# ICONIC GRAPHS:
# AN EXERCISE IN TOPOLOGICAL PHENOMENOLOGY

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## 1. *Introduction*

John Sowa has often pointed out that his proposal of conceptual graphs develops and updates intuitions by Peirce, as well as by other thinkers in the areas of psychology and linguistics like Selz and Tesnière. To the ideas of the latter refers the Fields medal René Thom, who developed catastrophe theory and made several innovative proposals for the application of catastrophist formalism to natural language. Thom's ideas have been developed in specifically linguistic terms by Wildgen, while Petitot has paid particularly close attention to the relationship between language and visual perception (Cf. in particular [Wildgen 1982] and [1994], [Petitot 1985] and [1995]). The contributions of Thom, Wildgen and Petitot can be better understood as aspects of a broader research programme which we may call 'cognitive semantics'. In its turn, cognitive semantics is a component of an even broader programme which undertakes the transition from the paradigm of computational systems theory to the paradigm of dynamic systems theory.

The first embedding – that of the modern developments of proposals by Tesnière and other structuralists working in cognitive semantics – can be characterized by setting them against Chomskian theory. Indeed, cognitive semantics can also be viewed as a reaction against the cultural and academic hegemony of generativism, since cognitive linguistics regards language as a product of cognitive processes. For cognitive semanticists, "the basic principles of the cognitive organization of the world (perception of reality, construction of mental models, reference to encyclopedic knowledge, conceptualization, mental images and schemata, the grounding of meaning in bodily and social experience, and so on) can and should be accommodated into linguistic analysis … On the other hand, the idea that the components of grammar should be analyzed separately is also rejected" ([Serra Borneto 1993], 445-6). Cognitive semantics, moreover, rejects the thesis of the overall independence of syntax from

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semantics. Generally speaking, this theory articulates into the following two branches:

1. The case grammar of Fillmore and Anderson, which uses categories like Agentive, Dative, Instrumental, Locative, Objective and Benefactive as its primitives.
2. The outright cognitive semantics of Langacker and Talmy based on the geometric and gestaltist analysis of language. Wildgen and Petitot can be placed alongside Langacker and Talmy, together with Lakoff, Johnson, Herskovits, and Manjali.

The second embedding involves the insertion of these proposals into a broader conceptual movement which acknowledges the intrinsic shortcomings of the computational paradigm and seeks to replace it with a dynamic one. Since space precludes consideration of this second embedding in any detail, the interested reader is referred to the recent and excellent collected work on the subject [Port and van Gelder 1995]. For my part, I merely point out that if a dynamic approach is used, many of Peirce's intuitions can be recovered. Wilden acknowledges as much when he states: "His [= Peirce's] logical and semiotic conceptions are a good framework for the development of a dynamic semantic theory" ([Wildgen 1982], 19). Also this component of Sowa's original ideas might therefore be located in the new context of dynamic studies.

In this essay I present some first aspects of the general framework of iconic graphs theory. I shall employ the term 'iconic graphs' to distinguish current ideas from Sowa's theory of 'conceptual graphs' and from Petitot's 'actantial graphs'. Notwithstanding their differences, it should be emphasised that a connection with Fillmore and Anderson's proposals is shared by the various graph theories that I have mentioned.

On the other hand, [Fillmore 1977], 70, acknowledges that the "truly worrisome criticism of case theory" is that "nobody working within the various versions of grammars with 'cases' has come up with a principled way of defining cases, or principled procedures for determining how many cases there are." As far as I know, only the approach developed by Thom allows formulation of a reasonable reply to this "truly worrisome" question. On this point, cfr. [Petitot 1995].

Since I am addressing an audience perfectly conversant with the theory of conceptual graphs, I shall leave the theory of Sowa and colleagues in the background and instead say something about the other two approaches. I accordingly point out that Petitot's actantial graphs are geometric diagrams plotted by projecting the dynamic of the underlying phase space onto the space of the control parameters. A difficulty that I readily admit is that Thom, Petitot and Wildgen set out their theory using a mathematical formalism so formidable that it is almost incomprehensible to non-mathematicians (and perhaps to some mathematicians as well). The true problem, however, does not reside in the complexity of the mathematical tools employed.

Thom and his pupils seek to explain the emergence of meanings on the basis of an underlying dynamic that does not belong to the layer of meanings. In other words, they attempt to connect neuronal dynamics with the emergence of cognitive structures (which may be pre-linguistic in nature). However interesting this problem may be, it is not our problem, since we are interested, if anything, in the connection between these (pre-linguistic) structures and the actual structures of cognition and language. Moreover – as Petitot himself points out – one property of the emergent structures is that they are "to a large extent *independent* of the particular physical properties of the substrate on which the dynamics operate" ([Petitot 1995], 235). Secondly, if this proposal of an emerging structural semanticism of pre-linguistic nature broadly independent of its substrate is correct, it should be possible to use these structures *independently* of their underlying dynamics and therefore independently of the mathematical apparatus employed to model them. In other words, it should be possible to use these structures *directly*, without further mediations. The reason being that if these structures are cognitively valid structures, it should be possible to examine their basic semanticity without considering their underlying dynamics. This means that the dynamic component which causes these structures to emerge is used only as a deep-seated engine – a processing unit lying beneath the level of the schemata – and that graph theory uses the products or output of these underlying dynamics. For this reason, iconic graphs theory can be viewed as an exercise in descriptive phenomenology.

Taken as a whole, the theory envisages the co-presence of three interacting modules:

1. the geometric-configuration module
2. the ontological module
3. the semantic-domains module.

Each module contributes (in interaction with the other modules) to the cognitive schema as a whole. Before presenting a part of the geometric-configuration module, I shall briefly discuss the other two.

The ontological module governs information about:

a) the layers of reality (material, psychological, social) and their levels (for example, in the physical layer, the categorial difference between physical, chemical and biological levels. On the organization of the layers and levels see [Poli 1999]. For a brief summary see [Poli 1996].
b) the general categories (thing, event, whole, part, individual, collection, mass, quality, etc.) and their connections and dependences. For more details see again [Poli 1999].

The semantic-domains module governs information about the selection of the dominant interpretation (according to Wildgen [1982] these are (i) the localistic, (ii) the qualitative, (iii) the phase and (iv) the agent interpretations, the latter divided between (iv-a) the possession and (iv-b) the instrumental interpretations), the selection of context, the organization of semantic fields and their lexical covering. I shall return briefly to this module towards the end of this paper.

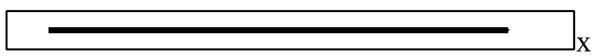
Here I shall present a number of elementary components of the geometric-configuration module: specifically, the section concerning the distribution of cases, that is, in linguistic terms, the structural semantics of verbs. The graphs presented consist of two basic components: (a) the representation of the 'participants' in the graph and their connections (life-lines and points of singularity); (b) the windowing component [Talmy 1996] that selects and activates the semantic potential implicit in the graph. These two components jointly cause the topological semanticity intrinsic in the graph to emerge.

## 2. *Life-lines*

An entity can be represented as a point and its duration as a line. For obvious reasons of clarity, I shall give a name to each line, using the letters *x*, *y*, *z*, *u*. I shall use boxes to represent the semantic windowing (focus), that is, the part of the graph that is semantically highlighted. Windowing makes explicit the semantic potential implicitly embedded in the graph.

That said, the most elementary graph is obviously:

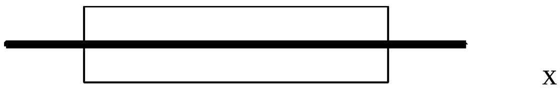
1.



Graph 1 represents a state, duration. For example, ‘it is raining’. Schema 1 does not only apply to impersonals, it can equally well represent the existence of something. Note that in this case the schema does not distinguish between the object and its existence. From the point of view of iconic graphs, an entity *is* its duration. Consequently there is no reason to draw the traditional distinction between the ‘essence’ (invariable part) and the ‘history’ (variable part) of an entity. For the iconic graphs represented here, object and the existence of the object are indistinguishable.

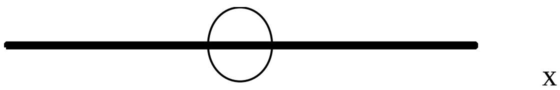
A windowing of 1 consists of:

2.




which expresses the durative (unbounded) valency of the entity. Alternatively, we may focus attention on a single instant of the duration, thus:

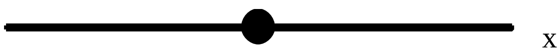
3.




This instant may be any point whatever of the duration of the entity which is entirely similar to any other point, or it may be a point in which ‘something happens’, i.e. a semantically significant point.

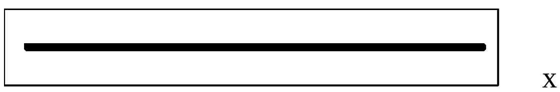
When we wish to graphically represent the fact that we are dealing with some ‘singularity’ (event), this semantically significant point can be represented as follows:

4.



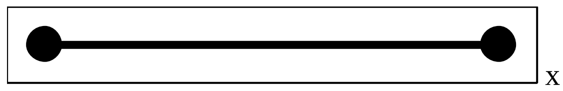

Among significant singularities (points in which something happens), mention should be made of the ‘birth’ and ‘death’ of the entity, i.e. the beginning and end of its duration, which can be represented as:

5.



where the windowing includes the endpoints of the entity. This representation is inadequate, however, for at least two reasons. Because of semantic pregnancy, it is advisable to mark the singularity points as clearly as possible (thereby avoiding the danger of confusing contingent qualities of the depiction with qualities of the phenomenon depicted). Thus 5 should be redrawn as follows:

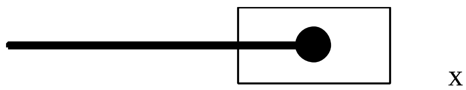
6.




Graph 6 can be broken down into the following graphs:

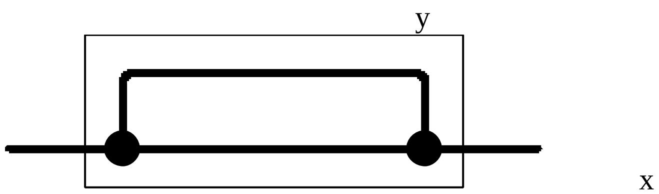
7.


8.



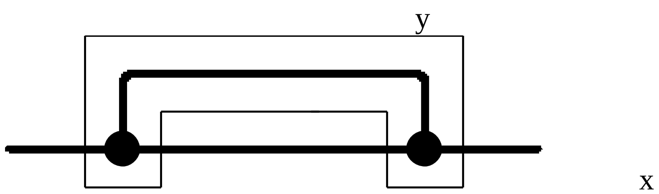

which emphasise the beginning and end of a state. Graph 5, however, contains a further inadequacy which neither 6 nor its breakdowns resolves. In effect, graphs 5-8 ‘state’ that *x* arises from nothing and vanishes into nothing. Although this might be the case of states, it apparently does not appropriately apply to other situations of existence. To deal with this shortcoming, one may reasonably assume that every singularity is always constituted by the transformation of something into something else. Singularities can therefore be represented by indicating not only the life-line that they constitute (the line of which they are the endpoints) but also the life-line from which they originate or with which they merge. Graph 6 should therefore be redrawn as:

9.



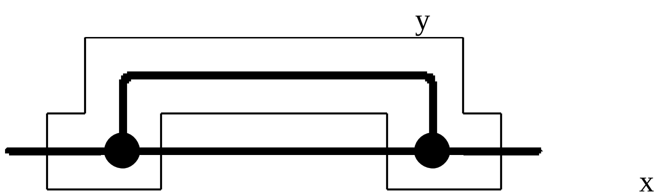

From the point of view of *y*, this graph tells us that *y* 'is born' by emerging from *x*, that it has a duration ('lives'), and then 'dies' by rejoining *y*. From the point of view of *x*, the graph tells us that *x* first 'emits' or 'launches' *y* and then 'captures' it. Should one wish to concentrate attention specifically on *y*, a more explicitly widowing is:

10.



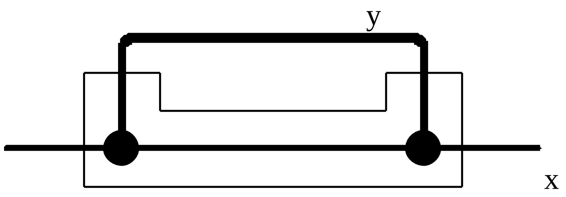

Graph 6 is obtained from 10 by 'detaching' line *y* from its substrate *x* and considering *y* independently from *x*. If attention is focused on *y*, 10 expresses the archetype of the 'leap', of the 'launch'. If instead 10 is transformed into 11, it expresses the passage of *y* to a state of excitement *x* and its subsequent return to a stable state:

11.



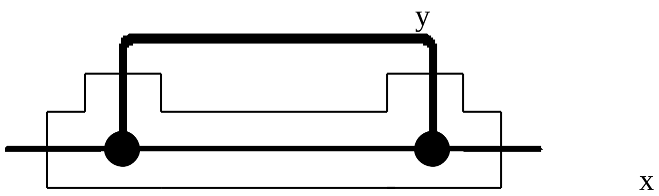

Complementary to 10 is the situation in which attention focuses on the life duration of *x* between the two significant events represented by the singularities:

12.



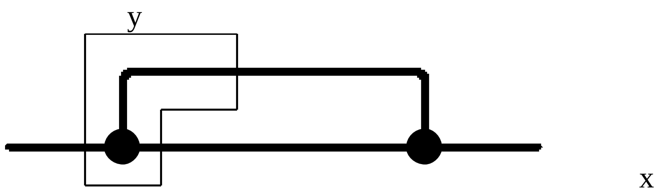

In order to emphasise the continuity of the life-line of *x* with respect to the singularities marked, the most pregnant window is:

13.

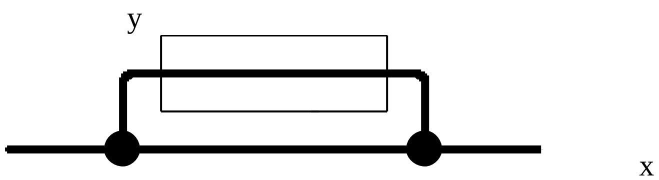



The lives of *x* and *y* can obviously be broken down into their ‘canonical’ phases. From the point of view of *y*, these are the already-seen phases of birth (of onset, of origin), duration and death (of merging, of end). Specularly, for *x* we have emission, duration and capture. Graphically, no problems arise with regard to *y*:

14.

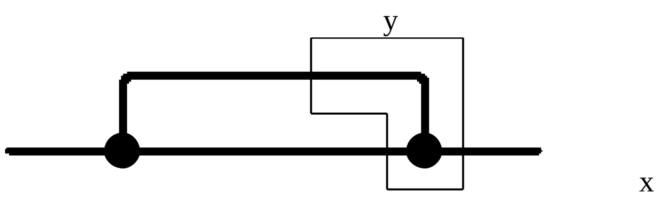



15.




(in which 2 ‘returns’)

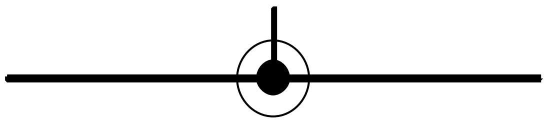
16.




For *x*, however, there is a difficulty connected with graph 4. The singularity in 4 'states' that something happens without representing at all what it is that happens. It is as if it represents a singularity wholly internal to *x*, entirely invisible from outside, and with no effect externally to *x*. But in this case it would have no semantic valency. At bottom, this is an entirely insignificant singularity. If we instead assume that something actually does happen, then it seems perfectly natural to assume that this something is in its turn representable by a life-line. Accordingly, this too will have its 'birth' and eventually its 'death'. On this basis, 4 can be more explicitly redrawn as graphs 14 or 16.

Moreover, one can also imagine a case in which attention concentrates wholly on the event. In this case, the most suitable representation seems to be:

17.



However, in this case – unless one has information about the 'inner' state of the bearer – it is impossible to decide whether this is an event of 'emission' or of 'capture'. This we can only know by 'extending' the window of 17 and verifying whether the new window is of type 14 or type 16.

By way of summary of the discussion so far, there is a universal substrate (continuous line) from which emerge, and to which may return, other lines. In this situation, the three windowings of birth/emission, duration and death/capture naturally impose themselves on our attention.

## 3. *Windowing*

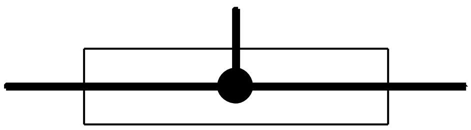
We have seen that there are two canonical cases of the windowing of singularities:

1. windowing of the singularity alone, in which the event as such is considered;

2. 'extended' windowing, in which the singularity is considered together with a surrounding (duration) which enables its classification.

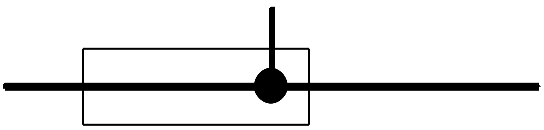
I continue this survey of topological phenomenology by considering the various 'expansions' of 17. The first case is that in which the windowing includes whatever surrounds the event in the substrate:

18.



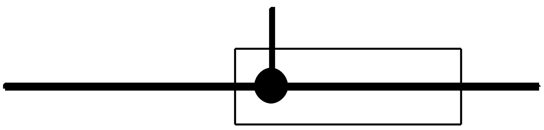
The diagram shows the windowing of the emission (or reception) of something by the substrate. By appropriately altering the window, the phase that *precedes* the singularity can be emphasised:

19.



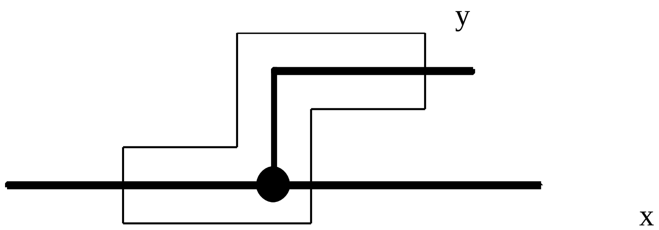
or the phase that *follows* it:

20.



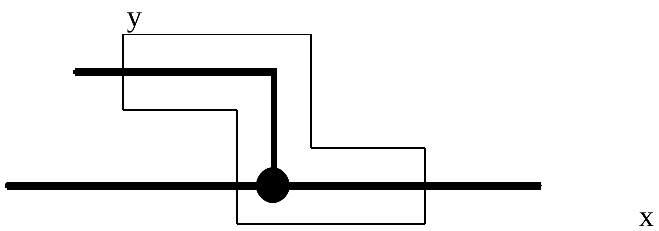
It will be seen that the various cases also depend on the type of event being considered. There remain some further, more intriguing cases where it is advisable to proceed by analysing scheme 14 separately from scheme 16. I begin with the birth schema.

21.




This could be called the transformation schema. 21 can be read as ‘*x* becomes *y*’, in the sense of: ‘*x* passes to’ (a new role, a new function, etc.), ‘*x* is reborn as *y*’. Complementary to 21 is the ‘death’ schema:

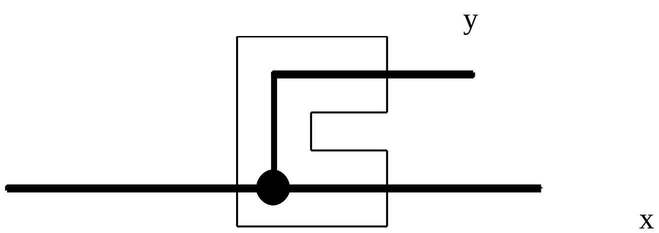
22.




Unlike 21, it is now *y* that becomes *x*. The difference between 21 and 22 is that 21 exhibits the transformation of *x* into *y* by emphasising the passage to a new life while 22 displays the transformation of *y* into *x* emphasising the ‘death’ of the old *y*. In both cases we have a transformation schema, except that the former manifests a positive valency, the latter a negative valency.

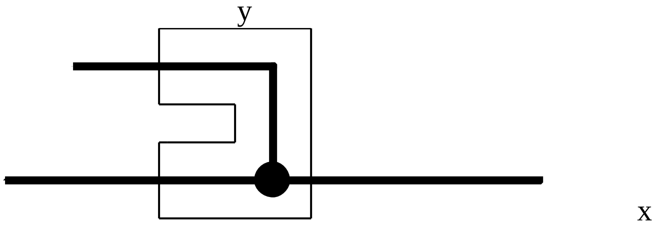
There remain the two following cases:

23.



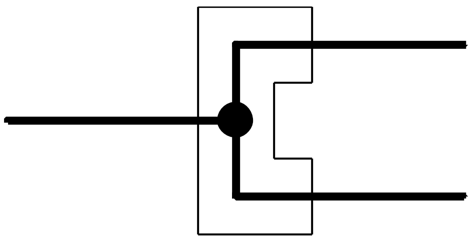

23 exemplifies the case in which the windowing comprises everything that follows the event, both in the object and in the substrate. Its complement is:

24.

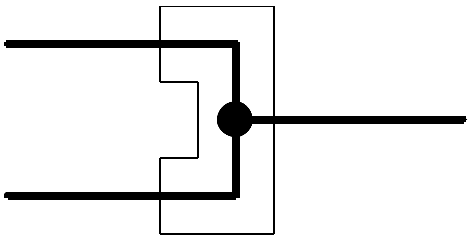



in which the windowing highlights everything that precedes the event, both in the object and in the substrate. In semantic terms, 23 and 24 seem less pregnant than the other schemata. The key to their semantic interpretation lies in their 'reconfiguration' into a more symmetric form:

25.



26.

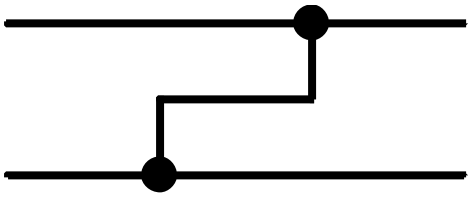


Thus reconfigured, the two graphs express 'division' and 'unification'. Graphs 25 and 26 do not contain a dominant life-line, unlike 23 and 14, where the dominant life-lines seemingly indicate 'excision' and 'attachment'.

## 4. *Graphs with two singularities*

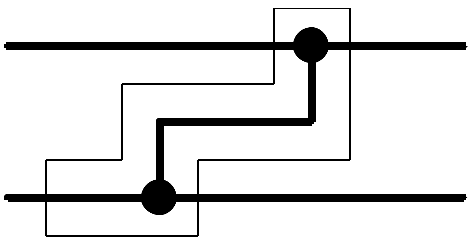
The next development concerns graphs with three actors and two singularities. The typical case is given by:

27.



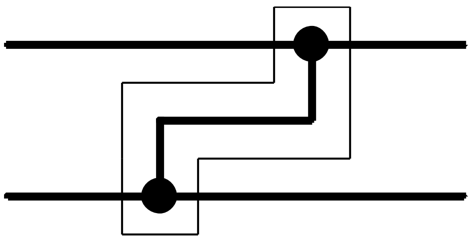
This graph shows the passage of *z* from *x* to *y*. One notes that 27 implicitly contains everything that has been said concerning graphs with two actors and one singularity, but that it manifests further valencies. The base version of 27 is '*x* gives *z* to *y*', the windowing of which is

28.



Note the difference between 28 and the following

29.

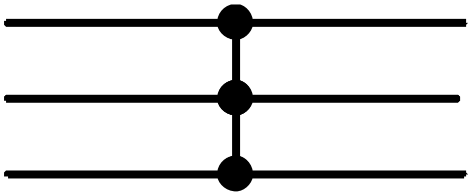


The difference between 28 and 29 resides in the fact that internally to the windowing 28 includes an extension which precedes the emission by the bearer. This inclusion manifests the presence of a duration in which the bearer prepares for the action and performs the action itself. The windowing of 29 does not consider this duration. It instead depicts an action with the valency of immediacy and which manifests a content like '*x* throws *z* to *y*' (in which case, though, the component 'speed' should be added).

5. *Graphs with three and four singularities*

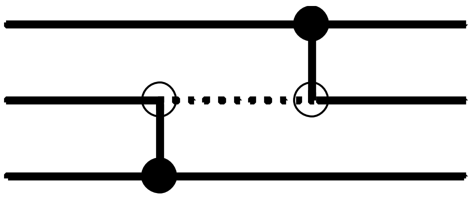
The canonical case of a three-singularity graph is apparently:

30.



The emission of *z* by *x* reaches *y* after encountering *u*. However, there is something that does not function in this graph, which can be understood if we pass to the four-singularity graph. The canonical expression of this latter is '*x* sends *z* to *y* by means of *u*'. In this case there is an actant (*u*) which acts as bearer to another actant (*z*). Note that this type of bearer is different from the one used earlier. Then it was a bearer, now it is a carrier. In the case of a bearer, one says that bearer *x* generates *y*, which is assumed as really bounded even when the windowing does not include its extremes. But in the case of a carrier one says that *v* receives *z* at time $t_1$ and then releases it at time $t_2$. In other words z has an indeterminate story before $t_1$ and after $t_2$. In graphical terms, the situation can be depicted as follows:

31.



The grapheme

32.

displays the presence of a superposition, which can be expressed as:

33.

or even better as:

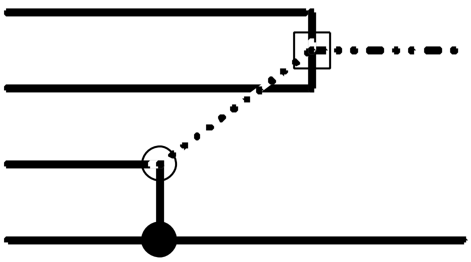
34.

The significance of 33 (34) is that 'z receives *u*, conveys it for a certain duration and then releases it'. Graphs 7 and 33 (34) display the various couplings of the singularities that distinguish the case 'bearer' from the case 'carrier'.

Analysis of these graphs enables us to understand what is wrong with 30: the fact that the carrier is orthogonal to what it is supposed to carry.

The archetype of 'tie' is represented by the graph:

35.

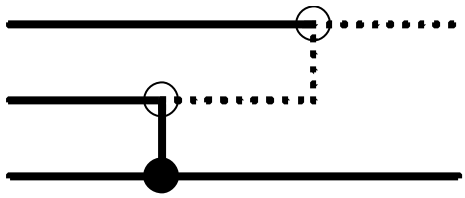


which reads: 'x ties y to z with u'. Note first the graphical distinction among the various types of singularity. As in 31, the circle represents a dual superimposition. The square instead is used to indicate three or more superimpositions. The dotted line following the circle represents the superposition of two life-lines; the alternately dotted and broken line after the square represents the superposition of three (or more) life-lines.

Graph 35 states that the tying event ('issued' or realized by *x*) requires first the 'capture' of *z* and then the release of *z*, which continues its life superimposed on other lives. The latter have a life-line which is first independent of the singularity and then proceeds solidly after it.

A variation of 35 is the following graph 36, where only one entity is 'tied'. It can be used to represent every procedure designed to make an entity more ‘compact’. The underlying idea is that the more compact an entity, the better it functions.

36.

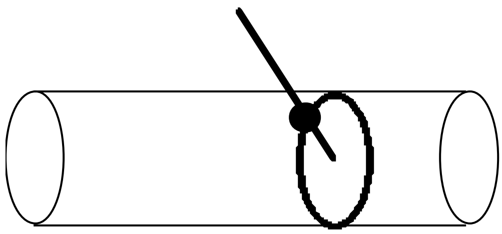


## 6. *Graphs of other levels and other categories*

All the graphs presented hitherto model a specific level of the ontological category of ‘process’. To model other levels of this category, as well as other ontological categories, appropriate alterations must be made to the iconic graphs. Consider the following example.

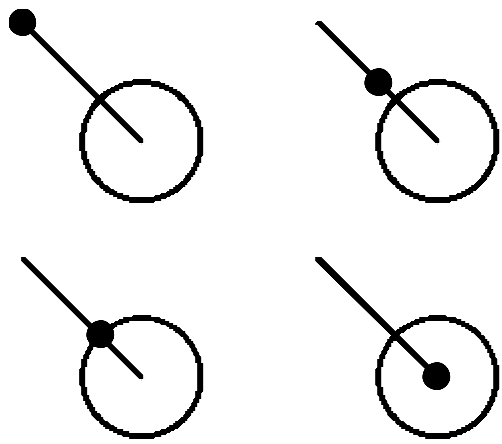
17 contains a singularity whose structure is not further analysed. If for some reason one wishes to magnify the granularity of the graph, it can be ‘exploded’ *in order to bring out its internal structure*. Let us consider 17 from the point of view of ‘capture’. For this to be cognitively meaningful, ‘capture’ by the substrate can be interpreted as ‘ingestion’. With a section of the substrate magnified, 17 becomes

37.



This event can be variously segmented, thereby evidencing the multiplicity of internal boundaries that it contains (on the idea of internal boundary see [Fleck 1996]). Thus 37 can be decomposed into the following graphs:

38.



which interpreted in the static sense depict the cases of 'distant', 'close', 'touches' (coincides with), 'in'. Understood collectively and read in succession, these four graphs represent the schema of 'entering' (see [Langacker 1987], who proposes two different types of scanning, i.e. two different ways to 'read' a collection of graphs of the same phenomenon). By developing this type of depiction, it is possible systematically to reconstruct the basic cognitive schemata ('metaphors') of the type container/contained, centre/periphery, etc., proposed by Lakoff and Johnson.

## 7. *Conclusions*

Perhaps the most surprising result of the foregoing brief exercise in topological phenomenology is the notable semantic precision and the great variety of meanings yielded by the coupling of an elementary geometric schematism with an equally simple windowing mechanism. Although I have omitted all the mathematical apparatus underlying Thom's theories, the pregnancy and the range of possibilities exhibited by iconic graphs is obvious. For reasons of space, many aspects of the theory have been omitted; others still await development. Among the aspects omitted are various topological features of the components indicated.

A question that inevitably arises is the following: are there scattered windowings? The natural answer seems to be 'no', but perhaps there are cognitive conditions (for instance in certain psychiatric pathologies) in which the windowing is structurally scattered.

Secondly, the graphs that I have used here are extremely elementary. If the theory is to be adequately developed, specification is required of the composition mechanisms that yield higher-order graphs starting from elementary ones. Accordingly, both the component representing the 'participants' and their connections, and the windowing component, should be further developed. On the former see [Widgen 1982], on the latter [Talmy 1996].

Thirdly, it is evidently necessary to make more explicit comparison between iconic graphs and other proposals of the same kind (from Shank's scripts to Fillmore's frames to Sowa's conceptual graphs). [Petitot 1995, 252] shows, for example, that the local content of actantial graphs (and therefore *a fortiori* iconic graphs) is like (but richer than) the content of a frame or script.

Finally, I have said nothing about the inferential possibilities of graphs. In this connection, the idea of dynamic inference first advanced by [Wildgen 1982] warrants analysis and further development.

Nor should one forget that the graphs used by the geometric-configuration module furnish only part of the content of a cognitive schema. The other parts are provided by the ontological module, which 'specializes' the positions of the graph by attaching specific ontological labels to them (like animate object, inanimate object, quality, etc.), and by the semantic-domains module, which selects the canonical interpretation, specializes the context (e.g. the prototypical commercial context of buying and selling), structures the semantic fields activated, and selects a suitable lexical covering.

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