Enhancing the Diagramming Method in Informal Logic

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ABSTRACT

The argument diagramming method developed by Monroe C. Beardsley in his (1950) book *Practical Logic*, which has since become the gold standard for diagramming arguments in informal logic, makes it possible to map the relation between premises and conclusions of a chain of reasoning in relatively complex ways. The method has since been adapted and developed in a number of directions by contemporary informal logicians and argumentation theorists. It has proved useful in practical applications and especially pedagogically in teaching basic logic and critical reasoning skills at all levels of scientific education. I propose in this essay to build on Beardsley diagramming techniques to refine and supplement their structural tools for visualizing logical relationships in a number of categories not originally accommodated by the method, including dilemma and other disjunctive and conditional inferences, *reductio ad absurdum* arguments, efforts to contradict arguments, and logically circular reasoning, with sugestions for improved diagramming of logical structures.

1. DIAGRAMMING ARGUMENTS

As a tool in understanding and evaluating arguments, diagramming techniques offer a useful and elegant representation of inferential structure. Diagramming the informal interrelations between an argument's assumptions and conclusions helps us to appreciate the logic of its implicational connections, and to identify its strengths and weaknesses[1].

For simplicity, and because the needed examples tend to be more univocal in informal logical structure, we confine attention exclusively to de-

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[1] The standard diagramming method was originally proposed by Beardsley (1950), and further refined by Thomas (1973) and Scriven (1976).

ductive inferences. Modifications for inductive and other kinds of argument diagramming are intuitive and straightforwardly modeled structurally on corresponding deductive paradigms, and logically valid ones at that. There is accordingly scant motivation, especially in the first instance when the basic enhancements of standard argument diagramming are being presented and proposed, for going beyond deductive inference as the simplest and the most important to make sure at the outset of getting right. What kind of argument diagramming could we reasonably be said to have, if we cannot even explain how to diagram the inferential structures of deductively valid arguments? We have to start somewhere, and we choose for good reasons to start with deductive validity among the kinds of arguments that informal logic is most often expected to analyze[2].

2. STANDARD DIAGRAMMING IN THE SIMPLEST CASE

The first step in the standard method of diagramming in informal logic is to number an argument's assumptions and conclusions, typically distinguished in their ordinary language expressions by inference indicator terms, like 'thus', 'therefore', 'hence'. In the simplest case, where a single conclusion is supposed to follow from a single assumption, the assumption and conclusion numbers are written out horizontally with the conclusion below the assumption, connected by a vertical arrow running from assumption to conclusion. Here is an argument with this straightforward structure.

    1. Today is Tuesday.
    ————————————
    2. Tomorrow will be Wednesday.

The argument can be represented by the following most basic diagram:

    (1)
    ↓
    (2)

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[2] I prefer the terminology of *assumptions* and *conclusions* connected by *inference indicator terms*, in describing the informal logical anatomy of a typical argument and in the most general sense, deductive, inductive, or of any other type. Among assumptions in turn there can be both ordinary *premises*, if we choose to call them that, and the *hypotheses* of *reductio ad absurdum* inferences.

More interesting arguments typically have more than one assumption, and sometimes more than one conclusion, and the assumptions and conclusions can be related together in any of several ways. The standard diagramming method is equipped with conventions to represent arguments in which multiple assumptions contribute to a single conclusion, and single assumptions imply multiple conclusions.

3. ADDITIVE AND NONADDITIVE ASSUMPTIONS

To begin with assumptions, the standard diagramming method depicts these as related in two ways, additively and nonadditively.

Several assumptions taken together are sometimes required to support a conclusion or multiple conclusions, which would not follow if the assumptions were not combined or supposed jointly to hold true. These assumptions are said to be additive. They are diagrammed by connecting their numbers in the standard argument diagram with a '+' sign, and drawing a horizontal line under all of the additive assumptions, as though they were being added together in an addition column in arithmetic. Finally, an inference arrow is drawn, running from below the line to the conclusion or conclusions that are supposed to follow. Here is an example for the following argument, in which the conclusion follows from the combined logical input of two distinct assumptions.

1. All rattlesnakes are poisonous.
2. This snake is a rattlesnake.
———————————
3. This snake is poisonous.

The two assumptions in steps (1) and (2) are both required in order to support the conclusion in (3). Neither assumption by itself is sufficient to imply the conclusion. The additive relationship between the assumptions in upholding the conclusion is diagrammed in this way:

(1) + (2)
———————
    ↓
   (3)

Of course, it is possible for any number of assumptions to be additively related to the conclusion of an argument. Above we considered only the simplest case involving two additive assumptions. But in principle we could

have three, four, or, indeed, any number. Here is another example, this time involving three additive assumptions:

1. Either the Republicans or the Democrats will win the Senate.
2. If the Republicans win the Senate, universal health care will be indefinitely delayed by their desire to appease conservative members of the AMA who oppose universal health care.
3. If the Democrats win the Senate, universal health care will be indefinitely delayed because of internal party disagreement about how to finance the best health care pakkage.
————————————
4. Universal health care will be indefinitely delayed.

This argument is correctly diagrammed as involving three additive assumptions in (1), (2), and (3), all of which are required to uphold the conclusion in (4):
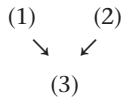
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(1) + (2) + (3)
   —————————
        ↓
       (4)
```

Alternatively, assumptions can be nonadditive or independent in that they do not all need to be combined or supposed jointly to hold true in order to support the conclusion. This occurs, for example, when several different reasons each give sufficient grounds to uphold a conclusion. Nonadditive or independent assumptions in argument are diagrammed by writing the assumptions' numbers above the conclusion or conclusions, dispensing with the short horizontal line required in the case of additive assumptions, and drawing separate arrows from each, departing at an angle and converging on numbers representing the conclusion or conclusions.

Here is a simple case of two assumptions nonadditively or independently supporting the same conclusion (the relationships diagrammed below could hold for any number of two or more assumptions, and any number of one or more conclusions).

1. 5 is an odd number.
2. 7 is an odd number.
————————————
3. There is at least one odd number.

The nonadditive relation between assumptions (1) and (2) and the conclusion in (3) is standardly diagrammed to look like this:

(1)   (2)

     ↘   ↙

       (3)

The intuitive test for whether assumptions are additive or nonadditive is whether or not the conclusion would hold if one of the assumptions were eliminated. If it appears that the conclusion would still be adequately supported even if an assumption did not hold, then most probably that assumption is independent of the others. If, on the other hand, it seems likely that the conclusion would fail if any assumption were eliminated, then the assumptions are additive, and must be supposed jointly to hold in order to imply the conclusion.

In the above example involving the occurrence of odd numbers, either assumption (1) by itself or (2) by itself would be enough to guarantee the truth of the conclusion in (3) that there are at least some odd numbers. The reason is that a single example is sufficient to prove that there are at least some instances of the kind. If we eliminate assumption (1), the conclusion still follows on the strength of (2); if we eliminate assumption (2), the conclusion still follows on the strength of (1). In the previous two examples, by contrast, the conclusion on reflection appears to be inadequately supported if any of the assumptions are eliminated.
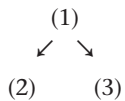
4. DIVERGING CONCLUSIONS

The conclusions that are supposed to follow from either additive or nonadditive assumptions can be also be diverging. This occurs when a single set of assumptions in additive or nonadditive configuration support several different conclusions. Consider, for example, the following argument:

1. Tom is a rational animal.
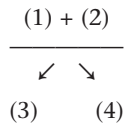————————————
2. Tom is rational.
3. Tom is an animal.

The diverging conclusions in (2) and (3) are diagrammed to show that they are equally implied by assumption (1), in this way:

      (1)

   ↙   ↘

(2)   (3)

Multiple conclusions can also diverge from additive as well as single assumptions in an argument. Here is a specimen argument of this type:
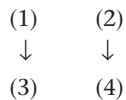
1. Picasso was a great painter.
2. All great painters are true artists and visual poets.
——————————
3. Picasso was a true artist.
4. Picasso was a visual poet.

The assumptions in (1) and (2) are clearly additive, since neither of the diverging conclusions in (3) or (4) follows from (1) alone or (2) alone. The diagram for this argument with diverging conclusions from additive assumptions has this form:

```
  (1) + (2)
 ——————
   ↙  ↘
(3)     (4)
```

Multiple conclusions diverging from nonadditive assumptions are represented simply as parallel basic inferences. This is exhibited in the following argument and accompanying standard diagram:

1. Tom is a rational animal.
2. Oaks are deciduous trees.
——————————
3. Tom is an animal.
4. Oaks are trees.

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(1)      (2)
 ↓        ↓
(3)      (4)
```

5. IMPLICIT ARGUMENT COMPONENTS FOR ENTHYMEMES

As a final refinement of the standard diagramming method, the structural relationships between implicit or suppressed assumptions, conclusions or inference indicators are interposed to reconstruct an explicitly deductively incomplete argument with all essential elements charitably added to maximize the argument's prospects as a deductively valid inference. Such a potentially significantly reconstructed argument is known as an enthymeme. The general idea is to present an argument worthy of more penetrating criticism than that it fails to re-

ach a deductively valid inference, and, perhaps more importantly, to appreciate the argument on its merits more in the way that we may imagine it to have been intended. We may want to learn more from the argument by interpreting it as involving suppressed argument components by which a variety of background considerations can be said to have been justifiably taken for granted by the argument author.

Here is an example of an argument that benefits from the interposition of implicit assumptions, along with a diagram representing what we might plausibly regard as its real more deeply underlying, rather than explicitly stated, structure. The argument is a modification of the previous example. First, we see the argument in deductively incomplete form as it might be most directly reconstructed from its enthymematic ordinary language expression.

    1. Tom is a cat.
    ————————————
    2. Tom is an animal.

The argument evidently leaves out an important assumption needed make the inference valid. This is obviously something like the assumption that 'All cats are animals', or 'Whatever is a cat is also an animal'. The missing or implicit assumption is supplied in this reconstruction, according to the principle of charity, using the standard bracketing convention for implicit argument components described above:

    1. Tom is a cat.
    [a. All cats are animals.]
    ————————————
    2. Tom is an animal.

Now the conclusion in (2) explicitly follows deductively from (1) and [a]. Diagramming this expanded version of the argument by the convention described for arguments with implicit assumptions, we have:

        (1) + [a]
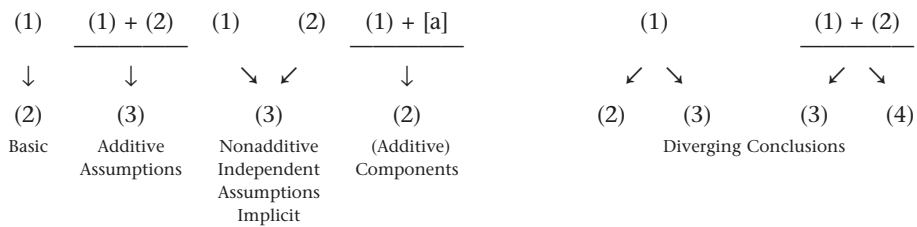   ——————————
           ↓
          (2)

This completes the standard set of diagramming methods. Diagramming makes it possible to depict an inference holding between stated

and implicit additive and nonadditive assumptions and stated and implicit converging and diverging conclusions. The standard method can be used to diagram any inferential relationships that belong to these categories, both simple and the most interesting and complex, built up out of simple inference units in complicated configurations. The method can also be extended to represent disputes involving the interrelation and contradiction of arguments and counterarguments.

6. SUMMARY OF STANDARD DIAGRAMMING TECHNIQUES

The standard diagramming patterns for arguments with six types of relationships between assumptions and conclusions are summarized in the following chart.

STANDARD ARGUMENT DIAGRAMMING CONFIGURATIONS

(1)	(1) + (2)	(1)	(2)	(1) + [a]		(1)		(1) + (2)	
↓	↓	↘ ↙		↓		↙ ↘		↙ ↘	
(2)	(3)	(3)		(2)	(2)	(3)	(3)		(4)
Basic	Additive Assumptions	Nonadditive Independent Assumptions Implicit		(Additive) Components		Diverging Conclusions			

The basic patterns in these standard rules for diagramming arguments are found in most introductory informal logic texts. They are similar in obvious ways to the diagramming techniques used for analyzing the noun-verb-modifier (etc.) structure of sentences in standard treatments of natural language grammars[3].
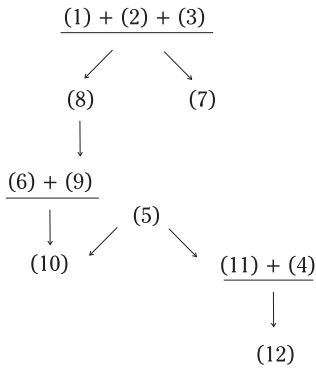
    An application of the standard diagramming method to a relatively complex argument is seen in the following example concerning the metaphysics of substance.

    1. Substance is eternal.
    2. Time is infinite.
    3. If time is infinite, then whatever is eternal is uncreated and endures throughout infinite time.

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[3] Standard diagramming is emphasized as an informal diagnostic technique for evaluating inferential validity by Kelley (1990: 85–160). See also Copi and Cohen (1994: 21–49); Reed, Walton and Macagno (2007).

4. If the world appears to change because substance is constantly changing, then the appearance and substance of the world are identical.

5. Substance cannot remain the same from instant to instant, because its existence explains the world's continuously changing appearance.

6. Whatever endures through time is constantly changing.
———————————
7. Substance endures throughout infinite time.

8. Substance is uncreated.

9. Substance endures through time.

10. Substance is constantly changing.

11. The world appears to change because substance is constantly changing.

12. The appearance and substance of the world are identical.

The complex relations between the assumptions in propositions (1)–(6), and the subconclusions and main conclusions in propositions (7)–(12) can be standardly diagrammed in this way:

The standard diagramming method is complete in the sense that it can be used to diagram the inferential structure of any argument, valid or invalid, sound or unsound. The completeness and comprehensiveness of the method is assured by the definition of an argument as a sequence of propositions distinguished as assumptions and conclusions by inference indicator terms. Regardless of its complexity, the argument components of any argument can always be numbered, implicit components can be interposed in brackets and labeled by letters of the alphabet, the stated and implicit assumptions can be distinguished as additive or nonadditive, the stated and implicit conclusions can be distinguished as divergent or nondivergent, and the stated and implicit assumptions and conclusions so distinguished can in every case be related by direct, convergent, or divergent inference arrows.

7. LIMITATIONS OF STANDARD DIAGRAMMING

The diagramming method provides a way of representing some of the inference relationships that hold between any argument's stated and implicit assumptions and conclusions. There are nevertheless some important elements of the logical structure of an argument that the diagramming method does not picture. The standard diagramming method is complete in a sense, as far as it goes, but it is also limited. It is not as informative as it might be about the inferential relationship between certain kinds of assumptions and conclusions.

We notice at once that the diagramming method does not distinguish between many types of widely diverging arguments that all share the exact same inference diagram. This is clear in the case of any argument in which two assumptions are additively required to deduce a conclusion. All such arguments must be diagrammed in precisely the same way, regardless of the content of the assumptions and conclusion, and regardless of the logical connections and relations that may obtain between the assumptions and conclusion by virtue of which the conclusion is supposed to follow from the assumptions. Here are two examples of quite distinct arguments which we are required by standard diagramming methods to picture as having the very same inference structure.

1. If it is raining, then the rooftops are wet.	1. Alice is taller than Bob.
2. It is raining.	2. Someone is taller than Alice.
———————————	———————————
3. The rooftops are wet.	3. Someone is taller than Bob.

The two arguments are logically fundamentally very different from one another. The argument on the left is a familiar form of conditional detachment or *modus ponendo ponens*. The argument on the right is an inference involving the transitivity of the relation or relational property of being taller than. Both arguments are, nevertheless, standardly diagrammed in exactly the same way, by the familiar additive assumptions diagram, with a horizontal line beneath the two assumption numbers joined by an addition sign, from which a vertical arrow below points to the conclusion number. The two arguments share precisely the same standard diagram form:

$$(1) + (2)$$
$$\overline{}$$
$$\downarrow$$
$$(3)$$

Although the standard diagramming method tells us something about an argument's inferential structure in the relation between its assumptions and conclusions, it also leaves out important features that ideally we might like to have represented. Notice in particular that in using the standard diagramming method we have no good way to represent the branching structure of dilemma arguments, in which two (or more) choices lead to the same conclusions. This is seen in a comparison of the following two arguments:

1. Either it will rain or snow.	1. Roses are red.
2. If it rains, then the rooftops will be wet.	2. Violets are blue.
3. If it snows, then the rooftops will be wet.	3. Sugar is sweet.
————————	————————
4. The rooftops will be wet.	4. Roses are red, violets are blue, and sugar is sweet.

The argument on the left is a disjunctive dilemma. The argument on the right is a conjunctive inference, in which the conclusion merely collects together the three assertions individually stated by the assumptions. Despite these differences, both arguments once again must be standardly diagrammed as having precisely the same inferential structure. The arguments are additive as above, though this time each incorporates three instead of two additive assumptions in support of the conclusion. They share this common form:

$$(1) + (2) + (3)$$
$$———————$$
$$\downarrow$$
$$(4)$$

Another limitation of the standard diagramming method is its inability to depict the inferential relation between the conclusions and assumptions of a deductively circular or question-begging argument or *petitio principii*. The standard method depicts logical inference in a *petitio* as extending from assumptions to conclusions, but fails to depict the backward inference from conclusions to assumptions by virtue of which an argument is caught in circularity. The standard diagram of a circular argument is indistinguishable from the standard diagram of many noncircular arguments. Consider these inferences:

1. God exists.	1. God exists.
————————	————————
2. God exists.	2. God exists or God does not exist.

Both arguments are naturally diagrammed in the same way, with the same numbering of assumptions and conclusions, and an inference arrow extending from the one and only assumption to the one and only conclusion, (1) → (2). Yet the argument on the left is unmistakably circular, while the argument on the right is not. We can write the vertical equivalent of (1) → (1), (1) | (1) or (1) → (2), (1) | (2), where [(2) = (1)], to show that the argument's conclusion merely repeats one of the assumptions. There are unfortunately objections to this practice in some cases, which makes the proposal unsuitable for diagramming all circular reasoning. The problem is that in many arguments circularity does not appear simply between a proposition and itself, but, as far as the argument's inferential structure is concerned, by means of syntactically distinct propositions, in some instances, quite distant from one another in immediate lexical content. More importantly still, the problem in circular argument is not merely that (1) → (2), where (2) in some way restates (1), but rather that (2) → (1). This is true of the argument above on the left, but not of the argument on the right. To show this structural feature of circular reasoning we need an arrow that literally circles back from a conclusion of the argument in which it occurs and singles out the assumption by virtue of which its conclusion is trivialized. We need in compact diagrammatic form the fact that where (1) → (2), it is also the case that (2) → (1), as provided in the enhancement. If we are sensitive to the particularities of circular arguments more generally, in complex as well as in the simplest applications, then we will already be aware that circularity sometimes only affects part of an argument, and that it is often useful to know at a glance exactly which sub-inferences are caught up in circularity, and which are free of that complaint.

Finally, *reductio ad absurdum* arguments are evidently indistinguishable as special argument forms by the standard diagramming method. The standard method has no provision for representing the status of assumptions introduced only for purposes of indirect proof, sometimes referred to as *reductio* 'hypotheses', to be rejected as false when reduced to an absurdity or when a logical contradiction is deduced. The standard diagramming method cannot show that at least some of the assumptions of a *reductio* argument contribute additively to the argument's conclusion in an importantly different way, by supporting a contradiction that leads to the assumption's rejection. The relationship between explicitly stated and implicit assumptions and conclusions is usually diagrammed by making some implicit assumptions explicit as opposed to explicitly stated assumptions and conclusions, labeling them by letters of the alphabet rather than numbers, and placing them in square brackets rather

than parentheses in the diagram. We shall generally follow a version of this convention, although other equally and potentially more informative alternative graphic devices may also be available.

8. PROPOSAL TO ENHANCE STANDARD DIAGRAMMING

The moral of these illustrations is not that standard diagramming is hopelessly faulty. The point is rather that we should be aware of some of the limitations of the diagramming method, and not expect more information from the method than it is capable of providing. Logically interesting features by which some arguments are distinguished even informally from one another are invisible to standard diagramming.

Perhaps the main failure of the standard diagramming method is its failure to exhibit any of the internal structural features of assumptions and conclusions that are relevant to their inferential relationships. The standard method has no way of showing that one proposition is the negation of another, or that a proposition is disjunctive, conjunctive, conditional, or biconditional in form. These characteristics of propositions are vitally important to the logical connections that govern inference relations between an argument's assumptions and conclusions.

It is worthwhile for these reasons to consider substantial revisions of the standard diagramming method. For the present it will suffice to illustrate the possibilities of enhancing standard diagramming by proposing innovations that will make it possible to diagram the internal structures of arguments more sensitively with respect to the internal logical form and content of their assumptions and conclusions, in these categories: (i) circular or question-begging arguments (*petitio principii*); (ii) disjunctive dilemma (and disjunctive syllogism); (iii) conditional inferences (*modus ponens*, *modus tollens*, hypothetical syllogism, and combined types); (iv) *reductio ad absurdum* arguments.

9. DIAGRAMMING CIRCULARITY

The circularity in question-begging or *petitio principii* arguments can be graphically represented by running a half-circle arrow in the argument's diagram from the conclusions or subconclusions to the assumptions the conclusions or subconclusion presuppose. This indicates pictorially in an immediately intuitive way that there is an inferential relation not only

from top to bottom in the diagram, as we expect in a noncircular argument, but also bottom to top, as the mark of circular reasoning[4].

To show the circularity that obtains in arguments where the conclusion must already be accepted in order to accept the argument's assumptions in the simplest case, such as the reiterative example above in which the conclusion that God exists is deduced from the assumption that God exists, we make use of a (semi-) circle or looping inference pattern:

In some applications, we can represent inferential circularity as previously mentioned by writing $(1) \rightarrow (1)$ or $(1) \mid (1)$[5]. Such a method is proposed already by Beardsley, but it is clearly suboptimal[6]. If our purpose is to differently number every syntactically distinct proposition, however, then this strictly reiterative diagramming device will not be equal to the task. If I argue: An infinite spirit reigns supreme throughout the universe, therefore, God exists, I will have engaged in an especially blatant manifest circularity, but the reasoning is not readily represented by $(1) \rightarrow (1)$ or $(1) \mid (1)$. If we try to fill in the suppressed assumptions in this way: (1) An infinite spirit reigning supreme in the universe exists + [(a) God = an infinite spirit reigning supreme in the universe] $\rightarrow$ (2) God exists, then the circularity is just as present as before, but it is not graphically displayed either as $(1) + (2) \rightarrow (3)$, $(1) + (2) \rightarrow (1)$ or $(1) + (2) \rightarrow (2)$. The first effort does not graphically indicate circularity even by labeling, and the second two do not accurately number distinct propositions expressing different meanings.

Circularity, even in a single argument, is often more difficult than this to represent. Question-begging inferences that are spread out over a series of subarguments can occur in which one conclusion or subconclusion is linked to another main conclusion in a circular configuration. Here is an example:

(A) 1. If it is hard to find the circularity in a series of arguments, then circularity can take us by surprise.
2. It is sometimes hard to find the circularity in a series of arguments.
———————————
3. Circularity in some series of arguments can take us by surprise.

———————————
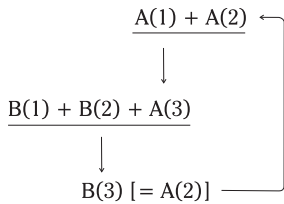[4] Cf. Jacquette (1993); Jacquette (1994a).
[5] Throught, '$\rightarrow$' in not the material conditional, but a horizontal sign for the vertical inferential arrow in standard argument diagramming.
[6] Cf. Beardsley (1950: 389).

(B) 1. To be taken by surprise is to encounter the unexpected.
     2. The circularity in a series of argument is unexpected only when it is hard to find.
     [a. The circularity in some series of arguments can take us by surprise.]
     [from (A)]
     ————————————
     3. It is sometimes hard to find the circularity in a series of arguments.

The circularity is seen in the fact that the conclusion of (B) follows in part from the conclusion of (A), while it is also at the same time one of (A)'s assumptions. The same proposition appears as (B3) and (A2), which in content are precisely identical. This constitutes a circularity in the series (A)–(B). The main conclusion of (B), which derives in part from (A), is already assumed in (A), in this circular series of arguments. We must already accept the conclusion of (B) in order to accept the second assumption of (A), in order to derive the conclusion of (B). Thus, we assume what we are trying to prove. The circularity can be diagrammed in a self-explanatory way:

Diagramming circularity by a (semi-) circular or looping graphic device is the easiest and most obvious method of enhancing standard diagramming in order to represent an important inferential structural feature of many arguments that is otherwise overlooked or graphically less informatively depicted by the standard method.

10. CONVENTIONS FOR DIAGRAMMING CONTRADICTION AND DISJUNCTION

To continue, we require special conventions for representing contradiction and disjunction. We can borrow an icon used in diagramming disputes between multiple arguments, by which conflict arrows bisected by short slant-bars indicate that the propositions so related are mutually contradictory[7].

————————————

[7] Cf. Kelley (1990: 151–160). Kelley (1990: 152) refers to conflict arrows as 'negative arrows'. I have borrowed this device for representing contradictory propositions as one that has already gained recognition among informal logicians for diagramming disputes involving arguments and counterarguments. A disadvantage of the symbol, even for Kelley's

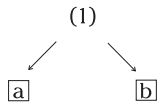Thus, in the diagram below, propositions (1) and (2) are shown to be logically incompatible or contradictories:

(1) ⟺̸ (2)

Exploiting the fact that in classical inference semantics a contradiction implies any and every proposition (sometimes known as one form of the paradox of material implication and one form of the paradox of strict implication), we can further use conflict arrows together with the horizontal line and inference arrow to diagram the inference of any proposition (3) from any mutually logically incompatible or contradictory propositions (1) and (2), in the following T-pattern diagram:

(1) ⟺̸ (2)
      ↓
    (3)

This device will prove useful later in diagramming conditional inferences and *reductio ad absurdum* arguments. Alternative conventions might be developed for nonclassical valid inference systems, such as those available in relevance and paraconsistent logics.

Another new diagramming method is required to represent the composition of a disjunction by its disjuncts. If proposition (1) is the disjunction *a* or *b*, then we can picture its internal disjunctive logical structure in the following intuitive way as a *delta pattern*.

            (1)
          ╱   ╲
        ↙   ↘
      [a]   [b]

Proposition (1) is shown to consist of the two disjuncts, *a* and *b*. The two disjuncts are labeled by letters of the alphabet rather than numbers, enclosed within boxes, at the ends of diverging lines. This convention is appropriate, because by hypothesis the disjuncts are not explicitly given in the argument statement as distinct propositions, but are contained within the disjunction. There is nothing significant about the choice of

graphic purposes, is that an inference arrow divided by a slant-bar more naturally suggests that the inference from proposition to proposition merely does not hold, rather than that one proposition is logically incompatible with or contradicts the other. C. S. Peirce's method of Existential Graphs (EGs) nealty solves this problem by permittig any combination of propositional symbols to be circled in order to indicate graphically that the propositions are jointly negated.

boxes to enclose the terms representing the disjuncts, but something comparable is needed to distinguish them graphically from the parentheses used to represent stated argument components and the square brackets used to represent the implicit argument components in the reconstruction of enthymemes. The boxed terms appear at the end of diverging lines in the delta configuration to depict the fact that the disjunction allows the truth of either one or the other or both possibilities represented by its disjuncts. The idea is to show something like alternative paths or channels that might be taken. The lines are tipped with inference arrowheads. Divergent arrows terminating in boxed letters as opposed to paranthetical numbers do not indicate divergent conclusions, but divergent possible conclusions a divergent disjunctive possibilities.
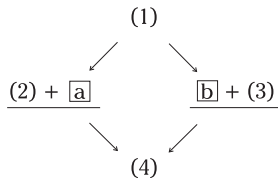
11. DIAGRAMMING DISJUNCTIVE INFERENCES

The conventions proposed in the previous section make it relatively easy to diagram disjunctive arguments. We notice that in the absence of such methods disjunctive arguments are not distinguished as having any special inferential structure by standard diagramming. The standard method does not exhibit the internal logical connectives by which simpler propositions are truth-functionally combined into more complex composites.

Consider an elementary instantiation of argument by disjunctive (sometimes called constructive) dilemma:

1. Either today is Monday or today is Tuesday.
2. If today is Monday, then today is a weekday.
3. If today is Tuesday, then today is a weekday.
———————————
4. Today is a weekday.

As observed above, this argument is pictured by the standard diagramming method as nothing but an inference involving three additive assumptions supporting the conclusion. By representing the disjunctive composition of proposition (1) as consisting of the disjuncts *a* (Today is Monday) or *b* (Today is Tuesday), together with the conditional assumptions in (2) and (3), we can graphically depict the dilemma structure of the argument in a more interesting and informative way. By this method, the two possibilities contained within the disjunction, and the fact that either choice leads to or converges on the same outcome or conclusion, are visually obvious. The diagram in this case can be referred to as a *diamond pattern*.

```
                    (1)
                  /     \
      (2) + [a]          [b] + (3)
                  \     /
                    (4)
```

We shall return to this example in the next section immediately following. There we will further exhibit the logic of conditional inference from the boxed disjuncts *a* and *b* in the disjunctive composition of (1) and the conditional propositions in (2) and (3) (unanalyzed here) as converging on the conclusion in (4).
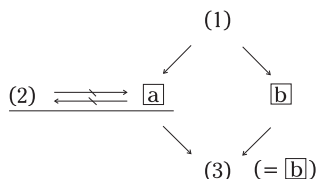
The fruitfulness of this enhancement of standard diagramming techniques is seen in the following application. Disjunctive syllogism is a popular argument form in which a disjunction is advanced, and all but one of the disjuncts are rejected, from which the remaining disjunct is validly inferred. This is also the underlying logic of reasoning by 'exhausting the alternatives', leaving the one unrejected possibility as the only conclusion. By the enlargement of the diagramming method proposed here, inferences by disjunctive syllogism are readily identifiable as special case instances of disjunctive dilemma.

Take the following disjunctive syllogism as an example.

> 1. Either the Pro-Life advocates or the Pro-Choice advocates will triumph in their Supreme Court battle.
> 2. But the Pro-Life advocates will not triumph.
> ————————————
> 3. The Pro-Choice advocates will triumph in their Supreme Court battle.

Using both the disjunctive composition lines to indicate the disjuncts of which assumption (1) is composed, and conflict arrows to show that one of the disjuncts *a* (The Pro-Life advocates will triumph) contradicts assumption (2) (The Pro-Life advocates will not triumph), along with the fact that any proposition follows from such a contradiction, the inference is naturally pictured as a particular form of disjunctive dilemma, in which both horns of the dilemma converge on the same conclusion.

```
                    (1)
                  /     \
      (2) ⟺ [a]          [b]
                  \     /
                (3)  (= [b])
```

The notation by which a proposition in the diagram is identified under different terms provides a useful reminder of the proposition's content, or what it expresses, but is unnecessary in applying the enhanced diagramming method to represent more sensitively the internal propositional relations within an inferential structure.

12. DIAGRAMMING CONDITIONAL INFERENCES

The fact that conditional propositions are truth-functionally reducible to disjunctions, in which the negation of the conditional's antecedent is disjoined with the conditional's consequent, can be invoked to enhance the standard diagramming method in representing conditional inferences such as *modus ponens*, *modus tollens*, hypothetical syllogism, and related forms. Any conditional proposition can be diagrammed as a disjunction of two disjuncts, to adopt a univocal convention, with the negation of the antecedent on the left fork, and the consequent on the right.

This choice represents an interpretation of the conditional in informal logic as a material conditional, and as such requires justification. Although the diagramming method developed here is intended as an adjunct to informal deductive reasoning in the paradigm, we consider the material conditional also as it is defined in formal symbolic logic. The explanation is that:

(1) It is simpler, more univocal and better understood than other conditionals.

(2) There is nothing inherently formalist about understanding conditional statements in relation to disjunction and negation, which, indeed, can be done formally or informally.

(3) By interpreting conditionals even informally as the material conditional, also interpreted informally, we establish and illustrate the fact that the resources for defining the material conditional are already available to informal logic, ancillary to the concept of a mathematical logical truth function.

(4) There are many candidate conditionals beyond the material conditional whose *deductive* inferential structure, as in *modus ponens* and *tollens*, is properly explicated in relation to disjunction and negation (or equivalently, but graphically more complexly, to conjunction and negation), and it would be prejudicial even to their informal critique to choose from among them.

(5) It would be a serious distraction, in the present context, to treat a naturally unsystematic subject either exhaustively or by elevating some

types of conditionals over others with no available graphic guidelines as to how each might be applied to ostensibly different colloquial arguments, where there is in fact no better way to represent the inferential logical structure involving any nonmaterial conditional proposition except by the previously discounted equivocal $(X) \rightarrow (Y)$.

(6) Finally, informal logic need not be seen as isolated from formal symbolic logic, but rather as an ally, part of a spectrum of methods contributing in different ways to a complete logical analysis of an argument. We may begin informally at some level or point of historical origin, and end with the most sophisticated notations, axiomatizations and algorithms of contemporary mathematical logic, set theory, and their formal semantics. If informal logic is understood as at least potentially part of such a spectrum of methods, if we do not have good reasons for excluding it as such, then enhanced diagramming in informal logic, without shaming its informal ethos, can nevertheless welcome the graphic diagramming, itself an inherently formal activity and end-result, of inferential relations in ways that dovetail smoothly with their counterparts in formal symbolic logic[8]. The example of note in the present application is that of reading the logical structure of conditionals in enhanced diagramming as that of material conditionals.

There still remains the greatest difference in the world between formal and informal logical treatment of the material conditional, since our preferred choices for enhanced argument diagramming do not, significantly, have anything to say about truth values, the conditional as a truth function, about truth table definitions of the conditional by cases, or about decision methods for the conditional or any of the rest of an algebraic propositional logic to which the material conditional might formally belong, and in terms of whose interrelations with which it can only be fully understood. Enhanced argument diagramming, though still squarely part of informal logic, thereby makes a point of positive contact with symbolic logic and facilitates one transition of analytic methods from established informal to established formal concepts, notations, and techniques. For these reasons, and with this informal justification, we consider the deductive logical-inferential structure of conditional reasoning to be that of the material conditional, for purposes of advancing an enhanced diagramming method in informal logic. The alternative, again, seems only to be the rather logically opaque and indistinct one-size-fits-all diagramming of conditionals generally as $(X) \rightarrow (Y)$. We show a deductively inferentially relevant internal structure belonging to $(X) \rightarrow (Y)$
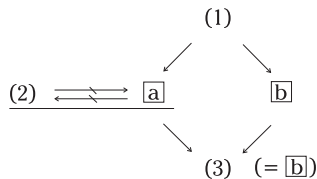
---

[8] Cf. Jacquette (2007).

by relating the → symbol to prior graphically interpreted and intuitively transparent informally understood devices for diagramming negation and disjunction. If there is both a preferred nonmaterial conditional that contributes to deductively valid reasoning and can be distinctively diagrammed as to its logical structure and contribution to deductive inference as something more logically informative than (X) → (Y), then it would make a splendid addition to enhanced diagramming in formal logic to set beside the proposed graphic analysis of the material conditional. Suffice it to say that such a proposal has yet to appear on the horizon.

Continuing now with the most basic form of *modus ponens*, we represent the inference by the identical diagram used above to depict the logical structure of one basic form of disjunctive syllogism, indicating their logical equivalence and interreducibility. Here is a conditional *modus ponens* rephrasing of the argument used to illustrate disjunctive syllogism:

1. If the Pro-Life advocates do not triumph, then the Pro-Choice advocates will triumph in their Supreme Court battle.
2. But the Pro-Life advocates will not triumph.
—————————————
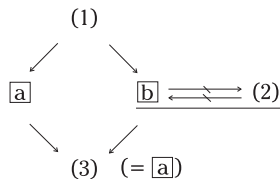3. The Pro-Choice advocates will triumph in their Supreme Court battle.

The diagram for the revised argument by the proposed enhancement has the very same pictorial structure, a variation of the diamond pattern, as that presented for disjunctive syllogism:

Similarly, *modus tollens* conditional inferences are reducible in this fashion, interestingly, as mirror-images of *modus ponens* arguments. Here is an ordinary language example and its corresponding diagram involving the reduction of the conditional major assumption (1) to a logically equivalent disjunction, and the dilemma convergence on a common conclusion. This time, the convergence occurs by inference from the contradiction of the conditional's consequent and the argument's minor assumption (2) (giving equal time to Pro-Lifers).
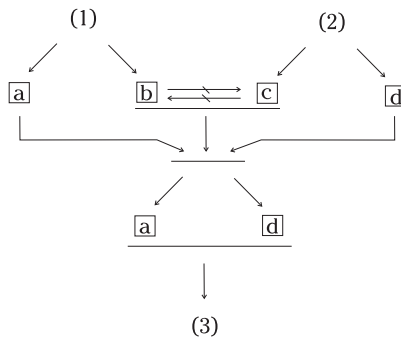
1. If the Pro-Life advocates do not triumph, then the Pro-Choice advocates will triumph in their Supreme Court battle.
2. But the Pro-Choice advocates will not triumph.
——————————
3. The Pro-Choice advocates will triumph in their Supreme Court battle.

The diagram for *modus tollens* has this corresponding form. Convergence on the conclusion this time is effected by contradiction with the argument's minor assumption on the right, rather than, as in the case of *modus ponens*, on the left.

```
        (1)
       /    \
     a       b  ⇌  (2)
       \    /
        (3)  (= a)
```

By extensions of the same diagramming methods, the logical inference in hypothetical syllogism, involving two conditional assumptions, and a conditional conclusion, in which the antecedent of the first assumption and the consequent of the second assumption are conditionally related as antecedent and consequent of the conclusion, can also be depicted. Here is a diagram in what we shall call the butterfly pattern for a simple example of hypothetical syllogism:
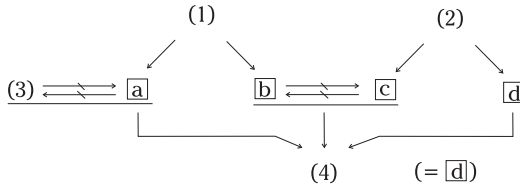
1. If we win the match, we win the game.
2. If we win the game, we win the tournament.
——————————
3. If we win the match, we win the tournament.

```
        (1)              (2)
       /    \           /    \
     a       b ⇌ c         d
      |        \    |    /    |
      |         \   ↓   /     |
      |          ‾‾‾‾‾‾‾      |
                /       \
              a           d
              ‾‾‾‾‾‾‾‾‾‾‾‾‾
                   |
                   ↓
                  (3)
```

The diagram is clearly more informative than the standard rendering by which assumptions (1) and (2) are pictured merely as contributing additively to the conclusion in (3), in (1) + (2) → (3) or (1) + (2) | (3).

Structures like this are now obtained for related inferences combining the features of hypothetical syllogism with *modus ponens* or *modus tollens*. The first is an argument form in which conditional assumptions of the form, If *P*, then *Q*; If *Q*, then *R*; and an assumption of the first conditional's antecedent *P*; supporting the conclusion, therefore, *R*. The pattern of interpretation by reduction of conditionals to equivalent disjunctive forms is predictable enough at this point to see at a glance how the enhanced diagramming method works when applied to reductions of successive conditionals as disjunctions.
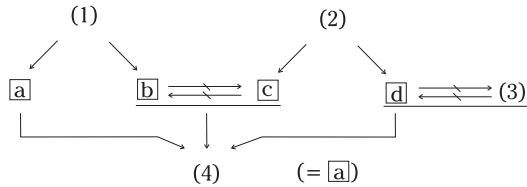
    1. If you give a mouse a cracker, she might want a cookie.
    2. If a mouse might want a cookie, she might also want a muffin.
    3. You give a mouse a cracker.
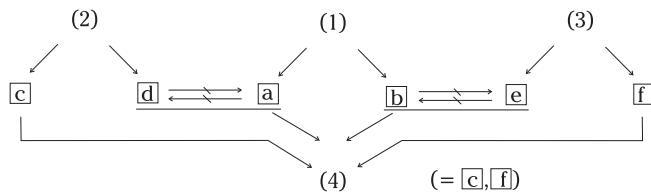   ─────────────
    4. A mouse might also want a muffin.

It is important to notice that although proposition *Q* is shared by the first and second conditional assumptions, as consequent of the first and antecedent of the second, the same terms do not appear as shared by the conditionals when they are reduced to disjunctive form. This is because the consequent *Q* in the first conditional is retained upon reduction to the equivalent disjunction, while the antecedent of the second conditional is reduced in the equivalent disjunction as not-*Q*. These are accordingly diagrammed with different boxed alphabet letters, *b* for *Q*, and *c* for not-*Q*, and their mutual logical incompatibility or contradiction is represented by the conflict arrow convention.

The second example is the mirror-image of the first, in the same way and for the same reason that the modified diamond diagram for *modus tollens* is the mirror-image of the modified diamond diagram for *modus ponens*. Consider the problem of diagramming conditional arguments like the following:

    1. If I could afford it, I'd buy you a new car.
    2. I'd buy you a new car, if money grows on trees.
    3. Money doesn't grow on trees.
    ─────────────
    4. I can't afford to buy you a new car.

As a final example in this category, let us return to the disjunctive dilemma considered earlier. The first assumption is a disjunction of the form, *P* or *Q*, and the second and third assumptions are conditionals of the general form, If *P*, then *R*, and If *Q*, then *R*. The conclusion that *R* follows by dilemma. Now we can represent the logical structure of the argument in more detail by further reducing the second and third conditional assumptions to disjunctive form. When we do this, the enhanced diagramming method yields the following variation of a butterfly diagram of its inferential relations:

13. DIAGRAMMING INDIRECT PROOF OR *REDUCTIO AD ABSURDUM*

In order to diagram *reductio ad absurdum* arguments, it is necessary to have a convention for representing assumptions introduced only as hypotheses for purposes of indirect proof, to be rejected when a contradiction is derived in part or in whole from them.

Whereas in non-*reductio* arguments the assumptions with which an argument begins remain the argument's assumptions throughout, in *reductio* arguments the negations of false assumptions are asserted as the argument's conclusion. For this reason, it is appropriate in diagramming *reductio* arguments to distinguish *reductio* assumptions from the other (sincere) assumptions in an argument by placing the numbers (or alphabet letters in the case of implicit *reductio* assumptions required in the reconstruction of enthymemes) that represent them within angle brackets: < >.
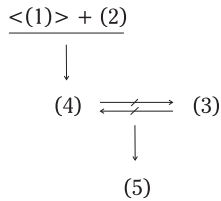
We can use this device even in reconstructing arguments from ordinary language as a preliminary step leading to diagramming. To do so is

analogous to the procedure involving square brackets in reconstructing enthymemes with implicit argument components. Consider this *reductio* argument:

> <1. Susan will not run for President.>
> 2. If Susan does not run for President, then Mark will not run for Vice-President.
> 3. Mark will run for Vice-President.
> ─────────────────
> 4. Mark will not run for Vice-President.
> 5. Susan will run for President.

The inference is not difficult to represent. The basic *reductio* strategy can nevertheless be built into much more complicated argument structures. The logic of the argument is pictured in this diagram. The essential diagramming element is the T-pattern:

```
 <(1)> + (2)
    |
    ↓
   (4) ⇄̸ (3)
         |
         ↓
        (5)
```

The argument is diagrammed by indicating the essential features of *reductio* assumptions and the absurd consequences that are supposed to follow from them. Angle brackets mark the *reductio* assumption to be rejected upon deduction of a logically contradictory consequence. To indicate that a logically contradictory consequence has been deduced, we use conflict arrows, as previously, to represent the fact that the propositions represented by corresponding numbers are logically incompatible.

One further convention that we deliberately do not adopt is the use of such a device as '<' and '>' or '<<' and '>>' to mark the *conclusions* in a *reductio* inference that follow only from the *reductio* hypothesis or hypotheses. The main reason for this decision is that many *reductio* inferences are deductively valid despite undercertainty as to which conclusion should be regarded as dependent on the *reductio* hypothesis or hypotheses. This is often a matter of dispute between an argument author and the argument's critics, and we should not prejudice the proper interpretation merely in diagramming the argument's inferential structure.

Where we have a relatively clear and confidant command of a *reductio* argument author's intentions, we could adopt such a device to keep

track of the direct inferences from *reductio* hypotheses in the argument. Such information may be useful when we have it, but often in diagramming arguments we do not know a *reductio* argument author's intentions. However, the most important objection to making the direct conclusions of *reductio* inferences stand out in the diagramming convention is that it requires diagrammer to have already fully interpreted the argument before diagramming its structure, whereas the purpose of argument diagramming is precisely to facilitate an understanding of the argument's inferential structure. Making that kind of labeling a requirement for diagramming puts the cart before the horse, and undermines one of the principal reasons for diagramming the logical inferential structures of deductive and other arguments. If we must know what conclusions are meant in earnest, and which are merely the implications of hypotheses we know to be false, in order to diagram an argument, then there seems little point in actually making the diagram. At least in those general instances when we are using diagramming in order to understand inferential structure, we may prefer not to mark the diagrams more than we need to in order to reflect the argument's internal inferential relations. We do not want to impose requirements on diagramming methods that might not be obviously or univocally fulfilled in all relevant applications, that do not in any case contribute to our understanding of deductive connections within the argument, and especially not if their restrictions preclude it from being used in all of the sorts of ways expected of argument diagramming. The diagrams are nevertheless to use as we see fit, so we certainly can mark them in any way we choose, including annotating the conclusions of *reductio* inferences, if doing so serves a practical purpose.
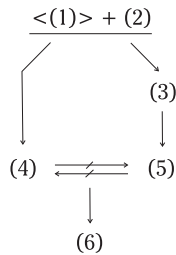
Here is another example, a simplified variation of Euclid's famous proof that there is no greatest prime number. Suppose I want to prove that there is no greatest even number. I assume the opposite of the conclusion I hope to establish, by beginning with the proposition that there *is* a greatest even number, which I call 'N'. If N is an even number, no matter how great, I can always obtain an even number greater than N by adding $N + 2$. Thus, I have reduced the assumption that there is a greatest even number to an absurdity, an outright logical contradiction — that N is the greatest even number, and N is not the greatest even number (since $N + 2$ is an even number greater than N)[9].

The *reductio* argument to prove that there is no greatest even number can first be reconstructed in the following way:

---

[9] Cf. Jacquette (2008).

<1. There is a greatest even number, *N*.>
2. If *N* is an even number, then *N* + 2 is an even number greater than *N*.
————————
3. *N* + 2 is an even number greater than *N*.
4. *N* is the greatest even number.
5. *N* is not the greatest even number.
6. There is no greatest even number.

The diagram for this basic *reductio* argument has this form, where again the T-pattern depicts the main point of logical interest:

```
        <(1)> + (2)
        ╱       ╲
       ╱          ↘
                   (3)
       ↓            ↓
     (4)  ⇄/⇄    (5)
       ↓
      (6)
```
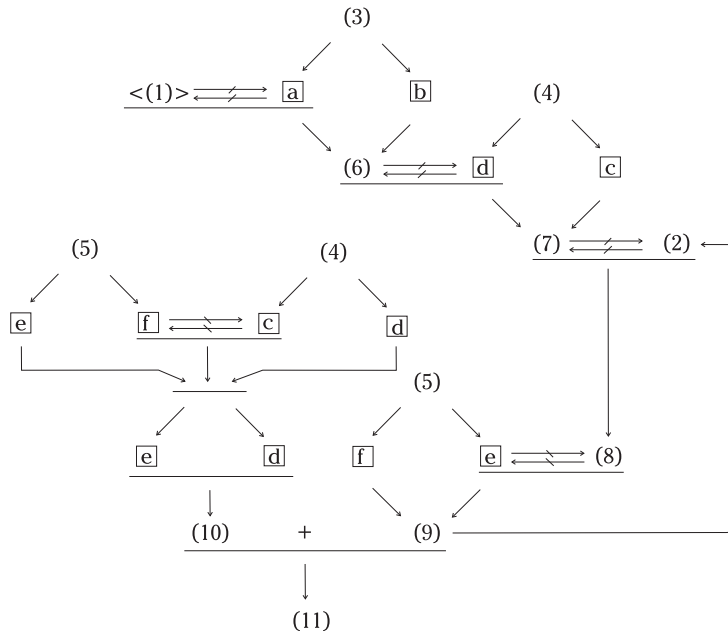
14. ENHANCED METHOD ILLUSTRATED

To demonstrate the advantages of the proposed enhanced diagramming method, we shall consider a contrived logic textbook argument of gratu-itous *reductio* reasoning, for purposes of illustrating enhanced diagram-ming of its inferential structure, and compare both kinds of diagrams. If we begin with the reconstructed inference, then we do not identify any assumptions as hypotheses of the *reductio*. The argument states:

1. All humans are mortal.
2. Not everyone has the good fortune to visit Carthage.
3. Either it's not the case that all humans are mortal, or I'm a monkey's uncle.
4. If not everyone has the good fortune to visit Carthage, then I'm not a monkey's uncle.
5. If it's not the case that all humans are mortal, then not everyone has the good for-tune to visit Carthage.
————————
6. I'm a monkey's uncle.
7. Everyone has the good fortune to visit Carthage.
8. It's not the case that all humans are mortal.
9. Not everyone has the good fortune to visit Carthage.
10. If it's not the case that all humans are mortal, then I'm not a monkey's uncle.
11. Not everyone has the good fortune to visit Carthage, and if it's not the case that all humans are mortal, then I'm not a monkey's uncle.

This sequence is easily identified as a valid inference. How should it be diagrammed for purposes of analysis in informal logic? The standard diagramming method has the following form:

$$(1) + (3)$$
$$\overline{}$$
$$\downarrow$$
$$(6) + (4)$$
$$\overline{}$$
$$\downarrow$$
$$(7) + (2)$$
$$\overline{}$$
$$\downarrow$$
$$(8) + (5) \qquad\qquad (4) + (5)$$
$$\overline{} \qquad\qquad \overline{}$$
$$\downarrow \qquad\qquad\qquad \downarrow$$
$$(9) \qquad + \qquad (10)$$
$$\overline{}$$
$$(11)$$

One might falsely conclude from the standard diagram that the argument involves only one logical operation, since all the inferences must be standardly represented as simply additive. There are, however, six distinct types of inference, and a vicious circularity contained within the argument, to which the standard diagram is oblivious. The depth of detail provided by the enhanced diagramming method is apparent in this alternative formulation, in which the argument's circularity, and its combined disjunctive syllogism, two kinds of conditional detachment, hypothetical syllogism, *reductio ad absurdum*, and conjunctive inferences, are easily discernible in the combination of characteristic modular diagramming patterns previously described. This is what the inferential structure of the argument looks like graphically in enhanced diagramming:

(3)

<(1)> ⇄ a   b   (4)

(6) ⇄ d   c

(5)   (4)   (7) ⇄ (2)

e   f ⇄ c   d

(5)

e   d   f   e ⇄ (8)

(10)   +   (9)

(11)

15. EXTRA CREDIT PROBLEM ON SHERLOCK HOLMES' LOGIC

As a final example, here is a challenge for the reader. The argument appears as part of Sherlock Holmes' reasoning in *The Adventure of the Cardboard Box*. Sir Arthur Conan Doyle's master detective is called in to investigate a peculiar occurrence in which a woman has been sent a small cardboard box packed with salt and containing two severed human ears.
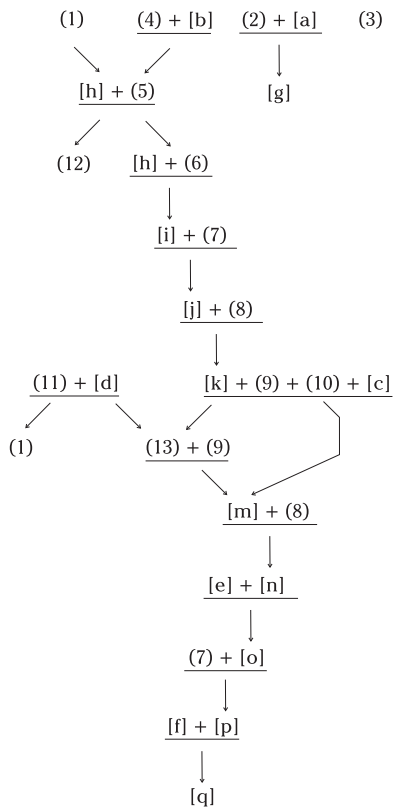
> Holmes answered, "and for my part I shall set about... by presuming that my reasoning is correct, and that a double murder has been committed. One of these ears is a woman's, small, finely formed, and pierced for an earring. The other is a man's, sun-burned, discoloured, and also pierced for an earring. These two people are presumably dead, or we should have heard their story before now. To-day is Friday. The packet was posted on Thursday morning. The tragedy, then, occurred on Wednesday or Tuesday, or earlier. If the two people were murdered, who but their murderer would have sent this sign of his work to Miss Cushing? We may take it that the sender of the packet is the man whom we want. But he must have some strong reason for sending Miss Cushing this packet. What reason then? It must have been to tell her that the deed was done! or to pain her, perhaps. But in that case she knows who it is. Does she know? I doubt it. If she knew, why should she call the police in? She might have buried the ears, and no one would have been the wiser. That is what she would have done if she had wished to shield the criminal. But if she does not wish to shield him she would give his name. There is a tangle here which needs straightening out" (Doyle 1986: 327–328).

Holmes is evidently engaged in a tricky bit of cogitation about the possibilities posed by Miss Cushing's receipt of the mysterious and grisly box. We can reconstruct this argument, as far as Holmes takes it in the above passage, with a bit of additional information from later in the story, and then diagram it according to the standard method as a preliminary step leading toward a more complete critical evaluation. The argument is interesting, because it is enthymematic, and involves multiple implicit inference components. It contains an implicit double *reductio ad absurdum* from two distinct but related *reductio* assumptions, an inference by disjunctive syllogism, and several types of conditional inferences. The *reductio* subarguments are not completed until later in the story. For convenience, the relevant assumption, unstated in the passage quoted above, is introduced in [e] as implicit. The following reconstruction seems appropriate:

1. A double murder has been committed of the two persons whose ears were contained in the box.
2. One of the ears is small, finely formed, and pierced for an earring.
   [a. A small, finely formed ear pierced for an earring probably belongs to a woman.]
3. The other ear belongs to a man, and is sunburned, discolored, and pierced for an earring.
4. If the two persons to whom the ears belong were not dead (murdered), we would have heard about what happened to them before now.
   [b. We have not heard about what happened to the persons to whom the ears belong before now.]
5. The ears were mailed to Miss Cushing on Thursday morning.
6. If the two people were murdered, then it was the murderer who sent the ears to Miss Cushing.
<7. If the murderer sent the ears to Miss Cushing, then the murderer has a strong reason for sending the ears to Miss Cushing.>
<8. If the murderer had a strong reason for sending the ears to Miss Cushing, then either the murderer sent the ears to Miss Cushing to inform her that the murder was done, or to cause her pain.>
9. If the murderer sent the ears to Miss Cushing to inform her that the murder was done, then Miss Cushing knows who the murderer is.
10. If Miss Cushing knows who the murderer is, then she would not have called the police about receiving the box of ears.
   [c. Miss Cushing called the police about receiving the box of ears.]
11. If Miss Cushing knows who the murderer is and wishes to shield the murderer's identity, then she would have buried the ears.
   [d. Miss Cushing did not bury the ears.]
   [e. The murderer did not send the ears to Miss Cushing to cause her pain.]
   [f. If it is not the case that if the murderer sent the ears to Miss Cushing, then the murderer has a strong reason for sending the ears to Miss Cushing, then the murderer may have sent the ears to Miss Cushing by mistake.]
   _____
   [g. One of the ears probably belongs to a woman.]

[h. The two persons to whom the ears belong are dead (murdered).]
12. The murder of the two persons to whom the ears belong occurred before Thursday.

[i. The murderer sent the ears to Miss Cushing.]

[j. The murderer has a strong reason for sending the ears to Miss Cushing.]

[k. Either the murderer sent the ears to Miss Cushing to inform her that the murder was done, or to cause her pain.]

13. Miss Cushing does not know who the murderer is.

[l. Miss Cushing does not wish to shield the murderer's identity.]

[m. The murderer did not send the ears to Miss Cushing to inform her that the murder was done.]

[n. The murderer sent the ears to Miss Cushing to cause her pain.]

[o. It is not the case that the murderer sent the ears to Miss Cushing either to inform her that the murder was done, or to cause her pain.]

[p. It is not the case that if the murderer sent the ears to Miss Cushing, then the murderer has a strong reason for sending the ears to Miss Cushing.]

[q. The murderer may have sent the ears to Miss Cushing by mistake.]

If we limit ourselves to the pictorial devices of the standard diagramming method, then the diagram of Holmes' reasoning looks like this:

This is an informative representation. It tells us quite a bit about the external inferential structure of the argument in Holmes' not-so-elementary-my-dear-Watson reasoning. However, the standard diagram also leaves many aspects of Holmes' thinking concealed. The exact nature of the disjunctive, conditional, and *reductio* inferences, essential to Holmes' logic, in particular, are obscured. The next step in understanding the argument might therefore be to sketch a diagram of the inference according to the enhanced diagramming method, working from the very same informal reconstruction.

I am not going to give away the ending — not of how Conan Doyle's sleuth solves the mystery of the salted ears, nor of how the enhanced diagram is to be completed. We can see clearly from the reconstruction of this portion of the story that Holmes has available for further reflection in trying to catch the murderer the information that the ears of the victims probably belong to a man and a woman, that the murder occurred before Thursday, that the murderer is probably unknown to Miss Cushing, and that the murderer probably sent Miss Cushing the ears by mistake (this subconclusion in fact turns out to be crucial to Holmes' eventual discovery of the criminal). There is an interesting logical twist to the puzzle, which, as Holmes says, needs to be untangled[10].

16. CONCLUSION: EXPLOITING GRAPHIC TECHNIQUES

It is only by enhancing the standard informal logic diagramming method by conventions equivalent to those proposed here that diagramming can represent the internal logical relationships that ensure the deduction of an argument's conclusions from it assumptions. The failure of the standard diagramming method to represent this internal structure explains the lack of interest formal logicians typically assume toward argu-

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[10] An enhanced diagram of Holmes' argument is prepared from the standard diagram by replacing additive inference icons with appropriate T-pattern, circle, delta, diamond, or butterfly diagramming modules. The difficulty lies in thinking through the original argument statement to determine where particular kinds of modules are needed, and in arranging and linking-up the component subdiagrams correctly and discernibly in two dimensions. The problem is alleviated somewhat by the fact that connecting inference arrows can be drawn from remote distances on the diagram surface to the proposition numbers to which they attach. In this sense, the method is less restricted than Venn and Euler diagramming techniques in depicting predicative inference relations among the extensions of four or five predicates. With enough paper and patience, it is always possible to prepare a more informative enhanced informal logic diagram from any preliminary standard diagram or directly from any ordinary language argument.

ment (as opposed to semantic tableaux or Smullyan truth-tree) diagramming[11].

The limitations of standard diagramming methods are not inherent. The standard diagramming method can be supplemented with additional conventions by which the logical structures of propositions that enter into arguments as assumptions and conclusions can further be pictorially represented within a recognizably standard framework, while going beyond its limited palette of diagramming devices. The enhanced argument diagramming method which has been proposed holds out the prospect of bridging informal and formal logic with a graphic resource that will be more useful to informal logicians, and that can be taken more seriously by formal logicians[12].

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[11] Evert W. Beth (1959) is credited with developing the method of semantic tableaux. Smullyan trees are adaptations of Beth's tableaux and Jaakko Hintikka's method for constructing 'model sets'. Cf. Hintikka (1955); Smullyan (1968).

[12] Cf. Jacquette (1994); Jacquette (2007).

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