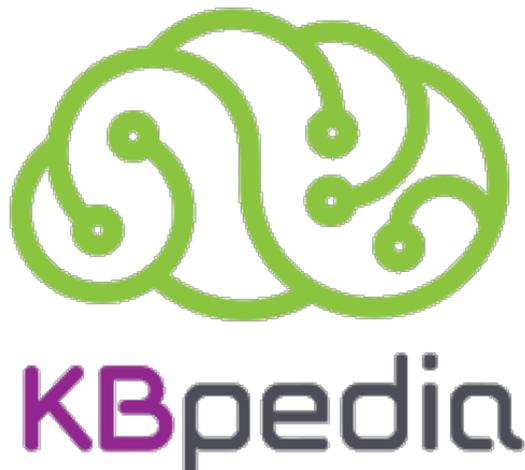# KBpedia Relations, Part III: A Three-Relations Model

by Mike Bergman - Wednesday, May 24, 2017

http://www.mkbergman.com/2045/kbpedia-relations-part-iii-a-three-relations-model/

Attributes, External Relations and Representations Form the Trichotomy

The forthcoming release of KBpedia version *1.50* deals primarily with the addition of a relations schema to the knowledge structure. In the previous part of this series, I discussed the event-action model at the heart of the schema. Actions are external relations between two objects, including parts, for which we use the variable shorthand of **A** and **B**. In terms of the universal categories of Charles Sanders Peirce [1], these dyadic relations are a Secondness that we formally term *External Relations*, or **A:B**.

But external relations do not constitute the complete family of relations. External relations are but one form of predicate we require. We need relations that cover the full range of language usage, as well as the entire scope of OWL properties. KBpedia is written in OWL2, which is the semantic ontology language extension of RDF. We need to capture the three types of properties in OWL2, namely object properties, datatype properties, and annotation properties.

In Peircean terms, we thus need relations that characterize the subject itself (**A:A**), which are mostly datatype properties, as well as statements about the subject (**re:A**), which are annotation properties. Most external relations are represented by object properties in OWL2, but sometimes datatype properties are also used [2].

We call relations of subject characterizations *Attributes*, and these are a Firstness within Peirce's universal categories. We call relations about the subject *Representations*, and these are a Thirdness within the universal categories. The purpose of this part in our series is to introduce and define these three main branches of relations -- *Attributes*, *External Relations*, and *Representations* -- within the KBpedia schema.

Nature of the Trichotomy

In accordance with the design basis of KBpedia, we use Peirce's universal categories and his writings on logic and semiosis (signs) to provide the intellectual coherence for the design. For the analysis of relations, two additional Peirce manuscripts were closely studied. The first manuscript is the first one on logic relations by Peirce in 1870, which goes by the shorthand of DNLR [3]. The second manuscript was from nearly 20 years later, known simply as the "Logic of Relatives" [4]. These two manuscripts deal with the ideas of internal and external relations, or the *Attributes* and *External Relations*, respectively, discussed above, and relate more to the predicate side of propositions. However, we also need to reference or point to the subjects of the proposition and to predicates, for which the *Representations* portion applies. Our need here was to organize a full breadth of relations in context with the universal categories, the needs of knowledge representation, and the structure of properties within OWL2 [5]. The result, we think, is consistent with the Peircean architectonic, but modernized for KR purposes.

For example, Peirce notes "the law of logic governs the relations of different predicates of one subject" (CP 1.485). In expanding on this law he states:

"Now logical terms are of three grand classes.

"The first embraces those whose logical form involves only the conception of quality, and which therefore represent a thing simply as "a ??". These discriminate objects in the most rudimentary way, which does not involve any consciousness of discrimination. They regard an object as it is in itself as such (quale); for example, as horse, tree, or man. These are absolute terms.

"The second class embraces terms whose logical form involves the conception of relation, and which require the addition of another term to complete the denotation. These discriminate objects with a distinct consciousness of discrimination. They regard an object as over against another, that is as relative; as father of, lover of, or servant of. These are simple relative terms.

"The third class embraces terms whose logical form involves the conception of bringing things into relation, and which require the addition of more than one term to complete the denotation. They discriminate not only with consciousness of discrimination, but with consciousness of its origin. They regard an object as medium or third between two others, that is as conjugative; as giver of ?? to ??, or buyer of ?? for ?? from ??. These may be termed conjugative terms.

"The conjugative term involves the conception of third, the relative that of second or other, the absolute term simply considers an object. No fourth class of terms exists involving the conception of fourth, because when that of third is introduced, since it involves the conception of bringing objects into relation, all higher numbers are given at once, inasmuch as the conception of bringing objects into relation is independent of the number of members of the relationship. Whether this reason for the fact that there is no fourth class of terms fundamentally different from the third is satisfactory of not, the fact itself is made perfectly evident by the study of the logic of relatives." (CP 3.63) [1]

We take the first "class" above as largely relating to the *Attributes*. The next two classes, including the conjugative terms, we relate to *External Relations*. To this we add the *Representations* as the Thirdness within our revised relations category. Each of these three categories is described more fully below with

further discussion as to the rationale for these splits.

We think this organization of relational categories is consistent with Peirce's thinking, even though he never had today's concepts of computerized knowledge representation as an objective for his analysis. For example, he labeled one of his major sections "The Conceptions of Quality, Relation and Representation, Applied to this Subject." (1867, "Upon Logical Comprehension and Extension"; CP 2.418) Thirty five years later, Peirce still held to this split,". . . there are but three elementary forms of predication or signification, which as I originally named them (but with bracketed additions now made to render the terms more intelligible) were qualities (of feeling), (dyadic) relations, and (predications of) representations." (1903, EP 424; CP 1.561)

And, of course, human intelligence and communication is a symbolic world. So, our computer-reasoning basis should also be geared to the manipulation of ideas, which in a knowledge context is the accumulation of (approximately) known false and known true assertions about the world. These are our statements or propositions or assertions. Peirce elaborates:

"Now every simple idea is composed of one of three classes; and a compound idea is in most cases predominantly of one of those classes. Namely, it may, in the first place, be a quality of feeling, which is positively such as it is, and is indescribable; which attaches to one object regardless of every other; and which is *sui generis* and incapable, in its own being, of comparison with any other feeling, because in comparisons it is representations of feelings and not the very feelings themselves that are compared [*Attributes*]. Or, in the second place, the idea may be that of a single happening or fact, which is attached at once to two objects, as an experience, for example, is attached to the experiencer and to the object experienced [*External Relations*]. Or, in the third place, it is the idea of a sign or communication conveyed by one person to another (or to himself at a later time) in regard to a certain object well known to both [*Representations*]." (CP 5.7) (Emphasis brackets added.)

Peirce's recommendations as to how to analyze a question proceed from defining the domain and its relations (the *speculative grammar*) to the logical analysis of it, including hypotheses about still questionable areas or emerging from new insights or combinations. The methods of this progression should be purposeful and targeted to produce a better likelihood of economic results or outcomes. This overall process he called the pragmatic maxim, and is a key insight into Peirce's reputation at the father of pragmatism.

The concepts above, then, represent our starting *speculative grammar* for how to organize the relations, including the choice of the three adics, or branches of the trichotomy [6]. We also set the guidance of how each adic branch may be analyzed and split according to the universal categories (which is the subject of the next Part IV in this series.)

Nature of Propositions and Predicates

In terms of Peirce's more formal definition of signs, a proposition is a *dicisign*, and it consists of a subject + predicate. (CP 2.316) A predicate is a *rhema* (CP 2.95). In terms of OWL2 with its RDF triples (*subject - property - object*), the predicate in this model is property + object, or a multitude of annotations that are representations of the subject. Further, "Every proposition refers to some index" (CP 2.369), that is its subject (also referred to as object). "Thus every kind of proposition is either meaningless or has a real

Secondness as its object." (CP 2.315) The idea of an individual type (or general) is also a Secondness [7]. "I term those occasions or objects which are denoted by the indices the **subjects** of the assertion." (CP 2.238) The assertion give us the basic OWL statement, also known as a triple.

A proposition captures a relation, which is the basis for the assertion about the 'subjects'. "Any portion of a proposition expressing ideas but requiring something to be attached to it in order to complete the sense, is in a general way relational. But it is only a **relative** in case the attachment of indexical signs will suffice to make it a proposition, or, at least, a complete general name." (CP 3.463) "But the Logic of Relations has now reduced logic to order, and it is seen that a proposition may have any number of subjects but can have but one predicate which is invariably general." (CP 5.151)

We now have the building blocks to represent the nature of the proposition:
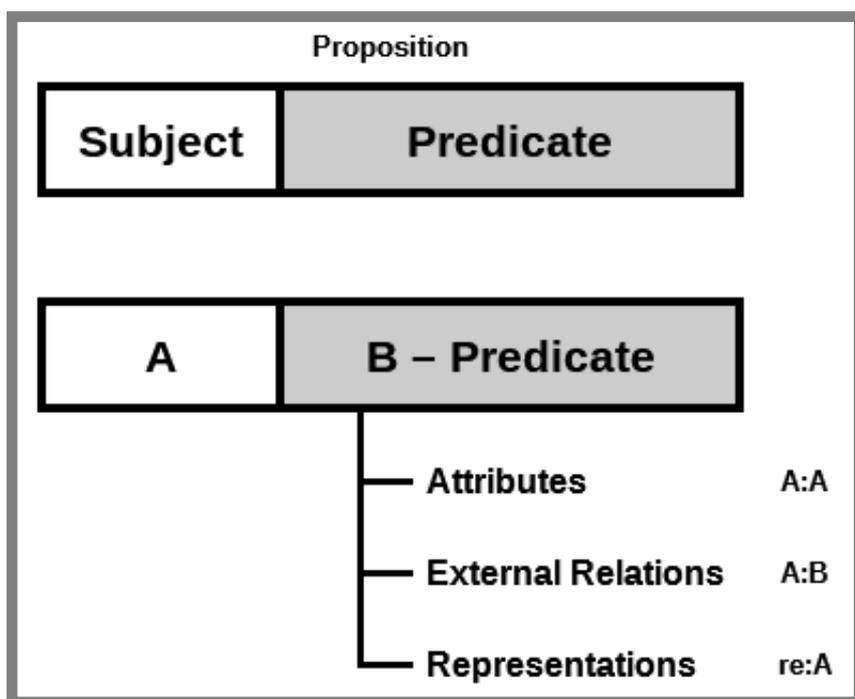
The Proposition Subject-Predicate Model

Subject(s) and a general predicate make up the proposition (statement, assertion). Subjects need to be individual things (including generals) and are defined, denoted and indicated by various indexical representations, including icons and images. Active predicates that may be reasoned over include the attributes (characteristics) of individual subjects or the relations between objects.

This basic structure also lends itself to information theoretics. "Every term has two powers or significations, according as it is subject or predicate. The former, which will here be termed its *breadth*, comprises the objects to which it is applied; while the latter, which will here be termed its *depth*, comprises the characters which are attributed to every one of the objects to which it can be applied." (CP 2.473) Peirce importantly defines the total *information* regarding a subject to consist of the "sum of synthetical propositions in which the symbol is subject or predicate, or the information concerning the

symbol." (CP 2.418) In other words, *information = breadth* x *depth*. We can reason over attributes and external relations, but our total information also consists in our representations.

These insights give us some powerful bases for defining and categorizing the terms or tokens within our knowledge space. By following these constructs, I believe we can extract the maximum information from our input content.

Definitions of the Relations

Best practice using semantic technologies includes providing precise, actionable definitions to key concepts and constructs. Here are the official statements regarding this trichotomy of relations.

Attribute Relations

Attributes are the intensional characteristics of an object, event, entity, type (when viewed as an instance), or concept. The relationship is between the individual instance (or Particular) and its own attributes and characteristics, in the form of A:A. Attributes may be intrinsic characteristics or essences of single particulars, such as colors, shapes, sizes, or other descriptive characteristics. Attributes may be adjunctual or accidental happenings to the particular, such as birth or death. Or, attributes may be contextual in terms of placing the particular within time or space or in relation to external circumstances.

Attributes are specific to the individual, and only include events that are notable for the individual. They are a Firstness, and in totality try to capture the complete characteristics of the individual particular, which is a Secondness.

These attributes are categorized according to these distinctions and grouped and organized into types, which will be presented in the [next part](#).

External Relations

External relations are assertions between an object, event, entity, type, or concept and another particular or general. An external relationship has the form of A:B. External relations may be simple ones of a direct relationship between two different instances. External relations may be copulative by combining objects or asserting membership, quantity, action or circumstance. Or, external relations may be mediative to provide meaning, context, relevance, generalizations, or other explanations of the subject with respect to the external world. External relations are extensional.

External relations are by definition a Secondness. These external relations are categorized according to these distinctions and grouped and organized into types, which will be presented in the [next part](#).

The events discussion in the [previous Part II](#) pertained mostly to external relations.

Representational Relations

Representations are signs (CP 8.191), and the means by which we point to, draw or direct attention to, or designate, denote or describe a particular object, entity, event, type or general. A representational

relationship has the form of re:A. Representations can be designative of the subject, that is, be icons or symbols (including labels, definitions, and descriptions). Representations may be indexes that more-or-less help situate or provide traceable reference to the subject. Or, representations may be associations, resemblances and likelihoods in relation to the subject, more often of indeterminate character.

The representational relation includes what is known as annotations or metadata in other contexts, such as images, links, labels, descriptions, pointers, references, or indexes. Representations can not be reasoned over, except abductive reasoning, but some characteristics may be derived or analyzed through non-inferential means.

These representations are categorized according to these distinctions and grouped and organized into types, which will be presented in the next part.

Summary of the Three Relations

We can now pull these threads together to present a summary chart of these three main relational branches:

			Definition
inference — relations — assertions — facts	Attributes	A:A	Attributes are the intensional characteristics of an object, event, entity, type (when viewed as an instance), or concept. The relationship is between the individual instance (or Particular) and its own attributes and characteristics, in the form of A:A. Attributes may be intrinsic characteristics or essences of single particulars, such as colors, shapes, sizes, or other descriptive characteristics. Attributes may be adjunctual or accidental happenings to the particular, such as birth or death. Or, attributes may be contextual in terms of placing the particular within time or space or in relation to external circumstances. These attributes have been categorized according to these distinctions and grouped and organized into types.
	External Relations	A:B	External relations are assertions between an object, event, entity, type, or concept and another particular or general. An external relationship has the form of A:B. External relations may be simple ones of a direct relationship between two different instances. External relations may be copulative by combining objects or asserting membership, quantity, action or circumstance. Or, external relations may be mediative to provide meaning, context, relevance, generalizations, or other explanations of the subject with respect to the external world. External relations are extensional. These external relations have been categorized according to these distinctions and grouped and organized into types.
	Representations	re A	Representations are signs, and the means by which we point to, draw or direct attention to, or denote or describe a particular object, entity, event, type or general. A representational relationship has the form of re:A. Representations can be denotative of the subject, that is, be icons or symbols (including labels, definitions, and descriptions). Representations may be indexes that more-or-less help situate or provide traceable reference to the subject. Or, representations may be associations, resemblances and likelihoods in relation to the subject, more often of indeterminate character. These representations have been categorized according to these distinctions and grouped and organized into types.

KBpedia Three Relations Model

This trichotomy sets the boundaries and affirms the method by which further sub-divisions will be presented in the next installment in this series.

A Strong Relation Schema

We now have a much clearer way for how to build up the assertions in our knowledge representations, according to linguistic predicate construction and predicate calculus. We can now explicitly state a premise underlying our choice of Peirce and his architectonic for the design of KBpedia: it is the most accurate, expressive basis for capturing human language and logical reasoning, both individually and together. Our ability to create new symbolic intelligence from human knowledge requires that we be able to compute and reason over human language.

In the next part we will establish sub-categories for each of these three branches according to the universal categories [8].

This series on KBpedia relations covers topics from background, to grammar, to design, and then to implications from explicitly representing relations in accordance to the principals put forth through the universal categories by Charles Sanders Peirce. Relations are an essential complement to entities and concepts in order to extract the maximum information from knowledge bases. This series accompanies the next release of KBpedia (*v 150*), which includes the relations enhancements discussed.

---

[1] Peirce citation schemes tend to use an abbreviation for source, followed by volume number using Arabic numerals followed by section number (such as CP 1.208) or page, depending on the source. For CP, see the electronic edition of *The Collected Papers of Charles Sanders Peirce, reproducing Vols. I-VI*, Charles Hartshorne and Paul Weiss, eds., 1931-1935, Harvard University Press, Cambridge, Mass., and Arthur W. Burks, ed., 1958, Vols. VII-VIII, Harvard University Press, Cambridge, Mass. For EP, see Nathan Houser and Christian Kloesel, eds., 1992. *The Essential Peirce - Volume 1, Selected Philosophical Writings, (1867–1893)*, Indiana University Press, 428 pp. For EP2, see The Peirce Edition Project, 1998. *The Essential Peirce - Volume 2, Selected Philosophical Writings, (1893-1913)*, Indiana University Press, 624 pp.

[2] *Attributes*, *External Relations* and *Representations* comprise OWL properties. In general, **Attributes** correspond to the OWL datatypes property; *External Relations* to the OWL object property; and *Representations* to the OWL annotation properties. These specific OWL terms are not used in our speculative grammar, however, because some attributes may be drawn from controlled vocabularies, such as colors or shapes, that can be represented as one of a list of attribute choices. In these cases, such attributes are defined as object properties. Nonetheless, the mappings of our speculative grammar to existing OWL properties is quite close. In the actual KKO, these labels are replaced with AttributeTypes, RelationTypes, and RepresentationTypes, respectively, when talking about Generals, to conform to the typing terminology of the ontology.

[3] C.S. Peirce, 1870. "Description of a Notation for the Logic of Relatives, Resulting from an Amplification of the Conceptions of Boole's Calculus of Logic", *Memoirs of the American Academy of Arts and Sciences* 9, 317–378, 26 January 1870. Reprinted, *Collected Papers* (CP3.45–149), *Chronological Edition* (CE2, 359–429).

[4] C.S. Peirce, 1897. "Logic of Relatives," *The Monist* Vol VII, No 2, pp. 161-217. See https://ia801703.us.archive.org/12/items/jstor-27897407/27897407.pdf

[5] The attributes-relation split has been a not uncommon one in the KB literature, insofar as such matters are discussed. For example, see Nicola Guarino, 1997. "Some Organizing Principles for a Unified Top-level Ontology," in *AAAI Spring Symposium on Ontological Engineering*, pp. 57-63. 1997. Also, see Yankai Lin, Zhiyuan Liu, and Maosong Sun, 2016. "Knowledge Representation Learning with Entities, Attributes and Relations." *ethnicity* 1 (2016): 41-52; the authors propose splitting existing KG-relations into attributes and relations, and propose a KR model with entities, attributes and relations (KR-EAR).

[6] See further M.K. Bergman, 2016. "A Speculative Grammar for Knowledge Bases", *AI3:::Adaptive Information* blog, June 20, 2016.

[7] Peirce recognized the importance of being able to talk of the individual type or general as an object in itself. It was only until the revision of OWL2 that such punning was added to the OWL language.

[8] Some additional useful quotes from Peirce related to this topic of relations and these splits are (with emphases per the originals):

- "Whether or not every proposition has a principal subject, and, if so, whether it can or cannot have more than one, will be considered below. A proposition may be defined as a sign which separately indicates its object. For example, a portrait with the proper name of the original written below it is a proposition asserting that so that original looked. If this broad definition of a proposition be accepted, a proposition need not be a symbol. Thus a weathercock "tells" from which direction the wind blows by virtue of a real relation which it would still have to the wind, even if it were never intended or understood to indicate the wind. It separately indicates the wind because its **construction** is such that it must point to the quarter from which the wind blows; and this construction is distinct from its **position** at any particular time. But what we usually mean by a proposition or judgment is a symbolic proposition, or **symbol**, separately indicating its object. Every subject partakes of the nature of an index, in that its function is the characteristic function of an index, that of forcing the attention upon its object. Yet the subject of a symbolic proposition cannot strictly be an index. When a baby points at a flower and says, "Pretty," that is a symbolic proposition; for the word "pretty" being used, it represents its object only by virtue of a relation to it which it could not have if it were not intended and understood as a sign. The pointing arm, however, which is the subject of this proposition, usually indicates its object only by virtue of a relation to this object, which would still exist, though it were not intended or understood as a sign. But when it enters into the proposition as its subject, it indicates its object in another way. For it cannot be the subject of that symbolic proposition unless it is **intended** and understood to be so. Its merely being an index of the flower is not enough. It only becomes the subject of the proposition, because its being an index of the flower is evidence that it was intended to be. In like manner, all ordinary propositions refer to the real universe, and usually to the nearer environment. Thus, if somebody rushes into the room and says, "There is a great fire!" we know he is talking about the neighbourhood and not about the world of the **Arabian Nights' Entertainments**. It is the circumstances under which the proposition is uttered or written which indicate that environment as that which is referred to. But they do so not simply as index of the environment, but as evidence of an intentional relation of the speech to its object, which relation it could not have if it were not intended for a sign. The expressed subject of an ordinary proposition approaches most nearly to the nature of an index when it is a proper name which, although its connection with its object is purely intentional, yet has no reason (or, at least, none is thought of in using it) except the mere desirability of giving the familiar object a designation." (CP 2.357)
- "But it remains to point out that there are usually two Objects, and more than two Interpretants. Namely, we have to distinguish the Immediate Object, which is the Object as the Sign itself represents it, and whose Being is thus dependent upon the Representation of it in the Sign, from the Dynamical Object, which is the Reality which by some means contrives to determine the Sign to its Representation. In regard to the Interpretant we have equally to distinguish, in the first place, the Immediate Interpretant, which is the interpretant as it is revealed in the right understanding of the Sign itself, and is ordinarily called the meaning of the sign; while in the second place, we have to take note of the Dynamical Interpretant which is the actual effect which the Sign, as a Sign, really determines. Finally there is what I provisionally term the Final Interpretant, which refers to

the manner in which the Sign tends to represent itself to be related to its Object. I confess that my own conception of this third interpretant is not yet quite free from mist." (CP 4.536)

- "A rhema which has one blank is called a **monad**; a rhema of two blanks, a **dyad**; a rhema of three blanks, a **triad**; etc. A rhema with no blank is called a **medad**, and is a complete proposition. A rhema of more than two blanks is a **polyad**. A rhema of more than one blank is a **relative**. Every proposition has an **ultimate predicate**, produced by putting a blank in every place where a blank can be placed, without substituting for some word its definition." [CP 4.438]

- "Hence, as soon as we admit the idea of absurdity, we are bound to class the rejection of an argumentation among argumentations. Thus, as was said, a proposition is nothing more nor less than an argumentation whose propositions have had their assertiveness removed, just as a term is a proposition whose subjects have had their denotative force removed." (CP 2.356)

- "The only way of directly communicating an idea is by means of an icon; and every indirect method of communicating an idea must depend for its establishment upon the use of an icon. Hence, every assertion must contain an icon or set of icons, or else must contain signs whose meaning is only explicable by icons. The idea which the set of icons (or the equivalent of a set of icons) contained in an assertion signifies may be termed the **predicate** of the assertion." (CP 2.278)

- "Thus, we have in thought three elements: first, the representative function which makes it a *representation*; second, the pure denotative application, or real connection, which brings one thought into *relation* with another; and third, the material quality, or how it feels, which gives thought its quality.†" (CP 5.290)

- "Every informational sign thus involves a Fact, which is its Syntax. It is quite evident, then, that Indexical Dicisigns equally accord with the definition and the corollaries." (CP2.320)

- "The monad has no features but its suchness, which in logic is embodied in the signification of the verb. As such it is developed in the lowest of the three chief forms of which logic treats, the term, the proposition, and the syllogism." (CP 1.471)

- "The unity to which the understanding reduces impressions is the unity of a proposition. This unity consists in the connection of the predicate with the subject; and, therefore, that which is implied in the copula, or the conception of being, is that which completes the work of conceptions of reducing the manifold to unity." [CP 1.548]

- "This search resulted in what I call my categories. I then named them Quality, Relation, and Representation. But I was not then aware that undecomposable relations may necessarily require more subjects than two; for this reason **Reaction** is a better term. Moreover, I did not then know enough about language to see that to attempt to make the word **representation** serve for an idea so much more general than any it habitually carried, was injudicious. The word **mediation** would be better." (CP 4.3)

- "Every thought, or cognitive representation, is of the nature of a sign. "Representation" and "sign" are synonyms. The whole purpose of a sign is that it shall be interpreted in another sign; and its whole purport lies in the special character which it imparts to that interpretation." (CP 8.191)

PDF generated by *AI3:::Adaptive Information* blog