, the field around it will be known as a scalar field.  
 70 At word level its semantic value or potential valency preferred to a measure of  
 71 components (words) to be combined with this word. Word as a component of syntax  
 72 structures (sentence) has vector quantity. The vector sum of all the forces (semantic and  
 73 pragmatic) acting on a word or sentence must be described as a net force:

$$F_{net} \sum_i F_i = F_1 + F_2 + F_3 + \dots$$

74 There is important to consider carriers of semantic and pragmatic forces. In quantum  
 75 semantics a word, semantic structure have nuclear and carrier components. Fundamental  
 76 interactions as a semantic and pragmatic forces, syntagmatic and paradigmatic forces  
 77 must be understood as the dynamics of (scalar or vector) field. Direct and non-direct  
 78 interactions between words at different distances and in different directions are closely  
 79 associated with ideas of quantum forces and fields.

80 In field theory word's value must be presented by the wave function ( $\Psi$ ) which is a  
 81 function of variables chosen to describe the word's behavior.  $\Psi = A\Psi = a\Psi$  where word  $A$   
 82 has the value  $a$  in the state given by  $\Psi$ . This idea is implied from quantum description of  
 83 the particle.

84 Dependence of value on position of word is observed in terms of word-word gravitation.  
 85 There is necessary to assume value density of word. Ideas of gravitation and magnetism  
 86 derived from physics are in agreement with description of semantic and pragmatic forces  
 87 in the framework of field theory. In linguistics cohesion between the two words excluding  
 88 noun (as a subject) and verb (as a predicate) is a kind of gravity. Gravity in linguistics is

89 semantic field and one of contact forces between the words. In linguistics gravitational  
90 force per unit must be referred to semantic value (or semantic weight) of a word.

91 Semantic relations between words in syntax structures must be described in terms of  
92 gravity (semantic gravity) and magnetism. Adjectives in relation to noun, adverbs in  
93 relation to verb must be described in terms of local gravity, but relations between noun  
94 (as a subject) and verb (as a predicate) is an object of analysis in terms of mutually  
95 dependent semantic magnetism.

96 There is applicable an idea of gravity  $F = \frac{G V_1 V_2}{r^2}$  where  $r$ -s the distance between the two  
97 values  $V_1$  and  $V_2$ . Idea of gravitational force per unit value (gravitational field strength  
98  $g = \frac{F}{V}$  is also useful for description of semantic field strength.

99 At the level of syntax structures semantic (in some case combined semantic and  
100 pragmatic) field is a framework to unify cohesion (gravity) between components of low-  
101 scale syntax structures. In that's way, we introduce the understanding of cohesion  
102 between components of low-scale syntax structure as a theoretical application based on  
103 classical idea of gravitation.

104 With simplification of the gravitation theory first, to take into account the fact that the  
105 semantic force is a vector quantity. Adding up a finite number of vectors is done in exactly  
106 the same way as it is done for two vectors-by taking and then adding components. If to  
107 introduce illocutive force, it is mainly theoretical enterprise based on quantum gravity  
108 which is important for analysis of large-scale verbal structures.

### 109 **1.2. Attributive (adjective-noun) constructions**

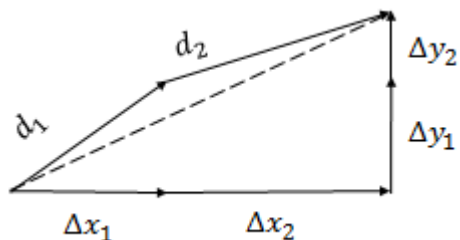
110 In the case of attributive structures its components are considered as a set of semantic  
111 values. Attributive constructions can be seen as a lower-dimensional multicomponent  
112 structures with respect to semantic gravity. These structures can be described on scalar  
113 or vector levels depending on number of dimensions. To a certain extent, semantic  
114 gravity started out a basis to quantum semantics theory.

115 Distance between two words (adjective and noun etc.) depends on force of semantic  
116 attraction between components (words) of syntax structure. Distance between  
117 components with mainly denotative semantic value (хар цамц, ном авах) must be

118 described in Euclidean space, distance between semantically transformed components  
 119 where connotative semantic value is emphasized must be presented as a kind of  
 120 Minkowski distance. Applicability of Hausdorff distance to description of semantically  
 121 transformed structures is a matter of discussion.

122 The magnitude of attributive components of noun phrase expressed in different forms  
 123 (adjective or noun: new red car of my friend, the boys easiest to teach) and components  
 124 of verb phrase in different forms (to speak clearly in a professional manner) must be  
 125 interpreted using Pythagorean Theorem. This theorem is applicable for adjective and  
 126 adverb components expressed in similar forms.

127 If the two components of syntax  
 128 construction be added are at right angles as shown below the magnitude (the resultant  
 129 vector) can be found by using Pythagorean Theorem.



$$d^2 = \Delta x^2 + \Delta y^2, \tan \theta = \frac{\Delta y}{\Delta x}$$

$$d = \sqrt{\Delta x^2 + \Delta y^2}, \theta = \tan^{-1} \frac{\Delta y}{\Delta x}$$

130 In attributive constructions a size, color, sharp, matter are features of object (noun  
 131 reference) and relations between attributive and object constituents are weak or strong in  
 132 terms of their cohesion. Position of the attributive components relative to the object must  
 133 be described in terms of scalar field if components have same direction. Scalar  
 134 multiplication is applied to structure components of attributive construction. Example of  
 135 scalar multiplication: *цэнхэр, улаан, шар бөмбөг (blue, red, yellow ball), black, green*  
 136 *tea, French, German and American cars.*

137 Resultant force of three constituents:

138  $\longrightarrow \longrightarrow \longrightarrow \quad 3N$

139 Vectors walking in the same direction but going a different distance:  $V_1 \quad V_2 \quad V_3 \rightarrow 0$ :

140 *Өндөр цагаан тоосгон байшин. (Tall white brick house.)*

141 Attributive structures (*Төмөр хаалгатай модон хашаа*. - *Wooden fences with iron door.*)  
 142 are described using addition of vector by components with same direction, but different  
 143 magnitude.

144  $R_x = A_x + B_x$   $\vec{R}$  is the vector sum (resultant) of  $\vec{A}$  and  $\vec{B}$

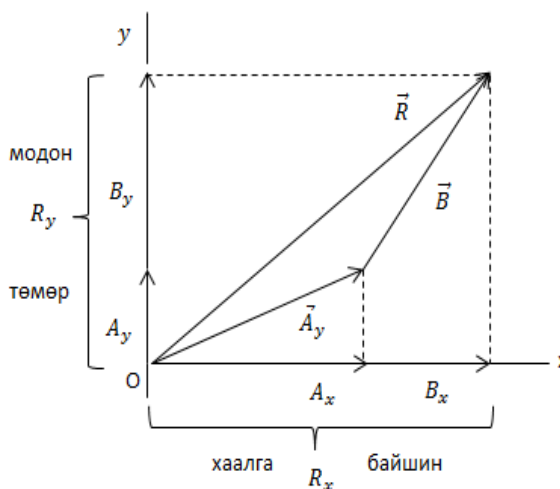
145  $R_y = A_y + B_y$

146 Magnitude of resultant:

147  $R = \sqrt{R_x^2 + R_y^2}$

148 Direction of resultant:

$$\theta_R = \tan^{-1} \frac{R_y}{R_x}$$



149 A-төмөр (хаалга)

150 B-модон (хашаа)

151 Combined effect of attributive components of noun phrase must be considered as  
 152 semantic value distributed over these components interacting with noun reference  
 153 (referent). All components of noun phrase being linearly ordered have a magnitude and  
 154 direction as a semantic value. The key idea is to integrate the total (perlocutionary) effect  
 155 of finite number of attributive components and to propose force (semantic) attraction  
 156 between attributive components and noun.

157 *Намхан шар модон байшин = намхан байшин + шар байшин + модон байшин,*

158 *Small yellow wooden house = small house + yellow house + wooden house*

159 Semantic values of first structure is a combined effect of semantic values of three  
 160 structures. So simultaneous effect of attributive components (намхан, шар, модон) can  
 161 be regarded as scalar waves in terms of quantum semantic gravity. This is only a case to  
 162 apply an idea of vector (scalar) field to semantics in correlation with theory of Quantum  
 163 consciousness and quantum mind. (Penrose, R. 1999).

164 Different interpretations of word and sentence sometimes depend on pragmatic's factors  
 165 which leads to an idea of complex scalar field (or vector field).

166 Complex scalar field is applicable to an analysis of structures *Залуу судлаач*

	<i>age</i>
	<i>experience</i>
	<i>sense of novelty</i>
	<i>new energy</i>

167

168

169 Perlocutionary act ( $W$ ) of illocutive force ( $F$ ) must be given by  $F(x)$ .

$$W = \int_a^b F(x)dx$$

170 Integral complex semantic value (space) (*White tall wooden house, brown tall wooden*  
 171 *box, brown wooden tall shoebox, Chinese hot green tea, genuine Japanese green tea.*)  
 172 can be described with means of dot and cross product. In addition to vector (scalar) field  
 173 analysis word order in typologically different languages must be described using idea of  
 174 abelian group as a commutative group in which result of applying the group operation to  
 175 two group elements does not depend on their order. So word orders such adjectives –  
 176 noun, noun – adjective, adverb – noun, noun-adverb and SOV, SVO are examples of  
 177 abelian group.

178 Vector multiplication also is applied to attributive structures with multiple directions of  
 179 cohesion:

180	Хар цамц – vector addition	- multiplying two vectors gives a scalar
181	Хар хайрцаг – black box	product (dot)
182	=	
183	Хар шөл – black (meat) soup	- multiplying two vectors gives a vector
184	Хар шөнө – black (no moon) night	product (cross)
185	Хар санаа – hostility idea	

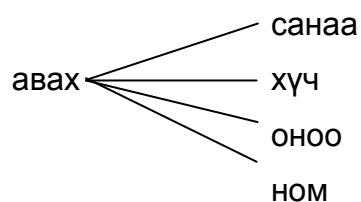
186 In attributive structures where semantic value of each component can be thought of as  
 187 waves combination of these attributive components must create superposition in  
 188 semantics. Structures expressing characteristics of action might be observed in terms of  
 189 geometry of perception in vector space: *High diving – manner of action*

190 *Прыжок в воду – object-oriented direction of action.*

### 191 1.3. Actional (verb-noun, noun-verb) constructions

192 Human conceptual system can distinguish two types of motion: manner-oriented and  
 193 path-oriented actions. In some cases manner and path can be encoded in the verb as  
 194 part of its core meaning reflecting basic features of action. It means that some action  
 195 verbs present an object of analysis in two dimensions. Syntax structures expressing  
 196 transitive action present a specific interest in terms of its vector-based description. In

197 these structures denotative component (meaning) is grounded and change in semantics,  
 198 connotative component, pragmatic meaning is conditioned by syntactic environment or  
 199 context. According to Van Dam, Bekkering. H, and Reuschmeyer, Sh. the motor  
 200 program typically associated with the word's referent if the context highlighted the typical  
 201 use of the object. (Wessel O. van Dam, Inti A. Brazil, Harold Bekkering, Shirley-Ann  
 202 Rueschemeyer. 2014). There is a semantic (and illocutive) force as a vector applied at  
 203 horizontal level. In structure with verbs having multiple meaning (avax) researches have  
 204 emphasized a distance between nouns related to verb.



205 Cosine distance between components  $\left( \cos(\theta) = \frac{A \cdot B}{\|A\| \|B\|} = \frac{\sum_{i=1}^n A_i \times B_i}{\sqrt{\sum_{i=1}^n (A_i)^2} \times \sqrt{\sum_{i=1}^n (B_i)^2}} \right)$  only

206 reflects similarity between components in terms of relative distributions. But there is  
 207 important to measure the coherence between components at syntagmatic level and  
 208 cosine distance must to define similarity between words at paradigmatic level.

209 In above named action structures verb (like avax) has not only magnitude, but a direction.  
 210 Vector dot product is applied to measure not only similarity between words but cohesion  
 211 between words which means gravitation degree between components of verbal  
 212 structures. Effect of combined semantic and pragmatic forces must be described in terms  
 213 of torque (cross product).  $\tan\theta$  is applied to determination of semantically or pragmatically  
 214 transformed meanings, to non-linear semantic/pragmatic transformations where a torque  
 215 is a product of complex semantic/pragmatic forces.

216

217

218 ширээ (career)

219 Pragmatic force

220 булаалдах ширээ (table)

Semantic force



221

222 *Булаалдах(to fight) ← шурээ (table, career)*223 *Угаах(to wash) → толгоу (mind, head)*

224 In some cases domination of pragmatic force leads to symbolic meaning and semantically  
 225 determined resistance which caused interference in verbal thinking, cardinaly different  
 226 (sometimes opposite) meanings and interpretations. Complex value of metaphoric  
 227 construction is an object of analysis in multidimensional space. For example,  
 228 constructions “од харвах + звезда упала (A star is falling) in Mongolian and Russian  
 229 language have apposite interpretations: (Somebody just died - New baby just born). So  
 230 non-linear association creating metaphoric constructions exists in multidimensional tensor  
 231 space. These examples are good illustration to an idea that conservation of word value  
 232 and its transformation are the product of the field and rules of verbal cognition do not  
 233 depend on our choice of coordinate system in human cognitive space. These rules are  
 234 invariant under mental transformations and thus semantic transformations relatively. Such  
 235 structures in some ways present a vector space of linear mapping and linear  
 236 transformation leading to homomorphism/ isomorphism of syntax structures.  
 237 Semantically/pragmatically originated curvature with regard to different types of  
 238 transformations reflect properties of reversibility/ irreversibility of mental processes. The  
 239 idea of reversibility marks back to the idea of entropy, which is measured by means of a  
 240 reversible processes. Interaction between verbal components (words) of lower and higher  
 241 value caused value distribution over verbal (syntax) construction. This interaction occurs  
 242 through semantic field leading to a decrease or to an increase of level of cohesion/  
 243 coherence.

244 In complex syntax structures illocutionary force comes into cohesion with semantic force  
 245 and combination of these forces has created complex semantic and pragmatic values as  
 246 a kind of “super” forces (or fields). Complex effect of semantic and pragmatic  
 247 transformations supports to an idea that in verbal cognition an attention and associative  
 248 perception have mainly vector quantities, intention has tensor quantity. It means that  
 249 human mental structures as primitives of verbal structures mainly present an object of  
 250 analysis in tensor space.

251 **2. Discussion & Conclusion**

252 Human mental space and verbal cognition present specific complex phenomena to be  
253 analyzed in terms of vector (scalar) field. Applying idea of quantum semantics to verbal  
254 cognition is an effective way to describe basic and high order verbal structures in terms of  
255 vector (scalar) and tensor fields. Different types of words comprise different vector  
256 spaces. Scalar-based description which is more effective than traditional component  
257 method was introduced to analyze word semantic value or potential valency. Low-scale  
258 syntax structures like adjective-noun, adverb-verb present object of interpretation on  
259 scalar level in terms of semantic gravity. Complex semantic effect of attributive  
260 components interacting with noun reference and regarded as scalar waves must be  
261 analyzed using scalar multiplication. Vector multiplication is applied effectively to analysis  
262 of attributive constructions with multiple directions of cohesion between components. In  
263 syntax structures expressing transitive action where semantic and pragmatic meanings  
264 are conditioned by context a cohesion between components (verb-noun) is described in  
265 terms of cosine (dot product). Vector cross product is applied to semantically and  
266 pragmatically originated curvature of syntax constructions with regard to linear  
267 transformations. In that's way a torque is effective to analyze semantic and pragmatic  
268 forces leading to non-linear transformations of syntax structures. Vector (scalar) based  
269 interpretation of word and syntax constructions presents new perspectives in neuro-  
270 cognitive linguistics.

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