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**Abstract:** The connections of Peirce's sign theory, his three-fold logic of deduction-induction-abduction, the importance of the scientific method, and his understanding about a community of inquiry have all fed my intuition that Peirce was on to some fundamental insights suitable to knowledge representation. This knowledge representation is like Peirce's categorization of science or signs but is broader still in needing to capture the nature of relations and attributes and how they become building blocks to predicates and assertions. Scholars of Peirce acknowledge how infused his writings on logic, semiosis, philosophy, and knowledge are with the idea of 'threes'.

## 6

# THE UNIVERSAL CATEGORIES

Knowledge representation has the mission to capture human knowledge and then be able to reason over it, in a form understandable to its designers, us humans, and interpretable by a Turing complete computer. The ability to represent natural (human) language and the ability to capture all basic logical premises and arguments are core KR requirements. As in human language, where we split our words into roughly nouns and verbs and modifiers and conjunctions of the same, we need a similar primitive vocabulary and rules for constructing statements. These basic building blocks are known as the *grammar* of the KR language. We then need to embed a well-considered grammar into formal, standardized languages that computers can readily interpret, backed with tools and a user community capable of exercising them to achieve our purposes. The three chapters in this *Part II* specifically talk to these needs.

Our KR language should represent how we, as humans, think about, organize, and reason about our world. Our KR language needs to address, as discussed in *Chapter 4*, the significant opportunities for data interoperability and artificial intelligence (machine learning and reasoning). To achieve these purposes, we need to integrate knowledge bases to provide the information pool and the testable bases upon which the KR language operates. To reason over this knowledge, we need a logical foundation that is consistent and coherent, for which we look to Peirce.<sup>1</sup> We begin, in this chapter, with a grounding based on Peirce's universal categories, then introduce our KR grammar in *Chapter 7* and our KR languages and models in *Chapter 8*.

## A FOUNDATIONAL MINDSET

Historically, Peirce is known as the father of *pragmatism* (*pragmaticism*, his preferred term). The ideas behind Peircean pragmatism are how to: think about signs and representations (*semiosis*); logically reason and handle new knowledge (*abduction*) and probabilities (*induction*); make economic research choices

(pragmatic maxim); categorize; and let the scientific method inform our inquiry. All of these contributions are grounded in Peirce's *universal categories* of *Firstness*, *Secondness*, and *Thirdness*. Herein lies the key to being informed by Peirce when it comes to representing new knowledge, categorization, or problem-solving. It is the mindset of *Thirdness* and the nature of *Firstness* and *Secondness* that provides that guidance.

### ***A Common Grounding in Peirce***

The essence of knowledge is that it is ever-growing and expanding. New insights bring new relations and new truths. The structures we use to represent this knowledge must themselves adapt and reflect the best of our current, testable understandings. We want a foundation to the KR language that can capture reality, from cosmology to thought, process, and action. We need a grammar expressed in computer-readable languages that can capture the possibilities and current facts of today, plus new potentials arising from emerging knowledge. We want open and standard computer-readable languages to encourage broader adoption and therefore greater availability of toolsets and expertise. For interoperability, the scaffolding, or knowledge graph at the heart of the system, must have the flexibility to model any knowledge domain, from math and philosophy to lifeforms, society, and technologies. Eventually, we want to express these capabilities in cost-effective, deployable platforms with acceptable maintenance costs and long service lives.

We want to link or integrate existing knowledge bases. That requirement means supporting formats and mapping methods to facilitate the exchange. More importantly, we need a knowledge representation framework and grammar for adapting or growing the knowledge graph, matching objects, attributes, referents, and relations. The framework needs to follow a grammar that enables making and testing logical statements, along with inferencing and other reasoning. We want to construct this entire scaffolding in such a way that we capture all relevant features to provide a rich structure for machine learners.

Studying Peirce is hard. This difficulty is partly the result of Peirce. In his quest for precision in terminology, Peirce has created a unique vocabulary, sometimes jaw-breaking, often with multiple terms that change over time for specific concepts. The difficulty partly comes from the cacophony of views about what Peirce did or intended to say. Complications also arise from the fragmentation of his manuscripts, some still unpublished, and sometimes confused chronologies that have, at times, led to questionable scholarship. I do not doubt that scholars will continue to tease out profound insights from Peirce, likely for centuries to come.\*

Peirce believed in the *real* as that which is as it is apart from what anyone thinks about it, a refutation of Descartes' view. He believed in *truth*, which the scientific method and social consensus (agreement of signs) can increasingly reveal, but current belief as to what is 'truth' is fallible and can never be realized in the absolute (it is a limit function). Distance and possible different understandings arise in the inter-

\* See *Appendix A* for further perspectives on Peirce.

play of the object, its representation, and its interpretation.\* Better approximations of truth come from questioning using the scientific method (via a triad of logics) and from refining consensus within the community about how (via language signs) we communicate that truth. Peirce termed this overall approach, pragmatism, in which he firmly grounded his logics and theory of signs. Through the scientific method and questioning, we may get closer to the truth and to an ability to communicate it to one another, even though absolute ‘truth’ may require infinite inquiry by an infinite community. At any point, new knowledge may change the basis of our truth-seeking.

The connections of Peirce’s sign theory, his three-fold logic of *deduction-induction-abduction*, the importance of the scientific method, and his understanding about a community of inquiry have all fed my intuition that Peirce was on to some fundamental insights suitable to knowledge representation. Peirce’s writings instruct us that, *firstly*, we need to embrace terminology that is precise for concepts and relations to communicate effectively within our communities. *Secondly*, we need to capture the right particular things of concern in our knowledge domain and connect them using those relations.† *Thirdly*, we need to organize our knowledge domain by general types based on logical, shared attributes, and embrace a process for expanding that structure with acceptable effort to deal with new or emergent information.

### ***Truth is Testable and Fallible***

Peirce’s time, as is our own, was one of great scientific advance and challenges to conventional understanding. During Peirce’s professional lifetime, advances were occurring in the knowledge of waves and fields, the chemical periodic table, evolution, electricity, and thermodynamics and gases. Given this ferment, it is clear why Peirce’s worldview supported the ideas of the potential fallibility of understood ‘truth,’ and the fact that truth itself stood upon a gradation of certainty.

Completeness of information and completeness of understanding are each, themselves, ideals. We strive for them, but we never can fully achieve them. While we may reach sufficient certitude to bring about belief, itself an essential motivator in this question, we will never entirely achieve it. ‘Truth,’ then, is ultimately (as a continuous limit function) unachievable. However, ‘belief,’ which guides our actions, may be achieved, and thus should be the objective of our inquiries. Any scientist spending much time on Peirce’s writings would quickly affirm that, in nature, Peirce is a scientist. His insights and attention are grounded in science. His understandings of measurement and error and precision are those of a scientific practitioner.

### ***Upper Ontologies, Context, and Perspective***

Some form of conceptual schema governs every knowledge structure used for knowledge representation (KR). In the semantic Web, such schema are known as *on-*

\* But this same logic provides the explanation for the process of categorization, also grounded in Firstness, Secondness, Thirdness; see *Chapter 10*.

† This approach naturally leads to a knowledge graph structure.

ologies, since they attempt to capture the nature or *being* (Greek ὄντως, or ontós) of the knowledge domain at hand. Because the word ‘ontology’ is a bit intimidating, a better variant is the *knowledge graph* (because all semantic ontologies take the structural form of a graph). In general knowledge domains, we call such schema upper ontologies. However, one of the first things we see with existing ontologies is that they are organized around a single, dyadic dimension, even though guided by a diversity of conceptual approaches. For example, in the venerable *Cyc* knowledge structure, one of the major divisions is between what is tangible and what is intangible. In BFO, the *Basic Formal Ontology*, the split is between a ‘snapshot’ view of the world (*continuant*) and its entities versus a ‘spanning’ view that is explicit about changes in things over time (*occurent*). Other upper ontologies have dyadic splits such as abstract v. physical, perdurant v. endurant, dependent v. independent, particulars v. universals, or determinate v. indeterminate.<sup>2 3</sup>

Except for Sowa’s ontology,<sup>4</sup> none of the standard upper ontologies embrace any semblance of Peirce’s triadic perspective. Further, even Sowa’s ontology only partially applies Peircean principles.<sup>2</sup> Such Cartesian dichotomies become the basis for arguments between their proponents. Moreover, a Cartesian and nominalistic view is precisely what is wrong with these viewpoints. Our states and phenomena are not on and off, but are probable or graded, likely or nuanced, or often shaded. Due to Cartesian thinking, we do not question why we continually apply a dichotomous schema to real-world phenomena. Knowledge, Peirce tells us, is a Thirdness, and therefore has context and perspective, continuity and generality.<sup>5</sup> Peirce was not so much a superhuman of intellect, but more that he rooted out what we need to question in our premises, using sound logic to tease out insight and make questions simpler.

We design ontologies for specific purposes, and the bases for these splits in other ontologies have their rationales and uses. Where the design objective for the ontology is *knowledge representation*, as it is here, we need to model the nature of knowledge explicitly. Knowledge, too, is not black and white, nor is it shades of gray along a single dimension or lacking color. Knowledge is an incredibly rich construct intimately related to context and perspective, with various degrees of vibrancy and nuance. The minimum cardinality that can provide such a perspective is three.

### ***Being Attuned to Nature***

The fierce realism that Peirce adopted and advocated, strongest in his later years, was premised on a belief of natural evolution and how its tendencies express themselves in nature. He mostly thought and wrote regarding the symbolic world, but he knew that was a continuation of the life and matter that precedes it. Nathan Houser, the profound Peirce researcher and keeper of the flame for many years, astutely observed:

“He [Peirce] had come to believe that attunement to nature was the key to the advancement of knowledge—as it was for life itself—and he thought that: the power to guess nature’s ways was one of the great wonders of the cosmos. Just as with animals, whose instinct enables them to ‘rise far above the general level of their intelligence’ in

performing their proper functions, so it is with humans, whose proper function, Peirce insisted, is to embody general ideas in art-creations, in utilities, and above all in theoretical cognition. But if attunement to nature is the key to the advancement of knowledge, it is at most a necessary condition; it puts thought on the scent of truth, which, to attain, must be won by skilled reasoning.”<sup>6</sup>

The importance of studying Peirce is to tease out those principles, design bases, and mindsets that can apply Peircean thinking to the modern challenge of knowledge representation. This knowledge representation is like Peirce’s categorization of science or signs but is broader still in needing to capture the nature of relations and attributes and how they become building blocks to predicates and assertions. In turn, these constructs should be systematized and subjected to logical tests to provide a defensible basis for what is knowledge and truth given current information. Then, all of these representations should be put forward in a manner (symbolic representation) that is machine readable and computable.

Peirce had insights and guidance on every single aspect of these broader KR problems. The objective has been how to take these piece parts and recombine them into a coherent whole that is consistent with Peirce’s *architectonic*.<sup>7</sup> How can Peirce’s thinking be decomposed into its most primitive assumptions to build up a new KR representation? Knowledge representation by computers that does not explicitly account for perspective, meaning, and interpretation is doomed as wooden and unable to handle context. We do not all need to agree on the specifics or any single interpretation of what our domains of inquiry may be. However, we do need a framework that can respect and model those differences. One of Peirce’s most famous admonitions is “there follows one corollary which itself deserves to be inscribed upon every wall of the city of philosophy: Do not block the way of inquiry.” (1898, CP 1.135) Knowledge representations based on dichotomous choices do just that.

## FIRSTNESS, SECONDNESS, THIRDNES

“A very moderate exercise of this third faculty suffices to show us that the word Category bears substantially the same meaning with all philosophers. For Aristotle, for Kant, and for Hegel, a category is an element of phenomena of the first rank of generality. It naturally follows that the categories are few in number, just as the chemical elements are. The business of phenomenology is to draw up a catalogue of categories and prove its sufficiency and freedom from redundancies, to make out the characteristics of each category, and to show the relations of each to the others.” (1903, EP 2:148)

Scholars of Peirce acknowledge how infused his writings on logic, semiosis, philosophy, and knowledge are with the idea of ‘threes.’ His insights are perhaps most studied regarding his *semiosis of signs*,\* with the triad formed by the object, representation, and interpretation. Peirce studied and wrote on what makes ‘threes’ essential and irreducible. His generalization, or abstraction if you will, he called simply

\* See further *Chapter 2* and the section *What is Representation?*

the ‘*universal categories*,’ and to reflect their fundamental nature, called each separately as *Firstness*, *Secondness*, and *Thirdness*. In his writings over decades, he related or described this trichotomy in dozens of contexts.\* We have adopted this naming, so also call the triad of the three categories of Firstness, Secondness, and Thirdness the *universal categories*.<sup>8</sup>

### ***Constant Themes of Three***

Trichotomies and triads permeate Peirce’s theories and writings in logic, realism, categories, cosmology, and metaphysics.<sup>73</sup> He termed this tendency and its application in general as first, second, and third. In Peirce’s words:

“The first is that whose being is simply in itself, not referring to anything nor lying behind anything. The second is that which is what it is by force of something to which it is second. The third is that which is what it is owing to things between which it mediates and which it brings into relation to each other.” (1897, CP 2.356)

Peirce’s fascination with threes is not unique. Scholastic philosophers, ranging from Duns Scotus and the Modists from medieval times to John Locke and Immanuel Kant with his three formulations, and Hegel with his triad, expressed much of their thinking in threes. As Locke wrote in 1690:<sup>9</sup>

“The ideas that make up our complex ones of corporeal substances are of three sorts. First, the ideas of the primary qualities of things, which are discovered by our senses, and are in them even when we perceive them not; such are the bulk, figure, number, situation, and motion of the parts of bodies which are really in them, whether we take notice of them or no. Secondly, the sensible secondary qualities which, depending on these, are nothing but the powers these substances have to produce several ideas in us by our senses; which ideas are not in the things themselves otherwise than as anything is in its cause. Thirdly, the aptness we consider in any substance to give or receive such alteration of primary qualities, as that the substance, so altered should produce in us different ideas from what it did before.”

### ***Summary of the Universal Categories***

The first hurdle, I think, in attempting to understand Peirce’s universal categories is the absolute abstractness of the terms Firstness, Secondness, and Thirdness. In this case, I believe Peirce’s terminology fussiness is proper. Since, ultimately, according to Peirce, all reality, all potential, and all emergence derives from these elements, nothing other than one, two and three will do. Everything that is, may be, or could surprise us arises from these elements. Nothing further can be decomposed from these elements, yet everything that is and is conceivable is built from these categories.

Across his voluminous writings, summarized across the listings in *Table 6-2*, I glean this summary understanding of Peirce’s three categories from the standpoint

\* See later *Table 6-2*.

of knowledge representation:

- *Firstness* [1ns] — these are *possibilities*, a ‘state’ of experience wholly in the absolute present, which are basic ‘monadic’ qualities that may combine in various ways to enable the real things we perceive in the world. They are unexpressed potentialities, the substrate of the real and actual. These are the unrealized essences or attributes or possible juxtapositions; indeed, “these” and “they” are misnomers because, once conceived, the elements of Firstness are no longer Firstness.<sup>10</sup> In the sense of categorization, think of Firstness as the universe of ideas or possibilities that might be brought to bear for the new category of inquiry;
- *Secondness* [2ns] — these are the *particular realized things, events or concepts* in the world, what we can perceive, point to and describe (including the idea of Firstness and Thirdness). All *particulars* are in Secondness and may be known as an entity, event, instance or individual. In the sense of categorization, we can understand Secondness as the particular instances that may populate the information space for the category, including the ideas of attributes and relations; and
- *Thirdness* [3ns] — these are the *laws, habits, thoughts, regularities or continuities* that may be generalized from particulars. All *generals* — what are also known as classes, kinds or types — belong to this category, as do all regularities, patterns, or logical groupings, or any combinations thereof. Changes in Firstness or Secondness are reasoned over in Thirdness, beginning the process anew. The method of finding and deriving these generalities may also lead to new insights or emergent properties, which, combined with absolute chance, are the source of what Peirce called the ‘surprising fact.’

We can summarize Peirce’s universal categories like this:

Name	Characterization	What	Quantity	How Defined	Valence
Firstness	Quality of feeling	Ideas, chance, possibility	Vagueness, ‘some’	Reference to a ground (pure abstraction of a quality)	Monadic
Secondness	Reaction, resistance, relation	Entities, events, brute facts, actuality	Singularity, discreteness, ‘this’	Reference to a correlate (by its relate)	Dyadic
Thirdness	Representation, mediation	Signs, habits, laws, necessity	Generality, continuity, ‘all’	Reference to an <i>interpretant</i>	Triadic

Table 6-1: Peirce's Universal Categories\*<sup>11</sup>

Understanding, inquiry, and knowledge require this irreducible structure; connections, meaning, and communication depend on all three components, standing in

\* Also called by Peirce the *Ceno-Pythagorean* categories (c.f., CP 2.87, 8.328).

relation to one another and subject to interpretation by multiple agents in multiple ways (Peirce's semiosis of signs). Contrast this Peircean view with traditional classification schemes, which have a dyadic or dichotomous nature and do not support such rich views of context and interpretation.<sup>12</sup>

Once the basic structure of the trichotomy and the nature of its primitives were in place, it was logical for Peirce to generalize the design across many other areas of investigation and research. Because of the signs' groundings in logic, Peirce's three main forms of deductive, inductive and abductive logic also flow from the same approach and mindset. How to think about categorization was another contribution.\* Using his terminology of the general triad, Peirce writes when the First and Second:

"... are found inadequate, the third is the conception which is then called for. The third is that which bridges over the chasm between the absolute first and last, and brings them into relationship. We are told that every science has its qualitative and its quantitative stage; now its qualitative stage is when dual distinctions — whether a given subject has a given predicate or not — suffice; the quantitative stage comes when, no longer content with such rough distinctions, we require to insert a possible halfway between every two possible conditions of the subject in regard to its possession of the quality indicated by the predicate. Ancient mechanics recognized forces as causes which produced motions as their immediate effects, looking no further than the essentially dual relation of cause and effect. That was why it could make no progress with dynamics. The work of Galileo and his successors lay in showing that forces are accelerations by which [a] state of velocity is gradually brought about. The words 'cause' and 'effect' still linger, but the old conceptions have been dropped from mechanical philosophy; for the fact now known is that in certain relative positions bodies undergo certain accelerations. Now an acceleration, instead of being like a velocity a relation between two successive positions, is a relation between three .... we may go so far as to say that all the great steps in the method of science in every department have consisted in bringing into relation cases previously discrete."  
(1888, CP 1.359)

Continuity is an aspect of Thirdness, what Peirce called *synechism*, and discovery of new knowledge is itself a process. We may better understand concepts like space and time when we embed them in the idea of continuity. Actions may also express triadic relations, the classic example being 'A gives B to C.' (1903, EP 2 170-171) The other classic triadic example is Peirce's sign relation between object, sign, and interpretant. The brilliance of Peirce's mindset is that first, second and third are a sufficient basis to bootstrap how to represent the world.

### ***The Irreducible Triad***

Peirce saw the trichotomous parts of his sign logic as the fewest 'decomposable' needed to model the real world. Robert Burch has called Peirce's ideas of 'indecomposability' the 'reduction thesis.'<sup>13</sup> The thesis is ternary relations suffice to construct any arbitrary relation, but we cannot construct all relations from unary and binary

\* See the discussion on *prescission* in Chapter 7.

relations alone. Threes are irreducible to capture the basis of knowledge. Peirce did not provide a formal proof for his assertions; there was not yet a complete formalism for predicate calculus at his disposal.<sup>14</sup> Here are some of Peirce's thoughts as to what makes something 'indecomposable':

"It is a priori impossible that there should be an indecomposable element which is what it is relatively to a second, a third, and a fourth. The obvious reason is that that which combines two will by repetition combine any number. Nothing could be simpler; nothing in philosophy is more important." (1905, CP 1.298)

"We find then a priori that there are three categories of undecomposable elements to be expected in the *phaneron*: those which are simply positive totals, those which involve dependence but not combination, those which involve combination." (1905, CP 1.299)

"I will sketch a proof that the idea of meaning is irreducible to those of quality and reaction. It depends on two main premisses. The first is that every genuine triadic relation involves meaning, as meaning is obviously a triadic relation. The second is that a triadic relation is inexpressible by means of dyadic relations alone .... every triadic relation involves meaning." (1875, CP 1.345)

"And analysis will show that every relation which is tetradic, pentadic, or of any greater number of correlates is nothing but a compound of triadic relations. It is therefore not surprising to find that beyond the three elements of Firstness, Secondness, and Thirdness, there is nothing else to be found in the phenomenon." (1875, CP 1.347)

Peirce thus maintained that we could decompose all higher-order relationships (polyadic with more than three terms) to monadic, dyadic or triadic relations. Further, Peirce maintained that the triadic relation is primary, with monadic and dyadic relations being degenerate forms of it. An interesting aspect of Peirce's Thirdness is how to treat relations between Firstness, Secondness, and Thirdness. Because of the sort of building block nature inherent in a sign, we can not treat all potential dyadic relations between the three elements equally. According to the 'qualification rule,' "a First can be qualified only by a first; a Second can be qualified by a First and a Second; and a Third can be qualified by a First, Second, and a Third."<sup>15</sup> Note that a Third cannot be involved in either a First or Second.\*

Researchers have now formally proven these assertions by Peirce. Herzberger<sup>16</sup> and then Burch<sup>13</sup> were the first independent researchers to establish the irreducibility of the basic relations of threes in a constrained form, but this was later more broadly proven using Peirce's existential graphs in two different papers by Correia and Pöschel<sup>17</sup> and then Hereth and Pöschel.<sup>18</sup>

\* See the related discussion under the last section on 'Representation' in *Chapter 2*.

## THE LENS OF THE UNIVERSAL CATEGORIES

Still, the question remains: How can one apply Peirce and his ideas to today's challenges in knowledge representation? What is the essence of trying to approach and solve problems by Peircean means? Is there a lens through which we can think through contemporary problems in domains unheard of in Peirce's time?

One approach taken by scholars is to attempt to complete Peirce's sign classification system. As noted in *Chapter 2*, Peirce expanded his original three universal categories to six (three, plus the degenerate form of Secondness and the two degenerate forms of Thirdness<sup>19</sup>); then to 10 in the fuller explication of the sign (see *Table 2-1*); and then to incomplete 28- and 66-sign versions toward the end of his career. Researchers such as Borges,<sup>20</sup> Burch,<sup>21</sup> Faria *et al.*<sup>22</sup> and Jappy<sup>23</sup> have attempted to 'sign-trace' these late, incomplete versions. These are laudable attempts, and often creative and insightful. However, these later Peirce sign systems are incomplete, require filling in the blanks for what Peirce intended, and are not directly relevant to modeling knowledge representation. My first attempts at using Peirce for KR tried to follow this same path, but I abandoned it as being too removed and speculative.

### ***An Aha! Moment***

I was first attracted to Peirce's universal categories because of my interest in representing human language and its meaning. Only through context and perspective — Thirdness — may we hope to capture and understand the nuances of meaning. When I first saw this strength in Peirce's worldview, that (and his writings) led me to look at its applicability elsewhere. My *Aha!* moment, if I can elevate it as such, was when I realized that trying to cram these insights into Peirce's elaborate sign terminology and other literal aspects of his writing were, at least for me, self-defeating. The *Aha!* arose when I chose instead to understand the mindset underlying Peirce's thinking and the triadic nature of his universal categories and semiosis.

I find it amazing and consistent how much Peirce himself relies on the universal categories in his thinking and analysis. His method of thinking through to foundations, *prescission*,\* is invaluable in deciding edge cases for categorization. I believe he applied this approach, for example, to his later sign expansions. There must be something at the heart of these universal categories that make them such a powerful lodestone. The very generalizations Peirce made around the somewhat amorphous designations of Firstness, Secondness, and Thirdness seemed to affirm that what he was genuinely getting at was a way of thinking, a method of 'decomposing' the world, that had universal applicability irrespective of domain or problem. Thus, to make my *Aha!* moment useful, I needed to understand the essence of what lies behind Peirce's universal categories.

Not only at the most fundamental level, but, at almost all levels of understanding and logic, Peirce articulated a worldview built around these universal categories.

\* See *Chapter 7*.

Peirce uses this triadic structure to describe language, signs, logic, relations, growth, emergence, science, truth, limits, meaning, community, categorization, and consensus-building. Though Peirce acknowledges natural classification systems, such as *trees of life* and *dichotomous keys* in taxonomy, in most areas of ideas and concepts and metaphysics, he boils down his arguments into the three universal categories. As noted, he argues that each alone is necessary, each is irreducible, and all three are required to adequately represent any information space, which is, after all, a sign.

Peirce’s triadic approach to logic is especially informative. The first leg of the logic triad is *speculative grammar*, in which one strives to capture the signs that most meaningfully and naturally describe the current and potential domain of discourse. The second leg of the logic triad is the means of *logical inference*, be it deductive, inductive or abductive (hypothesis generating). The third leg is the process or *method of inquiry*, what Peirce most often called the *methodeutic*. The methods of research or science, including the scientific method, result from the application of this logic.<sup>24</sup> The ‘pragmatic’ part of Peirce’s pragmatism arises from how to select what is essential and economically viable to investigate among multiple hypotheses.

Though scholars widely discuss Peirce’s universal categories, most Peircean research focuses on signs, a subset of the categories. Signs are more often the prism by which scholars probe Peirce’s philosophy. My approach, instead, has been to broaden my perspective to the universal categories and then to use Peirce’s methods to explore them. I have hoped to discern the mindset underlying them, which I could then apply to the contemporary challenges of knowledge representation.

### ***Grokking the Universal Categories***

Peirce expressed his notions of the universal categories in many different ways and contexts. Peirce’s students have further interpreted these notions. To get at the purpose of the triadic concepts, I thought it useful to research the question in the same way that Peirce recommends. After all, Firstness, Secondness, and Thirdness should themselves be prototypes for what Peirce called the ‘natural classes.’\*

I have assembled from Peirce’s writings as many examples of the three members of the universal categories as I could find. This assemblage is ‘an enumeration of tests’ to use Peirce’s phrase. The following table lists these more than 60 examples of Firstness, Secondness and Thirdness, the contexts in which they arose, and a citation where to find the supporting material in Peirce’s writings. I use lowercase for all assignments to the universal categories to put the listings on a common footing, though Peirce often capitalized his terms. Please do not confuse the three modes of the universal categories with the three entries in an RDF triple (see *Chapters 1* and *8*):

Context	Firstness	Secondness	Thirdness	
Moods or Tones	first	second	third	T1
Conceptions of First,	independent	relative	ediating	T2

\* See further *Chapters 6* and *12*.

A KNOWLEDGE REPRESENTATION PRACTICIONARY

<i>Context</i>	<i>Firstness</i>	<i>Secondness</i>	<i>Thirdness</i>	
<i>Second, Third</i>				
<i>The Categories</i>	monads	particulars	generals	T3
<i>Time</i>	“present”	“past”	“future”	T4
<i>Cognition / Space</i>	point	line	triangle / sphere	T5
<i>Movement</i>	position	velocity	acceleration	T6
<i>Modes of Being</i>	possibility	existence	law	T7
<i>Seconds</i>	internal	external	---	T8
<i>Thirds</i>	mixtures	comparisons	intelligibles	T9
<i>Modality</i>	possibility	actuality	necessity	T10
<i>Phenomena 1</i>	sensations	reactions	generals	T11
<i>Phenomena 2</i>	qualities of phenomena	actual facts	laws (and thoughts)	T12
<i>Phenomena 3</i>	chance	existents	continuity	T13
<i>Active Elements</i>	chance	law	habit-taking	T14
<i>Realism</i>	form	matter	entelechy	T15
<i>Existence</i>	chaos	regularity	continuity	T16
<i>Continuity</i>	feeling	effort	habit	T17
<i>Mathematics</i>	quality	facts	laws	T18
<i>Ceno-Pythagorean Categories</i>	originality	obsistence	transuasion	T19
<i>Form</i>	tone	token	type	T20
<i>Being</i>	quality	relation	representation	T21
<i>Protoplasm</i>	sensibility	motion	growth	T22
<i>Natural Selection</i>	individual variation	heritability	elimination of unfavored characters	T23
<i>Modes of Evolution</i>	absolute chance	mechanical necessity	law of love	T24
<i>Doctrines of Evolution</i>	tychasticism	anancasticism	agapasticism	T25
<i>Consciousness 1</i>	feeling	sense of action/reaction	sense of learning	T26
<i>Consciousness 2</i>	feeling	altersense	medisense	T27
<i>Consciousness 3</i>	immediate feeling	polar sense	synthetical consciousness	T28
<i>Thought 1</i>	abstraction	suggestion	association	T29
<i>Thought 2</i>	possibility	information	cognition	T30

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<i>Context</i>	<i>Firstness</i>	<i>Secondness</i>	<i>Thirdness</i>	
<i>Thought 3</i>	thought-sign	connected	interpreted	T31
<i>Synthetical Con- sciousness</i>	association by conti- guity	association by resem- blance	intelligibility	T32
<i>Mind</i>	feelings	reaction-sensations	conceptions	T33
<i>Logical Mind</i>	ideas	ideas from prior ideas	ideas from prior pro- cesses	T34
<i>Experiences</i>	simples	recurrences	comprehensions	T35
<i>Universe of Experi- ences</i>	ideas	brute activity	sign	T36
<i>Information</i>	intensions	extensions	comprehensions	T37
<i>Knowledge Represent- ation</i>	attributes	individuals	types	T38
<i>Characters or Predi- cates</i>	internal	external	conceptual	T39
<i>Relations</i>	attributes	external relations	representations	T40
<i>Representation</i>	representamen	object	interpretant	T41
<i>Sign-Object</i>	icon	index	symbol	T42
<i>Nature of Signs</i>	qualisign	sinsign	legisign	T43
<i>Kinds of Characters</i>	singular characters	dual characters	plural characters	T44
<i>Symbols</i>	words (or terms)	propositions	arguments	T45
<i>Sign-Interpretant 1</i>	emotional interpre- tant	energetic interpretant	logical interpretant	T46
<i>Sign-Interpretant 2</i>	rhemes	dicisigns	arguments	T47
<i>Signs 1</i>	possibles	things	collections	T48
<i>Signs 2</i>	abstractives	concretetives	collectives	T49
<i>Propositions</i>	hypothetical	categorical	relative	T50
<i>Logical Terms</i>	monads	dyads	triads	T51
<i>Separability of Ideas</i>	dissociation	pre-scission	determination	T52
<i>Assertions</i>	possible modality	actual modality	necessary modality	T53
<i>Reasoning</i>	what is possible	what is actual	what is necessary	T54
<i>Logical Thinking</i>	clearness of concep- tions	clearness of distinctions	clearness of practical implications	T55
<i>Clarity</i>	doubt	inquiry	belief	T56
<i>Logic Methods</i>	abductions	deductions	inductions	T57

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Context	Firstness	Secondness	Thirdness	
Logic	speculative grammar	logic and classified arguments	methods of truth-seeking	T58
Sciences of Discovery	mathematics	philosophy	special sciences	T59
Philosophy	phenomenology	normative science	metaphysics	T60
Normative Science	esthetics	ethics	logic	T61
Concepts of Meta-physics	spontaneity	dependence	mediation	T62
Others	complete in itself, freedom, free, measureless, variety, freshness, multiplicity, manifold of sense, peculiar, idiosyncratic, suchness, one, new, spontaneous, vivid, <i>sui generis</i>	otherness, comparison, action, dichotomies, mutual action, will, volition, involuntary attention, shock, sense of change, here and now ( <i>hinc et nunc</i> ), compulsion, state, occurrence, negation	idea of composition, intelligence, moderation, comparative, reason, sympathy, intelligence, structure, regularities, conduct, representation, middle, learning, conditional, diffusion	T63

Table 6-2: Peirce’s Universal Categories in Relation to Various Topics<sup>25</sup>

The table spans from the potential or abstract, such as ‘first’ or ‘third,’ to whole realms of science or logic. This spanning of scope reflects the genius of Peirce’s insight wherein semiosis can begin literally at the cusp of Nothingness<sup>26</sup> and then proceed to capture the process of sign-making, language, logic, the scientific method, and thought abstraction to embrace the broadest and most complex of topics.<sup>27</sup> I also find this statement by Peirce is another powerful expression of the universal categories: “The starting-point of the universe, God the Creator, is the Absolute First; the terminus of the universe, God completely revealed, is the Absolute Second; every state of the universe at a measurable point of time is the third.” (1888, CP 1.362)

Because I have taken these examples from many contexts, it is important to review this table on a row-by-row basis when investigating the nature of the categories. Review of the columns helps elucidate the ‘natural classes’ of Firstness, Secondness, and Thirdness. Some items appear in more than one column, reflecting the natural process of semiosis wherein more basic concepts cascade to the next focus of semiotic attention. The last row is a kind of catch-all trying to capture other mentions of the universal categories in Peirce’s phenomenology.

It took me a while to realize that Firstness, Secondness, and Thirdness are not a linear sequence, nor one in time. In fact, Peirce likens Firstness to the present, Secondness to the past, and Thirdness to the future (not in a predictive sense, but as probabilities continuing from the past).<sup>28</sup> All possibilities, Firstness, reside in the absolute present, “for nothing is more occult.” (1902, CP 2.85) The instant at which these possibilities act or are acted upon causes them to come into existence, or Secondness. These instances exist in relation or contrast with other instances and

events because what is real is past. The continuity of these instances through space and time, the probable future, enables new generalities arising from what we can learn from Secondness and Firstness, as well as to anticipate or plan. Chances or accidents in Firstness may spring ‘surprises’ in Secondness that trigger new cognition or mediation in Thirdness, which potentially predicates a new basis for categorization, in the sense of knowledge representation, our chosen frame of reference.

My thesis is that studying these assignments for the various contexts shown in *Table 6-2* is one way to internalize the mindset of the universal categories. At the most fundamental level, we can see Firstness as the raw, unexpressed possibilities of the current problem set, the building blocks for the new category, if you will. Chance is the root aspect of Firstness, which means any of these possibilities may express themselves in surprising ways, perhaps causing the need for new categorization. The actual things or events of the new category, as made manifest by their interaction or contact with what also exists in the domain at hand, provide the actual instances of Secondness. The generalities or continuities among these instances, classed into natural types as best we can, provide the Thirdness of this domain. We find much to plumb in Peirce’s universal categories.

### ***Applying the Universal Categories***

The lens of the universal categories provides a framework for how we may organize and settle upon terminology for existing and emerging knowledge, the first task of a knowledge representation system. Peirce, the logical categorizer, concerned with methods, and interested in pragmatic approaches and solutions, understood that how we categorize our continually emerging world was fundamental.

We see that the categorization effort may arise from one of three sources. We either are trying to organize a knowledge domain anew; we are splitting an existing category that has become too crowded and difficult to reason over; or we have found a ‘surprising fact,’ which is new knowledge that emerges from chance or anomalies observed when attempting to generalize or to form habits. The occasional surprising fact alters what we think we know about reality, which causes us to re-inspect and re-categorize our world. Abductive reasoning, a Peirce contribution, attempts to probe why the anomaly occurs. The possible hypotheses so formed constitute the Firstness or potentials of the new categorization (identification of particulars and generalization of the phenomena). We scope the category based on the domain and the granularity of the categorization effort.

I think it is evident in *Table 6-2*, sometimes to multiple levels depending on context (study some of the supporting material to the table), that Peirce applied this same method. As Peirce instructs, the dynamic universal categories, faced with the unexpected chance arising in Firstness, ripple through our awareness (reality) to cause a new understanding of the state of existence (Secondness). The universal categories give us the primitive elements by which we can generalize our new world, a factor of Thirdness. Peirce’s pragmatic maxim helps us decide among many possible alternatives. So the cycle continues. Truth, understood as a limit function, gets con-

tinuously exposed as we test and affirm these realities.

Start with any subject domain. We know the things, and therefore the characteristics, of the things that populate this domain. So, we first spend time enumerating and describing the features of the things in this domain. We will call this category of characteristics, Firstness. Then, we try to list and organize the actual things in this domain. These, individually, are the events and entities, that we can imagine or specify about this domain. This list of particulars, what we call Secondness, is surely always going to grow, so from an operational viewpoint, we want input files for these items that are easy to update and modify. The items in our domain also have generalities and shared aspects that help place those items into meaningful categories. These groupings, admittedly synthetic in one sense, are also real in another sense when the groupings make logical sense. These generalities are an expression of Thirdness. This categorization into Thirdness is straightforward to do on purely logical grounds but is more difficult when we desire explanatory power. Where questions arise about which universal category to assign something, we look to Peirce and later scholars to see if prior determinations have been postulated and argued. If so, we test those assumptions and adopt or not those assignments, based on our logical assessments. We continue this process as we get deeper and more specific in our categorizations. No matter what the assignment, each should be subject to questioning and testing by the community of users, perhaps altering those assignments as better information or better logic is applied.

This process is the one that we followed in developing the open source KBpedia Knowledge Ontology (KKO), the knowledge graph of some 200 concepts that provides the upper-level scaffolding for our knowledge representation efforts. KKO is the first knowledge graph to embrace the universal categories explicitly. We will get into specifics about KKO in later chapters.

I earlier mentioned my epiphany from specifics to mindset in Peirce's teachings. This insight has not caused me to suddenly understand everything Peirce was trying to say, nor to come to some new level of consciousness. However, what it has done is to open the door to a new way of how to think about and look at the world. I am now finding via the universal categories that prior, knotty problems of categorization and knowledge representation are becoming (more) tractable, as I discuss in subsequent chapters. Many of these problems, such as how to model events, situations, identity, representation, and continuity or characterization through time, may sound like philosophers' millstones, but they often lie at the heart of the most challenging problems in knowledge modeling and representation. Even the tiniest break in the mental and conceptual logjams around such issues feels like significant progress.

### *The Categories and Categorization*

The area of Secondness is where we surface and describe the particular objects or elements that define this category. Peirce described it thus:

“So far Hegel is quite right. But he formulates the general procedure in too narrow a way, making it use no higher method than dilemma, instead of giving it an observa-

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tional essence. The real formula is this: a conception is framed according to a certain precept, [then] having so obtained it, we proceed to notice features of it which, though necessarily involved in the precept, did not need to be taken into account in order to construct the conception. These features we perceive take radically different shapes; and these shapes, we find, must be particularized, or decided between, before we can gain a more perfect grasp of the original conception. It is thus that thought is urged on in a predestined path. This is the true evolution of thought, of which Hegel's dilemmatic method is only a special character which the evolution is sometimes found to assume." (1896, CP 1.491)

In Thirdness we are contemplating the category, thinking about it, analyzing it, using and gaining experience with it, such that we can begin to see patterns or laws or 'habits' (as Peirce so famously put it) or new connections and relationships with it. This contemplation or the occasional 'surprising fact' is where new knowledge arises, New knowledge causes us to split and then codify new signs and categories useful to the knowledge space. As domains are investigated to deeper levels or insights expand the branches of the knowledge graph, we tackle each new layer via this three-fold investigation. Of course, context sets the perspectives at hand; the multiple listings in Table 6-2 above can help stimulate these thoughts.

	<i>Firstness</i>	<i>Secondness</i>	<i>Thirdness</i>
<i>Symbols</i>	idea of; nature of; milieu; 'category potentials'	reference concepts	standards
<i>Generality</i>	cross-products of Firstness	language (incl. domain); computational	analysis; representation; continua
<i>Interpreters (human or machine)</i>	What are the ingredients, ideas, essences of the category?	What are the new things or relationships of the category?	What are the laws, practices, outputs arising from the category?

Table 6-3: Using the Universal Categories for Categorization

Interrelationships adhere to the Peircean Thirdness, and there continues to be growth and additions. Categories thus tend to fill themselves up with more insights and ideas until the scope and diversity compel another categorization. In these ways, categorization is not linear, but accretive and dynamic. Firstness, Secondness, and Thirdness inform how to think about the idea of categorization. I use the kind of mental checklist provided in Table 6-3 when it comes time to split a concept or category into a new categorization.

These Peircean ideas of the universal categories, applied against basic logical principals, and subject to the understanding about fallibility and the limits to truth, provide a basic set of methods of how to think about and categorize the world. When the 'surprising fact' arises that causes us to question premises and regularities, we can apply this same categorization logic to assess the next level of subject specificity. Now, we are in a mediating portion of our information space, likely again requiring

new categorization. Peirce’s universal categories provide a powerful unifying force for organizing and categorizing knowledge domains.

“Taking any class in whose essential idea the predominant element is Thirdness, or Representation, the self development of that essential idea — which development, let me say, is not to be compassed by any amount of mere ‘hard thinking’, but only by an elaborate process founded upon experience and reason combined — results in a trichotomy giving rise to three sub-classes, or genera, involving respectively a relatively genuine thirdness, a relatively reactional thirdness or thirdness of the lesser degree of degeneracy, and a relatively qualitative thirdness or thirdness of the last degeneracy. This last may subdivide, and its species may even be governed by the three categories, but it will not subdivide, in the manner which we are considering, by the essential determinations of its conception. The genus corresponding to the lesser degree of degeneracy, the reactionally degenerate genus, will subdivide after the manner of the Second category, forming a catena; while the genus of relatively genuine Thirdness will subdivide by Trichotomy just like that from which it resulted. Only as the division proceeds, the subdivisions become harder and harder to discern.” (1903, CP 5.72, EP 2:162)

The way I interpret this passage (in part) is that categories in which new ideas or insights have arisen — themselves elements of Thirdness for that category — are targets for new categorization. That new category should focus on the idea or insight gained, such that each new category has a character and scope different from the one that spawned it. Of course, depending on the purpose, some ideas or insights have a more substantial potential effect on the domain, and those should get priority attention. As a practical matter, this means that categories of more potential importance to the sponsor receive the most focus.

Peirce’s contributions can make a notable difference in how knowledge representation efforts move forward. I think that it is possible to codify and train others to use this mindset, one purpose of this book. Peirce stood on the shoulders of the giants before him. We can now stand on Peirce’s shoulders to mount the next rung on the ladder of knowledge. I believe Peirce’s universal categories and what they imply offer the next adaptive climb upward for knowledge representation.

## Chapter Notes

1. Some material in this chapter was drawn from the author’s prior articles at the *AI3::Adaptive Information* blog: “Give Me a Sign: What Do Things Mean on the Semantic Web?” (Jan 2012); “A Foundational Mindset: Firstness, Secondness, Thirdness” (Mar 2016); “Re-thinking Knowledge Representation” (Mar 2016); “The Irreducible Truth of Threes” (Sep 2016); “How I Study CS Peirce” (Aug 2017); “Why I Study CS Peirce” (Aug 2017); “How I Interpret CS Peirce” (Sep 2017).
2. Jansen, L., “Categories: The Top-Level Ontology,” *Applied Ontology: An Introduction*, 2008, pp. 173–196.
3. Guarino, N., “Some Organizing Principles for a Unified Top-Level Ontology,” *AAAI Spring Symposium on Ontological Engineering*, 1997, pp. 57–63.
4. Sowa, J. F., “Signs, Processes, and Language Games: Foundations for Ontology,” *Proceedings of the 9th International Conference On Conceptual Structures, ICCS’01*, 2001.

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5. "Facts" are in Secondness, but knowledge is a function of belief, which is inherently a Thirdness.
6. Houser, N., "Introduction," *The Essential Peirce: Selected Philosophical Writings, Vol 2 (1893-1913)*, Peirce Edition Project, ed., Bloomington: Indiana University Press, 1998, pp. xvii-xxxviii.
7. Atkin, A., "Peirce, Charles Sanders: Architectonic Philosophy," *Internet Encyclopedia of Philosophy*.
8. Peirce claimed the term *universal categories* in CP 1.526 (1903). CP 5.41-59 (1903) provides a longer treatment.
9. Locke, J., "An Essay Concerning Human Understanding," Yolton: Ed. Dutton, 1690.
10. One of the interesting things I have come to understand about Firstness (1ns) is that it ceases to be 1ns once it is expressed. Firstness does not exist, it is the absolute present, from which we understand the past is derived. In the absolute present everything is possible; what we remember of that moment is what actually existed. I use the term "reification" to denote when we try to express an unexpressed possibility. One fascinating aspect is how this parallels quantum theory and Schrödinger's cat. Once we try to describe or measure or understand something, we change its character, and never truly grok its essence.
11. Peirce, C. S., "Minute Logic: Chapter I. Intended Characters of this Treatise," 1902.
12. Michael Buckland points out that some systematic library classifications do include means for including contextual and relational aspects, such as facets or geographical, chronological or other contexts in the Universal Decimal Classification (among others). However, I maintain these mechanisms appear more as associations or contextual attributes rather than being an integral part of the ontological structure.
13. Burch, R., *A Peircean Reduction Thesis: The Foundations of Topological Logic*, Lubbock, TX: Texas Tech University Press, 1991.
14. Kleinert, E., "On the Reducibility of Relations: Variations on a Theme of Peirce," *Transactions of the Charles S. Peirce Society: A Quarterly Journal in American Philosophy*, vol. 43, 2007, pp. 509-520.
15. Savan, D., "An Introduction to C.S.Peirce's Full System of Semeiotic," *Monograph Series of the Toronto Semiotic Circle*, 1987.
16. Herzberger, H. G., "Peirce's Remarkable Theorem," *Pragmatism and Purpose: Essays Presented to Thomas A. Gouge, I.W. Sumner, J.G. Slater, and F. Wilson*, eds., Toronto, Canada: University of Toronto Press, 1981, pp. 41-58.
17. Correia, J. H., and Pöschel, R., "The Teridentity and Peircean Algebraic Logic," *Conceptual Structures: Inspiration and Application*, H. Schärfe, P. Hitzler, and P. Øhrstrøm, eds., Aalborg, Denmark: Springer, 2006, pp. 229-246.
18. Hereth, J., and Pöschel, R., "Peircean Algebraic Logic and Peirce's Reduction Thesis," *Semiotica*, vol. 2011, Jan. 2011, pp. 141-167.
19. Peirce expanded his original three universal categories to six by adding what he called one "degenerate" form to Secondness and two "degenerate" forms to Thirdness, increasing the original three by an additional three. See further CP 1.365-367 (1887-88). I discuss later sign expansions in the main text.
20. Borges, P., "A Visual Model of Peirce's 66 Classes of Signs Unravels His Late Proposal of Enlarging Semiotic Theory," 2010, pp. 221-237.
21. Burch, R. W., "Peirce's 10, 28, and 66 Sign-Types: The Simplest Mathematics," *Semiotica*, vol. 2011, Jan. 2011.
22. Farias, P., and Queiroz, J., "On Diagrams for Peirce's 10, 28, and 66 Classes of Signs," *Semiotica*, vol. 147, 2003, pp. 165-184.
23. Jappy, T., *Peirce's Twenty-Eight Classes of Signs and the Philosophy of Representation: Rhetoric, Interpretation and Hexadic Semiosis*, Bloomsbury Academic, 2017.
24. Realize, by expressing the triad of logic as *speculative grammar, critic* (the three modes of inference), and *methodetic*, we have already progressed through many cycles of semiosis in order to use symbols, embed them in a meta-symbolology of language, to have those symbols express accepted meanings, and then be applied to the question of categorizing the logic domain. This recursive and accretive nature of the universal categories demonstrates the innate power of Firstness, Secondness, and Thirdness.
25. Bergman, M. K., "How I Interpret C.S. Peirce," *AIB::Adaptive Information*, Sep. 2017.
26. The idea of Firstness may range from something like an energetic input that causes chemicals to combine into a new structured form or ordered state to something like a new recognition in the mind occasioned by

a flick of the eye or a shifting thought. The representamen is merely a potential sign until it is energized or intrudes on consciousness, wherein the object is now made apparent as interpreted.

27. Here are the references to the table: T1 - CP 1.355; also, Cosmogonic Philosophy, EP 1.297; T2 - See CP 6.32-34; T3 - This exact categorization was never used directly by Peirce (or so my investigations to date suggest). However, it is clear throughout his writings that he relates monads to Firstness, 'particulars' and 'particularities' to Secondness, and 'generals' or "generalities" to Thirdness. Further, these terms are understood and used in other categorization schemes, such as those by Aristotle and Kant. We also see, by this chart, that Peirce himself employs many different terms for his universal categories. We have chosen these to be the three main categories in the KBpedia Knowledge Ontology for these reasons. See further CP 1.300-338.; T4 - CP 2.84-86; see also 2.146; it is NO; T 1 -> 2 -> 3 present v hic et nunc; CP 5.459-463; T5 - CP 5.263; T6 - CP 1.337; T7 - CP 6.343-344; T8 - CP 1.365; these are the two degenerate forms; there is no Thirdness ; T9 - CP 1.366; This is an example of what Peirce called "degenerate" categories of the category. Degenerate means that it is a component of the category, but not sufficient as a concept in the 1o and 2o; T10 - CP 5.454; T11 - CP 1.418-420; T12 - CP 5.121; T13 - Per the discussion in *Appendix A*; T14 - CP 1.409; T15 - NEM 4:295; T16 - CP 1.411 and CP 1.175; T17 - CP 6.201-202; also called; Tritism or Synechism (or "all that there is"); T18 - CP 1.417-420; T19 - CP 2.87-89; Peirce using his obscure labels in seeking exactitude; T20 - CP 4.537; T21 - CP 1.555 and CP 2.418; the initial categories were actually bracketed by Being and Substance (5 categories total). In CP 4.3 Peirce re-named these labels as *quality*, *reaction* and *mediation*. However, in that same passage he says, "How the conceptions are named makes, however, little difference." I have chosen to retain his earlier names because they are more commonly referenced and it retains the idea of "representation", more allied with the idea of *knowledge representation*; T22 - CP 1.393; T23 - CP 1.398; T24 - CP 6.302; T25 - CP 6.302; T26 - CP 1.378; T27 - CP 7.551; thought is taken to be as equivalent to medisense; T28 - EP 1.260; T29 - The analysis of the labels and relations is provided in these two articles: M.K. Bergman, 2017. "KBpedia Relations, Part III: A Three-Relations Model," AI3::Adaptive Information blog, May 24, 2017; and M.K. Bergman, 2017. "KBpedia Relations, Part IV: The Detailed Relations Hierarchy," AI3::Adaptive Information blog, June 27, 2017.; T30 - CP 1.537; T31 - CP 5.283-284; T32 - EP 1.261; T33 - CP 6.18-20; T34 - CP 7.348; T35 - CP 7.528 cf; T36 - CP 6.455; T37 - Peirce did not explicitly list these terms, but they can be readily and logically derived from CP 2.419-421.; The idea of information being a product of depth (1o, intensionality) times breadth (2o, extensionality) is quite insightful; T38 - Though "general type" is a common term for Thirdness in Peirce's writings, he rarely used "attribute" and preferred particulars to "individuals". "Attributes" and "individuals" are now in modern usage, and clearly refer to 1ns and 2ns, respectively. We have chosen these two terms for use in the KBpedia Knowledge Ontology for these reasons.; T39 - Some-what modified from CP 5.469 cf, with external and conceptual replacements supported by the senses of the accompany text; T40 - Taken from the analysis of Peirce documented in T50; these are the terms chosen for use in terms for use in the KBpedia Knowledge Ontology; T41 - CP 1.339; "representation" is also called a "sign"; T42 - CP 1.191; can also be called "speculative grammar" or "nature of signs"; in Jappy 2017 this is called "Sign-Object";; Table 1.2 A Synthesis of MSS R478 and R540, 1903; T43 - CP 4.537 fn 3; called simply "Sign" in Jappy 2017.;; Table 1.2 A Synthesis of MSS R478 and R540, 1903.; T44 - CP 1.370-371; can substitute "facts" for "characters"; T45 - CP 2.95, also CP 8.337; CSP also expresses "arguments" as inferences or syllogisms; T46 - CP 5.475-6; T47 - From Jappy 2017.;; Table 1.2 A Synthesis of MSS R478 and R540, 1903; T48 - CP 8.366, with respect to the nature of dynamical objects; T49 - CP 8.366, with respect to the nature of dynamical objects; T50 - CP 2.325; T51 - CP 1.293; T52 - CP 1.353; T53 - CP 4.57; T54 - CP 1.369; T55 - CP 3.457; T56 - From Max H. Fisch 1986, Ken L. Ketner and Christian W. Cloesel, eds., *Peirce, Semiotic, and Pragmatism: Essays by Max H. Fisch*, Indiana University Press, p. 327; T57 - CP 2.98; in an earlier version, I listed "abduction" as a Thirdness, but I was corrected on the Peirce-L mailing list. On the other hand, abduction is at the interface between; Thirdness and Firstness, since it is the source of the possibilities that need to be considered for a given category.;; The dynamic nature of Peirce's semiosis is part of the sign-making and -recognition process.; T58 - CP 1.191; T59 - CP 1.239-242; the "special sciences" include the physical (physics, chemistry, biology, astronomy, geognosy, and whatever may be like these sciences) and the psychological (psychology, linguistics, ethnology, sociology, history, etc.) sciences; T60 - CP 1.280-282; T61 - CP 1.281; T62 - CP 3.422; also, Forms of Rhemata (singular, dual or plural); T63 - occasional mentions taken from various Peirce writings.'
28. Edwina Taborsky prefers to define Thirdness in this context as "past-future." Thirdness is a continuity of past laws into the future. In her 2006 paper, 'The Nature of the Sign as a WFF—A Well-Formed Formula,' (*AIP Conference Proceedings*, vol. 839, pp. 303-313), the three types of time are present, perfect and progressive, aligned with Firstness, Secondness and Thirdness.