SEMIOTIC IS AN OBSERVATIONAL SCIENCE

See for yourself: Developing Skills with Part of Peirce's Beta Existential Graphs

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1. Introduction

One of Thomas Sebeok's many merits is his clear vision that there is a vital connection between mathematics and semiotic (Sebeok 1977: 180f), a conclusion he shares with Charles Peirce. This condition is not without its disadvantages. For instance, after a particular Sebeok address, I was aware of some sentiment in the audience roughly captured as "What could he possibly see of relevance in mathematics?" This may be a fairly common attitude, for when students of Peirce's semiotic cite some of the more well-known places where he described it, essential parts of the description that refer to mathematics are selectively nonquoted. Among semioticians, such a popular description is found at *CP* 2.227, and quotations of it usually end somewhere just after the first sentence. Here is the whole thing – notice that the first sentence cannot be correctly interpreted without the remainder of the entire paragraph (and perhaps not without a few more paragraphs as well).

> Logic, in its general sense, is, as I believe I have shown, only another name for *semiotic* (semeiotike), the quasi-necessary, or formal, doctrine of signs. By describing the doctrine as "quasi-necessary", or formal, I mean that we observe the characters of such signs as we know, and from such an observation, by a process I will not object to naming Abstraction, we are led to statements, eminently fallible, and therefore in one sense by no means necessary, as to what *must be* the characters of all signs used by a "scientific" intelligence, that is to say, by an intelligence capable of learning by experience. As to that process of abstraction, it is itself a sort of observation. The faculty which I call abstractive observation is one which ordinary people perfectly recognize, but for which the theories of philosophers sometimes hardly leave room. It is a familiar experience to every human being to wish for something quite beyond his present means, and to follow that wish by the question, "Should I wish for that thing just the same, if I had ample means to gratify it?" To answer that question, he searches his heart, and in doing so makes what I term an abstractive observation. He makes in his imagination a sort of skeletal diagram, or outline sketch, of himself, considers what modifications the hypothetical state of things would require to be made in that picture, and then examines it, that is, *observes* what he has imagined, to see whether the same ardent desire is there to be discerned. By such a process, which is at bottom very much like mathematical reasoning, we can reach conclusions as to what *would be* true of signs in all cases, so long as the intelligence using them

was scientific. The modes of thought of a God, who should possess an intuitive omniscience superseding reason, are put out of the question. Now the whole process of development among the community of students of those formulations by abstractive observation and reasoning of the truths which *must* hold good of all signs used by a scientific intelligence is an observational science, like any other positive science, notwithstanding its strong contrast to all the special sciences which arise from its aiming to find out what *must be* and not merely what *is* in the actual world.

Note also that down somewhere near the base of the explanatory pile, there is something which is "at bottom very much like mathematical reasoning." And, it is also clear that "abstractive observation" of "skeletal diagrams" lies near the fundament of semiotic[1].

Perhaps the system of Existential Graphs (EG) was the principal means through which Peirce pursued the observation of such diagrams in the process of mathematical reasoning, as applied to semiotic (Ketner 1982 a). From the above considerations, it seems to follow that semioticians who wish to take up semiotic where Peirce, its founder, left it, should find EG essential. Again, Sebeok also discovered this truth (or something like it), for he has stated (1979: 117) of the Icon (an essential part of semiotic):

To put it tersely, I am of the opinion that no critique of iconicity that ignores Peirce's existential graphs in their multiform implications can be taken seriously or regarded as at all viable.

Why would this remark by Sebeok be correct? Perhaps some of Peirce's own reasoning here might help. Existential Graphs, like all diagrams, have a strong iconic element, although they are not pure icons (perhaps nothing is). In presenting an outline of the first part of a proof of the philosophy known as pragmaticism (in 1906, *The Monist*, 16: 492–546), Peirce began by mentioning (p. 495) that an analysis of the essence of any sign leads to the result that every sign is determined by its object in one of three ways, the iconic way being when a sign partakes in the characters of the object, which means they are identical in some characters.

Peirce's next step involved an examination of icons, indices, and symbols in terms of their efficiencies and inefficiencies. There is one efficiency that icons offer in the highest degree (p. 496), "namely, that which is displayed before the mind's gaze, – the Form of the Icon, which is also its object, must be logically possible." Continuing (p. 497), Peirce reached the conclusion we need:

1 I have discussed this paragraph at length in Ketner 1983 forthcoming, a presentation for the 1981 Hamburg Kolloquium of the Deutsche Gesellschaft für Semiotik. Hence I shall not repeat those elements here, but instead move to related goals. I have presented discussions of related issues at Ketner 1982 a, 1982 b, 1983 a. I was also able to show in the DGS presentation that, contrary to the claims of the editors of *CP*, this passage is not unidentified, and not a fragment in Peirce's MS.

That which we can learn from this division is of what sort a sign must be to represent the sort of Object that reasoning is concerned with. Now reasoning has to make its conclusion manifest. Therefore, it must be chiefly concerned with forms, which are the chief objects of rational insight. Accordingly, Icons are specially requisite for reasoning. A Diagram is mainly an Icon, and an Icon of intelligible relations. It is true that what must be is not to be learned by simple inspection of anything. But when we talk of deductive reasoning being necessary, we do not mean, of course, that it is infallible. But precisely what we do mean is that the conclusion follows from the form of the relations set forth in the premiss. Now since a diagram, though it will ordinarily have Symbolide Feature, as well as features approching the nature of Indices, is nevertheless in the main an Icon of the forms of relations in the constitution of its Object, the appropriateness of it for the representation of necessary inference is easily seen.

Any diagrammatic reasoning is an instance of mathematical method, yet Peirce distinguished between the diagrammatic thought of mathematics and of logic by means of their goals (p. 503):

The mathematician wants to reach the conclusion, and his interest in the process is merely as a means to reach similar conclusions. The logician does not care what the result may be; his desire is to understand the nature of the process by which it is reached. The mathematician seeks the speediest and most abridged of secure methods; the logician wishes to make each smallest step of the process stand out distinctly, so that its nature may be understood. He wants his diagram to be, above all, as analytical as possible.

Peirce then outlined the system of Existential Graphs, but beforehand saying that:

by means of this [EG], I shall be able almost immediately to deduce some important truths of logic, little understood hitherto, and closely connected with the truth of pragmaticism; while discussions of other points of logical doctrine, which concern pragmaticism but are not directly settled by this system, are nevertheless much facilitated by reference to it.

If we recall that in a number of places during his late career, Peirce identified logic with semiotic, the picture should be complete.

To summarize, if we proceed by means of the scientific method (if we are scientific intelligences), we first ask "What is the nature of any sign?". Thereby, we find icons, indices, and symbols; and wanting to study the nature of reasoning, we ask "What kind must a sign be to represent the kind of object with which reasoning is concerned?". Reasoning is concerned with relations and forms, something to which diagrams – which are mainly icons – give access in the richest way. Hence a system of logic that is the most iconic would be the best for studying reasoning. The system of EG is even more iconic than algebraic logical systems – an algebra is a diagram on Peirce's approach. Now reasoning and thought are the same, and are of the nature of sign processes. Hence, the grand conclusion is that EG is the best way to study semiotic. Peirce had earlier used algebra diagrams to study semiotic, but about 1897 he discerned the better EG system, and converted to it, using it as the lingua franca of his mature study of signs. So, surely if EG has this status for the whole study of signs, Sebeok's comment about its usefulness for studying just icons is triply justified. And, EG is not as difficult as some might have suspected, nor is it silly or foolish, as some have suggested (for instance, Gardner 1958: 54–58, or Goudge 1950: 6). Recently, I have been trying to produce some explanations of EG that nonspecialists in logic might find useful, especially in the sense of helping persons actually to aquire some skills in its use. (Other essays on EG are Roberts 1973, Zeman 1964, Thibaud 1975, and Faris 1981.) Another bonus of EG is the ease with which beginners can learn it. And, several of us who work with the system now come to view as prophetic a remark in this vein that Peirce made near the end of his life:

> The aid that the system of graphs thus affords to the process of logical analysis, by virtue of its own analytical purity, is surprisingly great, and reaches further than one would dream. Taught to boys and girls before grammar, to the point of thorough familiarization, it would aid them all their lives. For there are few important questions that the analysis of ideas does not help to answer. (*CP* 4.619)

Recently, a team of researchers at Texas Tech University (Gillis, Gustafson, Ketner, and Weiner), working under a grant from Apple Education Foundation, have found a way to mate EG with microcomputer capabilities, resulting in a smart tutor program that can supervise student exercise practice in EG, the graphs being drawn and manipulated upon a video monitor under control of the keyboard (Gillis 1982).

In the above context, then, the goal of the present essay is to continue such an account of EG, which was begun in Ketner 1981 a. This earlier discussion of the Alpha part of EG would be a good preliminary for the present attempt to explore portions of the Beta part of EG. The part of Beta discussed here corresponds roughly to syllogistic – other parts of Beta deal with other issues, which will not be addressed now. I hesitate to make comparisons between EG and present day formal logic. There are indeed similarities, but there are crucial differences such that approaches to EG via contemporary logic can create useless misunderstandings of EG, which should be approached in its own context and in its own terms. (For some accounts of misunderstandings of Peirce that were created in similar ways, see Herzberger 1981, and Brunning 1981.) It is these extras in EG that give it importance for semiotic. I hope to have expressed some of them in my own essays.

2. Enter the spot

With the Alpha part of EG we can deal with equivalences or arguments as far as analysis of simple and compound sentences will take us. Through a few modifications to our basic agreements and to the five rules of the system, it can be expanded to handle analyses of a second kind of argument, those based upon the simplest unit being classes, instead of sentences.

The changes needed for this Beta part are elementary. Uppercase letters will still represent simple sentences – for instance, P could mean "Petroleum is scarce". However, such letters don't help us understand classes; the point is, however, that they could appear in Beta and still be accomodated by the expanded Beta EG. To signify classes, we will employ lowercase letters. For example, b might stand for "is a Bolivian".

The second new item in Beta is called the SPOT. It is simply a dot on the sheet of assertion (hereafter SA, which is any location understood as a place where assertions are placed by a graph presenter, for interpretation by a graph evaluator – these pages are instances of SA). Here is a spot:

Fig. 1.

It shall be understood to mean "something exists". Two noncontinuous spots certainly would represent two existents, which may or may not be the same. A spot is a graph, and is thus subject to the five rules for graph transformations. To understand this part of Beta requires us to understand how the addition of this new graph requires modifications to our original rules in Alpha. (I regret that I cannot repeat an account of Alpha here.)

Let us first consider ITERATION. How can a spot be iterated? If we begin with:

Fig. 2.

and then transform that to:

Fig. 3.

it is possible that we may have created a second individual; or we may have simply created a repetition of the first spot. In short, based on present information, we can't tell which of these two cases is correct. In effect, we have two "somethings", but we have no further information as to whether these two "somethings" are identical or not in regard to whatever properties they may have. Since iteration is a rule that allows us to create identical copies of an already present graph, the above transformation is not the way to iterate a spot. To iterate a spot correctly, we may take a clue from geometry. A line is usually considered to be a series of continuously touching dots or points. So, we shall adopt the convention that, if two spots touch tangentially, they are considered to be identical, to be copies one of the other. This means that whatever properties a given spot might have (even though we are presently ignorant of any or all of them), if a second spot touches the first one, the second is considered to be an exact copy of the first, including whatever properties the first has, even though we may not now know what those properties are. Thus, the result of a correct iteration of the spot introduced above would look like this:

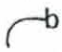
Fig. 4.

If we continue to iterate the first spot, we would get a whole string of spots on the level of the original spot, thus:

Fig. 5.

Since these spots touch at the edge of each circular shape, we thus represent that each is identical to every other one – that they are just the same individual repeated over and over again. Such a series of identical spots is known as a LINE OF IDENTITY. In order to continue exploration of spots and lines of identity, we need to see how lines of identity may contact letters and how such lines are affected by cuts. If a line of identity has one end terminating against the left side of a lowercase letter, we shall understand that to mean that there is an existing individual possessing the property which that letter represents. A line of identity may not touch an uppercase letter. Thus, if "is a Bolivian" is represented by b, then:

Fig. 5.



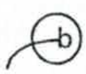
means "There is at least one existing Bolivian", or "Some things are Bolivians".

We now have to decide the meaning of putting a cut around a graph such as that just above. Such an operation would produce:

Fig. 6.

This would mean "Deny that some things are Bolivians", or "Nothing is a Bolivian", or "Bolivians don't exist". That is, a cut that completely encloses letters and lines of identity (with no part of the line of identity extending outside the cut area), will be understood as a denial of the line of identity's existence-asserting function. On the other hand, if we had a cut with a line of identity that ran outside a cut, such as:

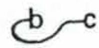
Fig. 8.



that would mean something quite different. In understanding this case, we remember that the line of identity is self-identical all along its extent, so the cut in this graph could not possibly be a denial of the line's existence-asserting function, for part of the line is off the cut and hence not even denied by the cut. Instead, this cut must serve the function of denying that the individual represented by the line has the property in question, b in this case. So we would read this graph as asserting that something existing has the property of being a "Not-Bolivian". Or, in typical English, "Something is not Bolivian".

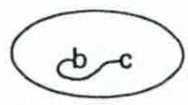
We now come to cases in which two letters are attached to a single line of identity. If we wanted to say, as we often shall, that a single existing thing has both of two properties, we would express it this way:

Fig. 9.



This means "Something that has the property b also has the property c", or "Some b is c". The denial of that sentence is:

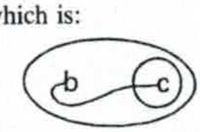
Fig. 10.



and this means that the existence function of the completely enclosed line of identity is denied, which in English would be expressed as "No thing whatsoever has the property b *and* the property c". In slightly fewer words, this would be "No b's are c's". A third common form often needed is "Some b's are not c's". Recalling how to write a nonproperty, we can represent that as:

What would its denial, which is:

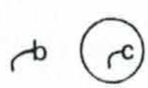
Fig. 12.



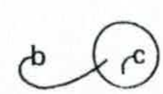
mean in English? The line of identity is completely enclosed in the largest cut, which means that the line of identity's existence-asserting function is being denied. This helps us to see that this graph can be read as "Nothing has the property b and the property not-c". In more standard English, this would be "All b's are c's".

Now back to our consideration of iteration in Beta. Suppose we had the following transformation to test (the '/?' means "Is this a correct transformation?" While '/' in the same place means "This is a previously confirmed correct transformation"):

Fig. 13.



/?



Would it be a correct transformation? Yes, because a line of identity can be extended on its own level through iteration, as we have already seen. And if we can imagine a line of identity extended so that adding one more spot to the end of it would place it across the boundary into the next highest level, we see that such an addition can be made to advance the line into the next higher level. This is because a spot is a graph, and a graph can be iterated into the next higher level, provided no valleys are involved.

And, once the line has grown into a higher level, it can be iterated around within that level as needed, or onto any higher levels, again provided no valleys are crossed. Moreover, iterating within a level includes branching a line of identity, in this way:

Fig. 14.

Finally, we can perform iterations in Beta that involve combined lower-case letters and spots or lines of identity.

The following transformations comply with Beta iteration:

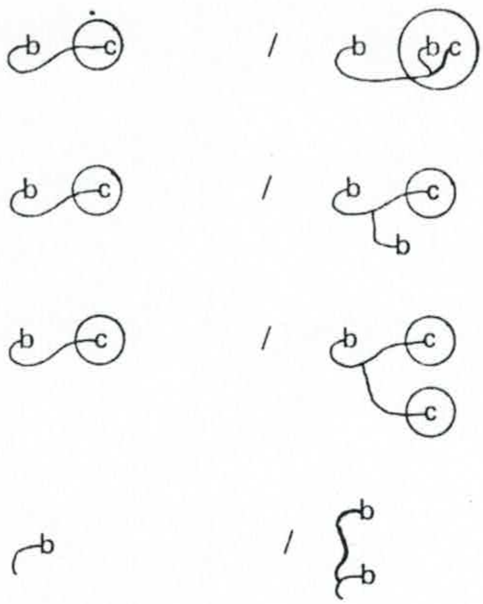


Fig. 15.

All these new functions are added to the older capabilities of Alpha iteration which are retained in Beta. Beta DEITERATION is very straightforward. Any graph that could have been the result of Beta iteration can be undone. Beta DOUBLE CUT has a few changes, but these are fairly simple. In these cases the double cuts can be removed:

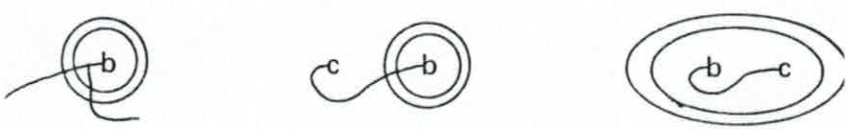


Fig. 16.

Here, the pattern may look like a double cut, but upon closer examination it is not one, and the two cuts cannot be removed:

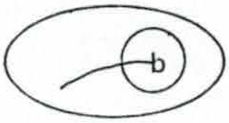


Fig. 17.

This is the case because each spot on a line of identity is identical to every other spot on that line. For example, in:

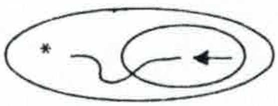


Fig. 18.

the spot marked by the asterisk is not twice eclosed, and since the asterisk spots are identical to the arrowed spot, the arrowed spot is not twice enclosed (in a double cut). This graph:

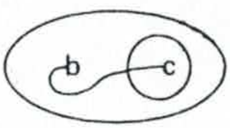


Fig. 19.

would read "Nothing is b and not c". This is not a double negative. Compare that to the English versions of the three graphs at the start of this paragraph: "Something is not not b"; "Something is c, and not not b": "Deny deny that some b is c". These three cases are genuine double negatives, hence cases of double cut. In Beta double cut, we can say that all the forms of Alpha double cut are retained, and if a line of identity is involved, the entire line must be completely enclosed in the innermost of the two cuts, or the line of identity must pass through both cuts.

For the rule of ERASURE, there is some slight change. The principal one is that a line of identity on an even level may be broken. We can see how this is permitted through the strategy of assuming that this new aspect of the erasure rule is not truth-preserving. We know that it will be either truth-preserving or not (and not both). So, if our assumption that it is not truth-preserving produces a contradiction, we will know that it must be truth-preserving. Consider this case:

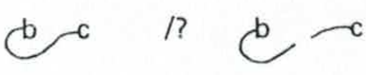


Fig. 20.

If we express that in English, we have "From: 'Something is b and c', can we transform, in a truth-preserving way, to: 'Something is b' and 'Something is c'?" To assume it is not truth-preserving, we make the left graph (the INITIAL GRAPH) true, and the right hand pair (the GOAL GRAPH) false. That assumption produces the following exhaustive set of possibilities (which includes the three ways the goal graph can be false):

T		F	
Something is bc	/?	Something is b and	Something is c
		F (= Nothing is b)	F (= Nothing is c)
		F (= Nothing is b)	T
		T	F (= Nothing is c)

Each of the three possibilities for the falsity of the goal graph produces a contradiction with the truth of the initial graph. For instance, in the last case ('Something is c' is F), if there are no things that are c's, there can be no things which are both bc (which is required for the initial graph to be T). A similar contradiction applies in the other two cases. Thus, this is not a non-truth-preserving transformation, and so must be a truth-preserving one. That means that with it, we would never go from true premisses (initial graphs) to get a false conclusion (goal graph). Similar tests would apply wherever this rule could be used, so the general form would be correct.

INSERTION is a bit different in Beta. Of course, since a spot is a graph, it may be inserted into any odd level. But a new feature of Beta insertion is that on an odd level, two separated lines of identity may be united if the level is continuous. Let us run this test case through the procedure just used to verify Beta erasure:

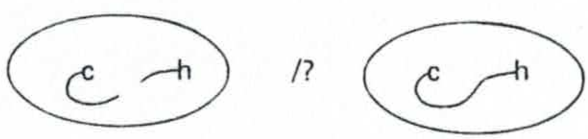


Fig. 21.

If we express that in English, we get:

T	F		F	T
Deny (Something is c and	something is h)	/?	Deny	(Something is ch)

F (= Nothing is c)	F (= Nothing is h)
F (= Nothing is c)	T
T	F (= Nothing is h)

To consider one of the possibilities for falsehood of the initial graph, in the last one, 'Something is h' = false, there would exist a contradiction. Namely, if there are no things that are h, it would be impossible for there to be any things that are ch, as required in the goal, where it is claimed that 'Something is ch' is true. All of the possibilities in the initial graph produce comparable contradictions. So, we may conclude that the transformation is truth-preserving. And, again, similar tests could be made for any instance of the rule, hence this rule is also truth-preserving.

3. Putting Beta to work

A person who has read the earlier account of Alpha and the above section on parts of Beta would be equipped to handle a great many formal semioses expressing some common equivalences and argument forms involving classes. For instance, here are the four traditional categorical sentences:

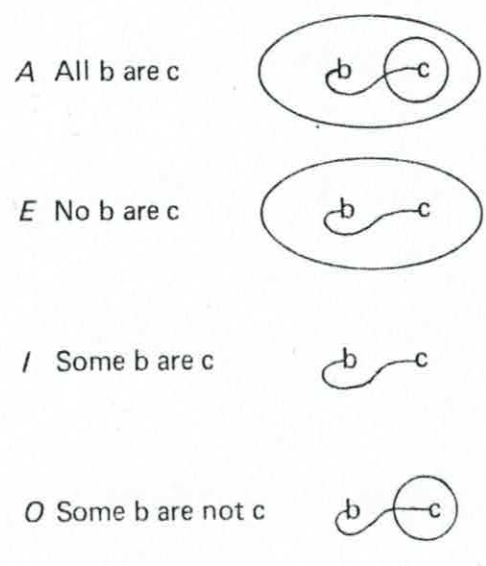


Fig. 22.

With the double cut rule, we can easily see that the following list of denial forms for the four categorical sentence forms are correct equivalences:

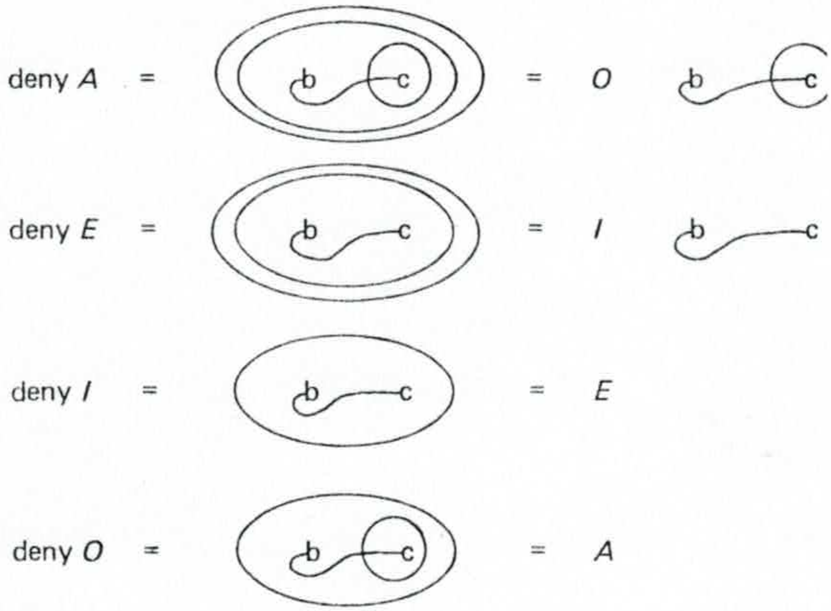


Fig. 23.

Here are the conversion equivalences, which follow from the conventional commutative feature which is a part of the meaning of SA:

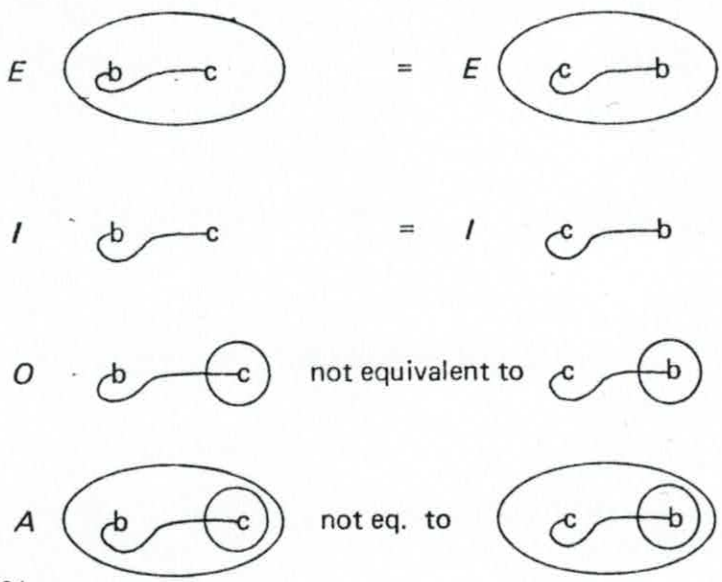


Fig. 24.

And here are the four obversion equivalences (again simply a matter of double cut use):

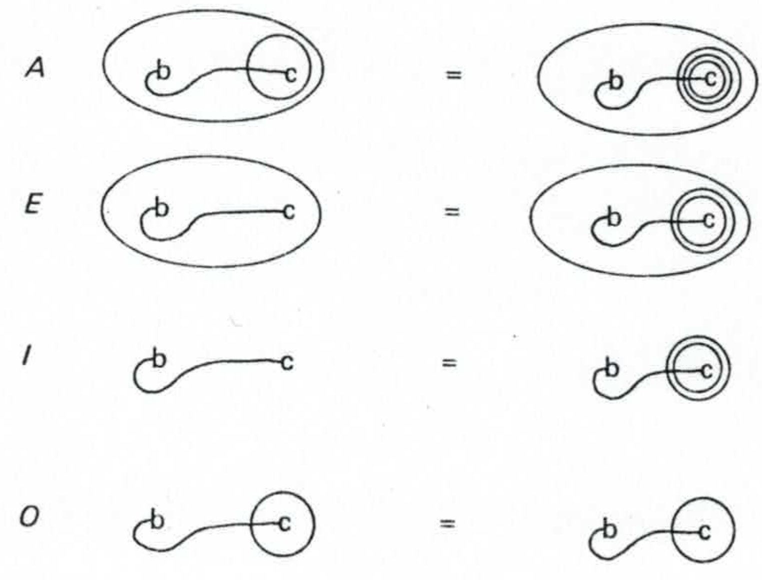


Fig. 25.

One familiar with the history of logic would have recognized that Beta EG is Boolean (Peirce was a disciple of Boole: see Eisele 1979, Putnam 1982, and Brunning 1981). That is, EG makes no committment to there being an existing member of the subject classes of universally quantified propositions. Aristotle, like most persons in everyday talk, assumed that discussion is of existing beings. In EG, we can simply add the assumption of existence as a second graph. Remember that Peirce's goal in creating EG was to provide a tool of analysis. The fact that we have to add the existence assumption as a second graph is then a plus or gold star for EG. With this idea, we can then perform the classical square of opposition with Beta EG.

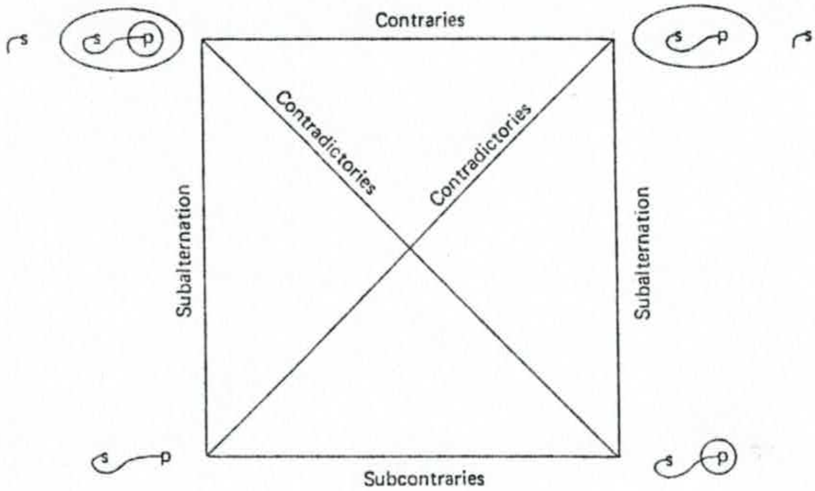


Fig. 26. *Aristotlean Opposition in EG*

To provide an example, let me present a proof of subalternation from A to I (you might wish to try the other relationships):

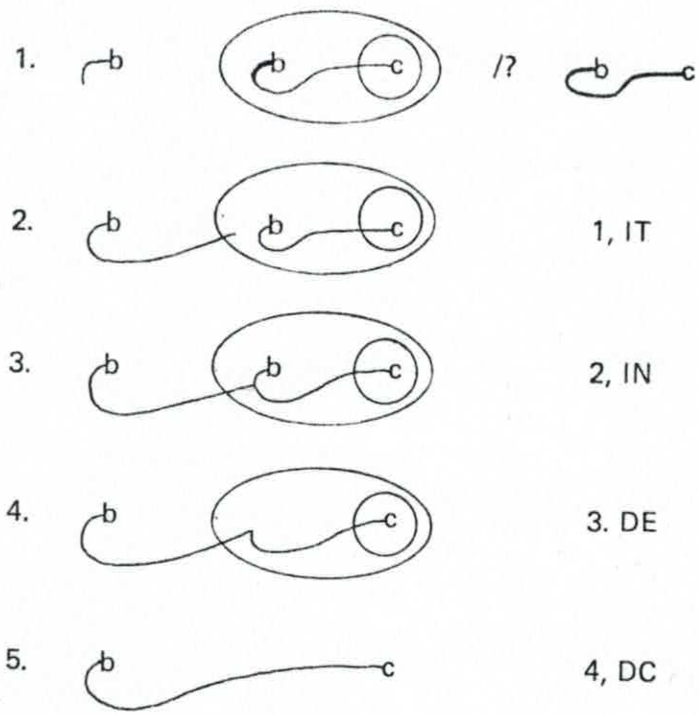


Fig. 27.

Concerning categorical syllogisms, Beta provides a very efficient means for checking them. With the help of my students, we have developed a single rule for testing such argument forms. Most logic books give from three to six rules for the same task (for instance, Copi 1982: 227 f). Here is the single rule: If one reaches the conclusion of a standard-form categorical syllogism by either the Tunnel sequence or the Wire sequence (but not both), then and only then is the syllogism valid. That means that if the conclusion is NOT reached at the end of one or the other sequence, the syllogism is invalid. "What the heck are Tunnels and Wires?" you will say. Here is an example of the Tunnel sequence:

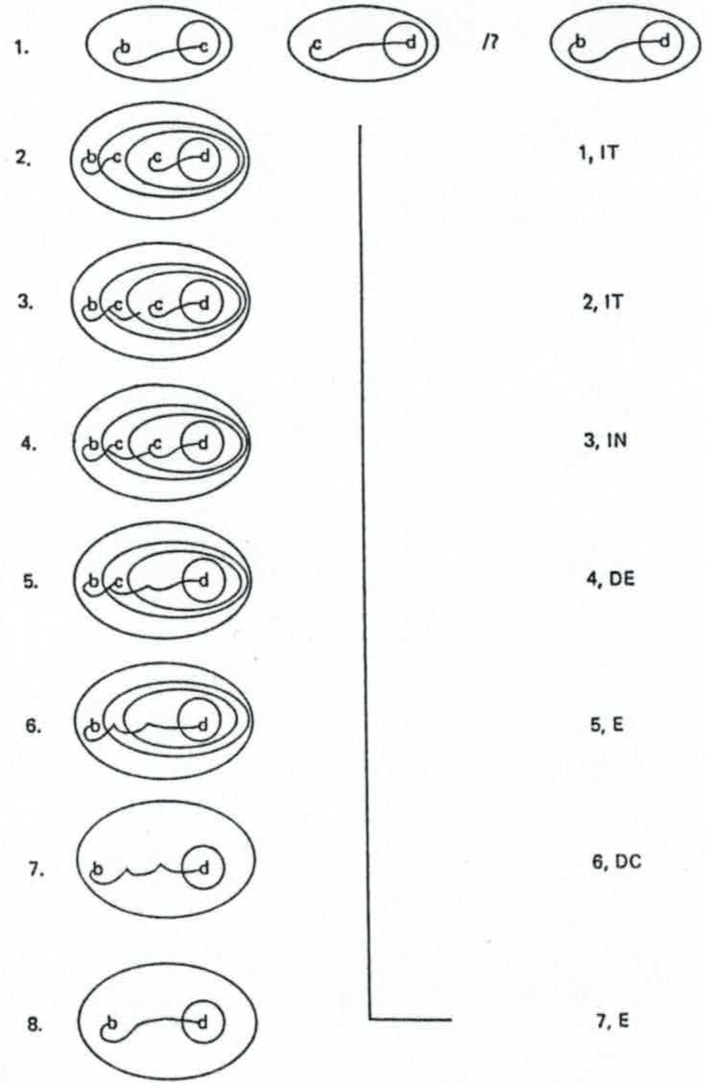


Fig. 28.

And here is an example of the Wire sequence:

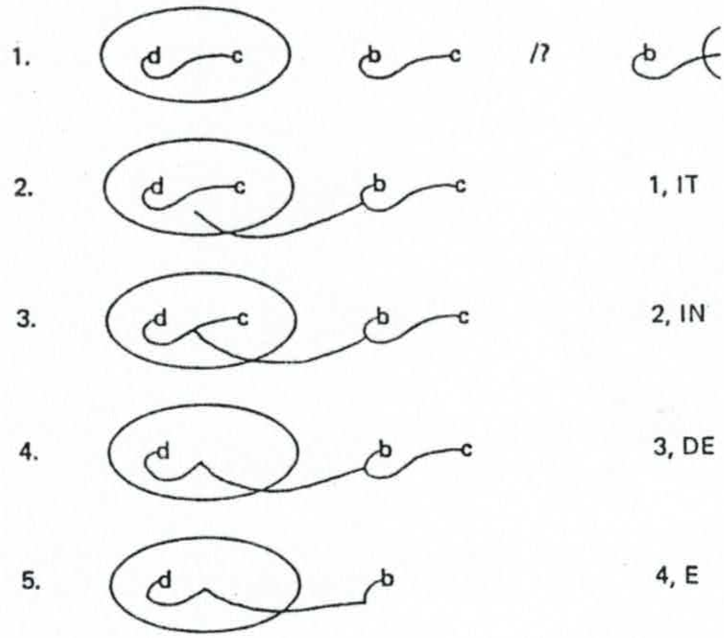
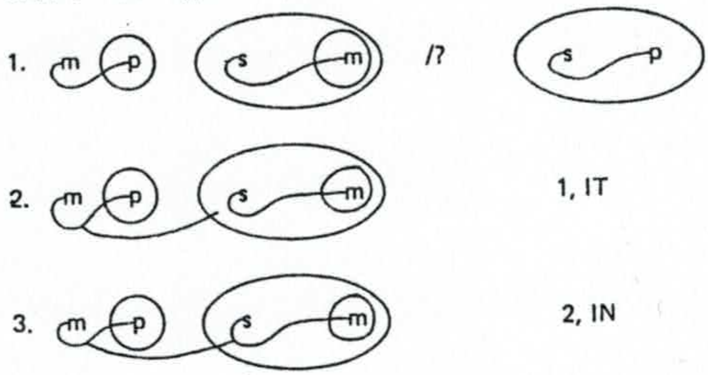


Fig. 29. *An optional DC step is allowed.*

Here are a few examples of some invalid syllogisms solved according to this one rule method:

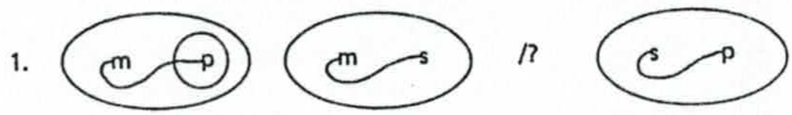
OAA-1 Wire type



Sequence is halted because the required next step, a DE involving m, cannot be performed; hence the argument is invalid.

Fig. 30.

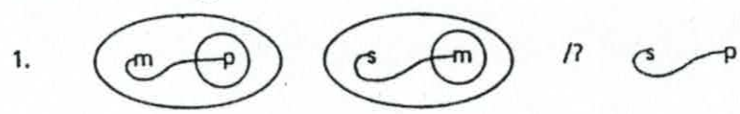
AEE-3 Tunnel type



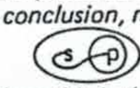
There are three different possible ways to perform the required IT step in this Tunnel sequence, but each of them will fail later because one of the m terms will always be on an odd level, and hence cannot be erased. So, the argument is invalid.

Fig. 31.

AIA-1 Tunnel type



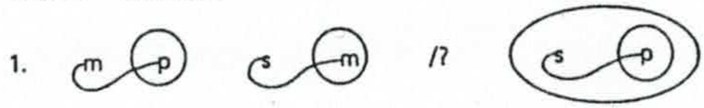
Following the prescribed Tunnel sequence produces a conclusion, namely:



However, since this is the wrong conclusion, the argument is invalid.

Fig. 32.

OOA-1 Wire type



It will not be possible to join the two lines of identity because they are on an even level. So, the argument is invalid.

Fig. 33.

4. Conclusion

I hope enough has been presented so that you can appreciate that Beta EG is a very efficient and quick calculus for traditional categorical logic, just as it also is for sentential logic. Of course, Beta includes many more topics than categorical logic. Some of you may have been wondering why Peirce named the system EXISTENTIAL graphs. He told us why in several places. My favorite explanation of it can be found at *CP* 6.318–324, written in 1909. If you take a look at that passage, I think you will see some of the reasons why we still have a great deal of work ahead before reaching a full understanding of EG, and its significance within Peirce's works. I hope my efforts will prove to be a contribution to that object.

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