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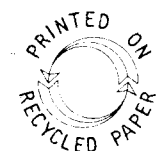
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**ABOUT CRITICAL GROUPSIZE**

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This paper by Yona Friedman was first presented at the GPID II meeting, Geneva, 9-14 January 1978. It can be considered a contribution to the Visions of Desirable Worlds and the Methods of Analysis sub-projects of the GPID Project.

Geneva, January 1980

Johan Galtung

It is being circulated in a pre-publication form to elicit comments from readers and generate dialogue on the subject at this stage of the research.

## I. INTRODUCTION: GROUPSIZE AS A KEY VARIABLE

It is evident for anybody ready to think about what he observes, that nothing in the world can grow without limits: things growing stop doing so when reaching some determined size. This fact seems so evident that most people (and most scientists) accept it without further thought, and without posing the questions: at which size, why and by what operation does an entity stop its growth?

We will call "critical size" the limiting size where growth stops and beyond which, if an entity continues to grow, the growing entity suffers important qualitative changes. "Critical groupsize" will thus be the size of a social group characterized by certain qualities, over which size this group can not keep these qualities. Critical groupsize is effectively critical to the good functioning of a group or of an organization.

Critical groupsize might be the number one problem for human social life. If human social organizations are considered as one of the most important "tools to assure survival" for the species, it is evident that, if this tool changes its quality simply by growing beyond a characteristic limiting size, it might lose its efficaciousness, and, instead of assuring survival of the species, it might become the tool of its destruction. We might today be facing this situation.

How to be masters of our own survival, if we don't gain knowledge about critical groupsize, and this in a stage when our instinctive knowledge about these limits is (at least, for a while) practically lost? We speak about "limits to growth" in many domains, except that of our own organizations; perhaps the inverse would be better, and we should think more about "limits to growth of human organizations" in order to understand and to avoid other problems of growth.

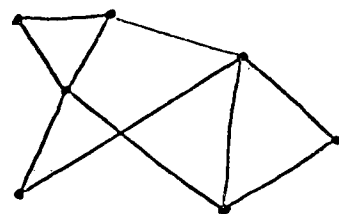
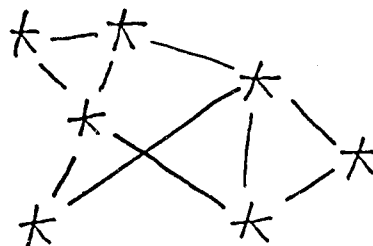
## II. GROUPS, GRAPHS AND GRAPH PARAMETERS

In order to consider critical groupsize otherwise than in a superficial manner, it could be useful to start with stating it as a principle expressing its relation to other factors characterizing organizations. In order to be able to achieve this, we have to look for an appropriate terminology.

I will call "group" a set of individuals in which there exists some sort of "relation" between any two individuals belonging to the set. A person who has no such "relation" to at least one other who in his turn is related to the others, can be considered a person "out of group."

Let us suppose that I would like to sketch the image of a group. I will first draw all persons belonging to it, then continue by drawing lines linking any two persons between whom I observe an existing relation. I will thus represent this group by means of a figure in which any one person will be linked to any other by at least one "path" passing from one to the other by the intermediary of other persons.

If I replace the "mannikins" of this map of the group by points, the result will be a figure consisting of points and lines, in which there is at least one path between any pair of points chosen arbitrarily (connected graph).



Obviously this graph gives an oversimplified image of a group. Using this figure will require further explanation.

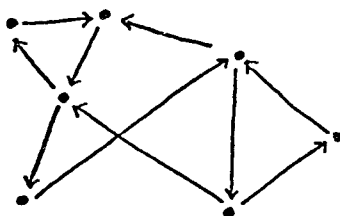
I will thus reexamine the concept of "relations," which I represented by lines in the figure. First I will try to find out who drew it. Otherwise stated, one has to know who the observer of this group is.

I should point out immediately that different observers will see different "maps" for the same group. In most cases it will be difficult to find two observers who would attribute the same importance to the same relation; thus the "importance" of relations cannot be observed without error, and therefore I will not introduce "importance" into my terminology.

On the other hand, the mere existence of a direct relation between two individuals belonging to a group can be observed. This means that the existence or the nonexistence of a "line" in a graph representing a group can be agreed on by a large number of potential observers. I will thus be content to note the existence of a relation.

Another characteristic of such relations can be observed and noted: their "direction." Let me explain the term.

In observing two persons who "communicate" (and thus a relation between them) we can generally state that once the communication is finished, one or the other (or both) of the two persons changes his previous behaviour. We will say, in such a case, that one of the two persons (or both of them) received an "influence" from the other one. This influence has a direction, which points from the person who exerts the influence to the other one who receives it.



I will define "influence" as a relation between two individuals which has an observable direction.

In conclusion, a society will thus be represented by a directed connected graph, that is, by a figure consisting of points and lines, in which there is no point not linked by at least one path to any other point (when arrow directions are not considered) and in which every line carries an arrow representing the direction of the influence in this particular link.

This representation of a society makes it possible to describe its structural characteristics by using maps constructed with graphs as explained above. Structural characteristics do not refer to any measurable size, as I had to exclude, first of all, the possibility of knowing importance, intensities, and so on, of influences in general. I have thus limited myself to considering certain topological properties of these graphs, in order to characterize social organization. These topological properties indicate characteristics implied by the linkage schemes, the paths, and the circuits within such maps of a group; they correspond to those of the influences within a set of individuals.

To get to the description of such important characteristics I shall invoke an image: the image of the "social situation" of a particular person within a group. This social situation will be defined by influences this particular person receives from and exerts upon the other members of the group. For example, if he exerts an influence upon four of his neighbours and he does not receive any influence from anybody, he could be considered as having more "power" than another person who also exerts four influences but receives two influences from others.

Thus the social situation of a particular person will be expressed by the difference between the sum of influences starting with him and the sum of influences having him as their endpoint.

In practice, the social situation of a particular person corresponds to his "balance of influences." But — and this is important — we calculate this balance without associating any difference in size with different influences, as we have agreed that "size" of influence is not observable.

This convention does not mean, obviously, that the two persons linked by this influence do not attribute to it any value, any importance whatever.

We can be sure that they do, and even that very probably this importance will be different for each of the two: the one who exerts the influence might consider it as important, and the other, who receives it, might ignore it; or inversely, one might ignore the influence he exerts on others and the ones who receive it might appreciate its importance.

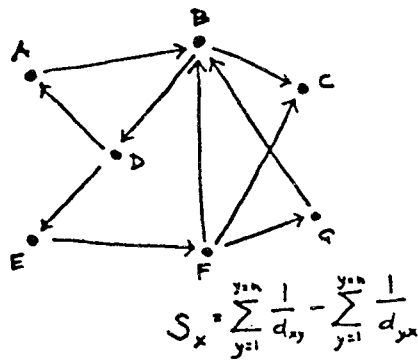
To avoid such ambiguity I had to take as a standard the observation of someone exterior to the society observed. But if this observer considers all direct influences as equal, he might observe a degradation of "indirect" influences (influences transmitted by several intermediary persons), degradation through errors, omissions, because of successive transmissions (degradation resulting from what information theory calls "noise").

We will use, in order to describe this degradation of an indirect influence because of the necessary transmissions, a simple rule: we will suppose that the "intensity" of an influence will decay in inverse proportion to the number of intermediary transmissions necessary to its forwarding.

We are now ready to define the social situation of any person within a group by an observer exterior to this group. It will be expressed by the difference between the sum of all influences (direct and indirect) exerted by this particular person upon all other persons within the group, and the sum of all influences starting from all other persons

in the group and received by him.

In order to do this simple calculation it is sufficient to construct the "path matrix" of the graph mapping the group in question. On the basis of this graph (or of this matrix) we can find both sums necessary to define the parameter of social situation.



$$S_x = \sum_{y=1}^{y=n} \frac{1}{d_{xy}} - \sum_{y=1}^{y=n} \frac{1}{d_{yx}}$$

TO:

FROM:	A	B	C	D	E	F	G
A	0	1	2	2	3	4	5
B	2	0	1	1	2	3	4
C	0	0	0	0	0	0	0
D	1	2	3	0	1	2	3
E	4	2	2	3	0	1	2
F	3	1	1	2	3	0	1
G	3	1	2	2	3	4	0

TABLE SHOWING THE NUMBER OF ARROWS ON A PATH  $(d_{xy})$

THE REAL HIERARCHY IN THE SAME SOCIETY



$(S_x)$

SOCIAL SITUATION OF ALL MEMBERS IN THE SOCIETY

TO:

FROM:	A	B	C	D	E	F	G	
A	0	1.00	0.50	0.50	0.25	0.25	0.20	2.70
B	0.50	0	1.00	0.50	0.25	0.25	0.20	3.00
C	0	0	0	0	0	0	0	0.00
D	0.50	0.50	0.25	0	1.00	0.50	0.20	3.00
E	0.25	0.25	0.25	0	1.00	0	0.20	2.00
F	0.25	0.25	0.25	0.50	0.25	0	1.00	2.50
G	0.20	0.20	0.20	0.20	0.20	0.20	0	1.20
	2.70	3.00	0.00	3.00	2.00	2.50	1.20	

TABLE SHOWING THE RESULT OF DIVISIONS AFTER REDUCTION  $(\frac{1}{d_{xy}})$

$S_A = 2.70 - 2.41 = 0.27$   
 $S_B = 3.00 - 2.41 = 0.59$   
 $S_C = 0.00 - 2.41 = -2.41$   
 $S_D = 3.00 - 2.41 = 0.59$   
 $S_E = 2.00 - 2.41 = -0.41$   
 $S_F = 2.50 - 2.41 = 0.09$   
 $S_G = 1.20 - 2.41 = -1.21$

Using this method, we can obtain not only the social situation of any person within the group of our example (here containing seven persons) that we obtained, but also the real "hierarchy" established (frequently in a tacit way) within the group. Obviously, the hierarchy we find in the figure is only the one observable by somebody exterior to this group. It is quite possible that the hierarchy as observed by Mr. A or by Mr. B differs sensibly from this "objective" hierarchy.

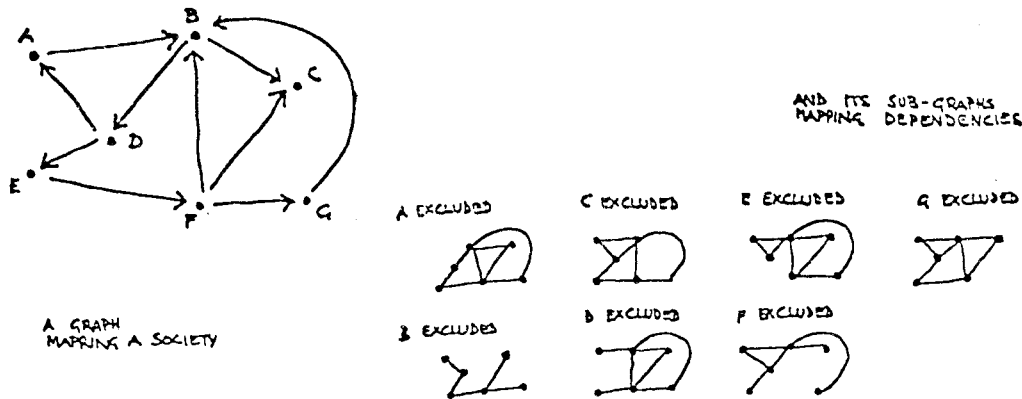
Let us suppose, now, that one member of this group decides to leave it for some reason of his own. Immediately the established hierarchy will be transformed as a consequence of his leaving it. Certain persons remaining within the group will benefit from his defection (their social situation will be improved); others will be prejudiced. Thus, if we suppose — in order to keep the example simple — that all members of the group want to get a "higher" place in the hierarchy, those who benefit by the defection of Mr. X can be considered his "adversaries,"



who are interested in removing him from the group. On the contrary, those who are prejudiced by the departure of Mr. X will try to keep him: they are his "allies."

Using this simple function, which I call "dependence" of a particular person in a group upon the departure of Mr. X, we can construct a "table of alliances" characteristic of this group.

"Dependence" can be calculated in a simple way: by obtaining the difference between the social situations of a person belonging to the group before and after the departure of Mr. X. The first social situation can be calculated on the graph which maps the group as a whole (Mr. X included); the second social situation will be obtained by calculating on a subgraph of the same graph, a subgraph which does not contain Mr. X.



We obtained thus, by a method sufficiently simple to be used by a ten-year-old child, a fairly good description of the real structure of a group. This method can be used for any imaginable society.

After all these preliminary explanations I would try to define, for the sake of example only, two concepts of group structure, concepts which I consider important: "egalitarian" groups and "hierarchic" ones.

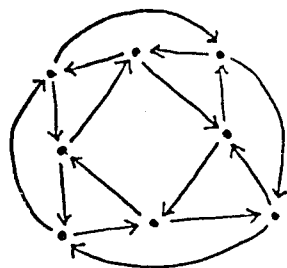
I call a group "egalitarian" if all its members have the same social situation. Put otherwise, in an egalitarian group the difference between the totality of influences exerted and the totality of influences received will be the same for everybody. Such a group does not

contain any "upper class" influencing the others.

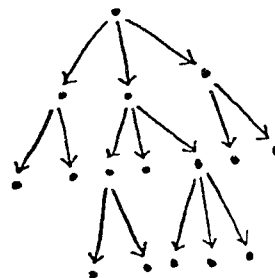
An egalitarian group is thus a possible one. There are a large number of graphs which satisfy this condition (even though certain constraints restrict this number, constraints we will investigate later on).

Another type of group having great importance because it is a very common one, is "hierarchic": this type of group can be represented by a "tree" (a graph in which between any pair of points there is but one path). This group is characterized by a "degressive" hierarchy of social situation, starting from the "apex" (i.e. the person represented by the apex is the most powerful, the persons just below him are somewhat less powerful, and so on). Its other characteristic is a "progressive" hierarchy of alliances, progression starting from the same apex; thus dependence, or change in social situation caused by the departure of somebody from the group, will be less noticeable for persons at the "bottom" of the group than at its "top."

A GROUP WITH  
"EGALITARIAN" STRUCTURE



A GROUP WITH  
"HIERARCHIC" STRUCTURE



We saw before that this method of representing a society is based on the exchange of influence within a set of individuals. The two types of groups sketched above are practically two schemes of exchange diametrically opposed. In egalitarian groups, exchange can start with any member of the group and will certainly reach all other members, perhaps slowly, but surely. On the other hand, in hierarchic groups, there is but one person who can start an influence which will reach all members of the group, and it will do so relatively quickly. As for the probability that this influence will reach everyone, it is very low (because the noncooperation of only one person somewhere in the group represents a blockage for a certain number of paths).

Obviously enough, these two types of society are not the only ones possible: I picked them because they are particularly important. As a matter of fact, all social utopias have as a goal an egalitarian society, and all technical organizations are based on hierarchic society. Evidently, neither is a perfect model, but there are many organizations tending toward the one or the other of these models.

To finish this section on terminology, I would like to correct a simplification I had to make (among others) when I began this paper. I defined groups as sets of individuals in which there exists some sort of relation (influence) between any two individuals. In reality, we are related not only to men by a system of influences, but also to objects.

I will thus be obliged to introduce a new definition for groups as being a set of persons and objects linked by a system of influences. Thus a group can be considered as a mixed mechanism containing both men and objects.

In order to be more precise, I have to state what I consider the criterion of difference between human beings and objects, from the point of view of this study. This difference results from the fact that men are conscious of their situation in a group, as opposed to objects which do not care.

This definition makes it possible for us to imagine other social alternatives, which could be realized more easily than most social utopias (even if these alternatives are submitted to the constraints I will talk about later). One such alternative would be a society egalitarian for human beings but hierarchic for the objects belonging to it.

The first important result we get by applying our new terminology (that of the definition of groups and their mapping by graphs) will be the equivalence of "society" and "environment."

This equivalence is expressed in the definition "set of persons and objects." Indeed, the definition generally used for environment, "the set of objects influenced by and influencing men," is inadequate. Why not "objects and persons"? As for the definition of society, it was sufficiently discussed above.

"Society" and "environment" are thus the same thing. My own term for it is "others." This term is really the most accurate, because it refers to the person who uses it. Thus, if Mr. X is talking about society or about his environment and he uses the term "the others" he includes Mr. Y, his house, and so on, but will not include himself. On the other hand, if Mr. Y uses the same term, he will include Mr. X, a tree, and so on, and the whole system he is linked to, except himself.

The "others" are others for every one of us.

### III. VALENCE AND DEGRADATION

After this long section about terminology we are still far from the conclusion of this study. We have still to make clear certain basic concepts but, happily, we have the most difficult ones behind us.

The first concept to be investigated is the one I call "valence": it signifies a property, observable and biologically determined, belonging to the human animal. This property defines how many centres of interest can simultaneously occupy the attention of man. For example, I can read two books simultaneously (even if with some difficulty), perhaps even three; but surely I could never understand ten different books at the same time. In this case my valence will be perhaps three, perhaps more, but by no means as much as ten.

"Valence" will thus limit the number of persons who can influence (or who can be influenced by) one member of a group during a given period of reference. Valence will be visualized in the map of a group (or of an environment) by the "degree" of a given point corresponding to a person (we call "degree" the number of links incident to a given point).

The second key concept, that is, the degradation of an influence by successive transmissions, was mentioned earlier, when I discussed the way to calculate real hierarchy (social situation) within a group.

Degradation of influence through successive transmissions also implies an observable and biologically determined property of the human animal: indeed, this degradation depends on our mental capacity. I call the "channel capacity" of a particular person (or of a species) the capacity for transmitting a message with a number of errors, where this number

is characteristic for this person (or for this species). It is evident that the "channel capacity" is dependent upon the period of reference, as was also the case with valence.

Evidently, both valence and channel capacity are dependent upon the language also; indeed, a densely coded message, for example, can be dealt with faster when less errors are committed in transmission; thus, during the same reference period one can deal with more messages (higher valency) or transmit more messages (higher channel capacity).

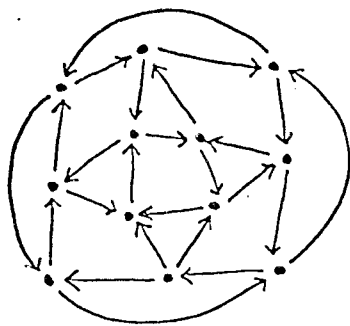
Channel capacity is a very limiting property for a social organization: it implies that an indirect influence submitted to more consecutive intermediary transmissions than admitted by the channel capacity will decay completely: such an influence will be indistinguishable beyond a given number of transmissions.

"Valence" and "channel capacity" of the human animal represent two natural thresholds which cannot be crossed without great difficulty. These two thresholds affect the rhythm of exchange of influences among human beings (and objects), and thus within social organizations (or environments) which in the end are dependent on the numerical value of these thresholds.

The possibility of practical application of these two thresholds for societies or environments comes from the fact that these two thresholds determine the numerical size of such organizations, i.e. the quantity of "elements" (men and objects) that can belong to a social organization without having a disturbing effect on its functioning. Implicitly, the same thresholds determine the number of links within an organization. Thus, for example, it would be impossible to realize an "egalitarian" organization containing more humans, objects and links than the respective thresholds admit, and it would be just as impossible to conceive a "hierarchical" group in which the number of members and the number of links between members would be larger than the corresponding threshold numbers. Expressed simply, a group or an environment having a determined structure (in the sense used in the preceding section)

cannot contain more elements and links than admitted by the threshold values which can be established on the basis of the respective valence and channel capacity.

We call "critical groups" the largest set of elements (humans, objects and links among them) for which the functioning of a group, characterized by a determined structure, still can be assured.



EXAMPLE:  
VALENCE:  $U = 4$   
CHANNEL  
CAPACITY:  $C = 5$   
STRUCTURE: EQUITARIAN  
IN THIS CASE  
THE CRITICAL GROUP  
CONTAINS 12 PERSONS

The concept of the "critical group" is perhaps, in spite of its seeming to be very theoretical, the most pragmatic concept for a period of crisis, because the comparison of any organization with the "critical group" corresponding to its category of structure shows immediately whether this organization is realizable or not. Most projects fail less because of the impossibility of realizing their idea's content than because their implementation is based on organizations which exceed critical group size associated with these organizations' structure. Sometimes it might be even the initial success of an organization that is the tool of its self-destruction, for this success promotes the organization's expansion and when expansion passes the critical group size, the organization "explodes."

"Critical group" is a result of two essentially biological factors (valence and channel capacity) and of one topological factor (the structure of the organization). Its size is thus independent of any ideology, technique, or knowledge; otherwise expressed, of any "artificial" factor invented by man. The three decisive factors depend thus on a "law of nature," and the rule of the critical group size is itself a "law of nature."

Two of these factors (valence and channel capacity) are of a biological nature: thus they differ with every species. The third factor is invariant in the sense that it is the same for any species.

Thus, critical groupsize varies with every species: it is different for men, for monkeys, lions, herrings, or bees. But for any species, it can be known, and the numerical size of the critical group could be considered as a species characteristic.

If we consider, for example, an animal species, let us say elephants, we will find that a herd of elephants varies with the number of individuals belonging to it, but that this herd never exceeds a given number: that of the critical groupsize of elephants.

Alienation of man could thus be a consequence of enormously exceeding human critical groupsizes: we live with more people than we can tolerate, and with more objects than we can rely on, and all this without becoming biologically a different species.



#### IV. FACTORS AFFECTING CRITICAL GROUPSIZE

The next step we have to take is to be somewhat more specific about critical group sizes: what are the data necessary to find out the critical size of a group of a given structural characteristic, and how should one proceed in order to get the appropriate numeric results?

When I mentioned valence and channel capacity above, I tried to accentuate that both factors depend strictly upon the period of reference. It is evident that the number of influences referred to by both valence and channel capacity is a different one if the reference period means ten minutes, or if it means ten days, or even ten years.

Thus the empirically defined numeric value of valence depends upon the reference period. But not only that: it depends also on the code (language) used for the transmission of the influence. It is evident that an influence which can be transmitted by using one unique word alone, can admit a much higher valence, and a much larger channel capacity, than would be observed when using a ten-word phrase for the transmission, the reference duration being the same in both cases. Military or commercial organizations make an ample use of this simple truth.

In consequence, the pragmatic statement about critical group size would sound something like this:

Critical group size depends upon the social structure of a group (which social structure can be deduced from the group's "mathematical structure," i.e. from the graph representing the influences within the group); it depends also on the two factors of a biological nature,

which are valence and channel capacity, and which can both be observed empirically, related to a given reference duration and to a given code.

This statement can be expressed by a formula:

$$G = R[s(m), v(tl), c(tl)]$$

The abbreviations in the formula have the following meanings:

G: critical groupsize

s: social structure (real hierarchy)

m: mathematical structure (topological structure of graph)

v: valence

t: period of reference

l: language or code

c: channel capacity

R being a hypothetical relation to be investigated. There is no actually known algorithm which could correspond to this formula, but the critical groupsize can be calculated by performing the following operations:

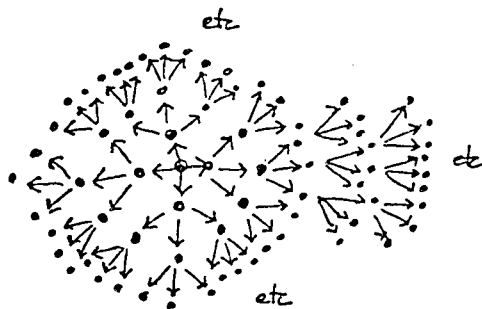
- a.  $v(tl)$  and  $c(tl)$  can be empirically determined (it is possible to dress tables indicating these factors corresponding to  $t$  and  $l$  as variables);
- b.  $m$  can be drawn by observation (for existing groups) or by planning (for projected groups) as a graph indicating the group's structure;
- c.  $G$  can be determined by redrawing the graph in such a manner that no summit of the graph should have a local degree greater than  $v$ , and that no path between any two summits in the graph should be longer than  $c$ .

Before concluding these considerations about how to find the critical size for a given group, let us see how to choose the "period of reference."

It is evident that critical groupsize can be as large as wanted, if the reference period can be as large as wanted. Both valence and channel capacity are enormous, if, for example, the reference period chosen is several hundred years.

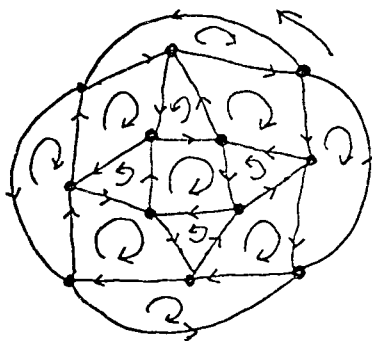
But the functioning of a group's structure (we saw it earlier) is never independent of the group's environment, and a well-functioning group has to be able to react on impulses coming from the outside. It is thus the rhythm of these impulses coming from the outside, and to which the group is supposed to react, which determines the appropriate reference duration. We can thus identify the appropriate reference period with the timespan the group disposes for its reaction in a given context.

So an army (or a guerrilla unit, or a task force) is supposed to react particularly fast, and its reference period is thus very short and the corresponding valence and channel capacity are very small ( $v=4$ ,  $c=6$ ). This reaction speed is enhanced by a very precise and rigorous code. Army units having a hierarchic structure, a valence of 4 and a channel capacity of 6, have thus a critical groupsize of about 1000 men (this critical groupsize was respected practically all through history).



Units of guerrillas (which often have to have an egalitarian structure for different reasons), having the same values of valence and channel capacity as does the army, can with difficulty grow beyond 16 men, as there is situated the critical groupsize for egalitarian groups. (The characteristic graph for an egalitarian group is a "completely orientable graph," in which all "edges" limiting a "face" follow a circuit whose arrow senses are coherent with the arrow senses of the circuit limiting the neighbouring "faces"; it is obvious that if the degree of a summit in such a graph is limited to four and the length of the longest path to six edges, the graph has to be very small.)

Governments are organizations operating with various reaction speeds, the shortest of which is seldom less than a month; a church (for



example) does not need to react faster, in general, than several decades after the impulse. Thus a government can function tolerably well in a country having several million inhabitants. This size cannot be exceeded except in countries with a particularly stable social context, wherein people are governed more by routine than by government decisions. For the same reasons a church can easily count several hundred millions of believers.

Thus critical group size becomes particularly important in periods of crisis, when routine breaks down, and the organization's reaction speed has to become particularly rapid.

## V. SOCIAL CONSEQUENCES OF EXCEEDING CRITICAL GROUPSIZE

A group or organization having a particular social structure (which can be defined by the mathematical structure), and the members of which have a characteristic valence and channel capacity (which can be defined empirically), and which group or organization is expected to act with a given speed, has a constraint on its size, a constraint which can be specified by the preceding data. We called the upper limit on the size of such a group the critical groupsize. All this looks rather theoretical at first glance.

What will happen if such a group outgrows critical groupsize?

This is a pragmatic question. Growing beyond critical groupsize means an overload on its members' capacities, and because of this overload they start to perform their respective tasks in the group or organization in an improper way: thus the whole group starts to work improperly. Messages get blurred, they will be switched erroneously, the feedback stops, etc. The decay of a group or organization can start with its growing beyond its critical size.

The process of decay of a group or organization growing beyond critical groupsize can follow different scenarios:

- a. the group starts to function more slowly and its "reaction speed" to external impulses will get slow: this phenomenon corresponds to an increase in the reference period in our formula, which can be admitted if the impulses of the exterior are themselves slow, but can be catastrophic in periods of crisis;
- b. the group makes efforts to keep the original character of its social structure, and in order to do so it has to split into

smaller groups: if, for example, an "egalitarian" group (which needs to stick to its fast reaction speed) grows larger than a group of 16 members, it cannot keep its "egalitarian" structure without splitting into two "egalitarian" and independent new groups;

c. the group does not split, but changes its social structure: for example, an egalitarian group of fast reaction speed, growing beyond 16 members and not wanting to split, can continue to function successfully by changing its social structure from an egalitarian into a hierarchic one (which has a critical groupsize, within the same conditions, of about 1000 persons); most successful egalitarian groups grow beyond their critical size (because they attract many new members) and thus lose very rapidly their egalitarian character: in a way, their success is the tool of their decay.

It is very important to note, in order to avoid any misunderstanding: critical groupsize is not a guarantee of the group's good functioning, it is but a condition: a group under critical groupsize does not necessarily function well, but a group over critical groupsize does necessarily malfunction.

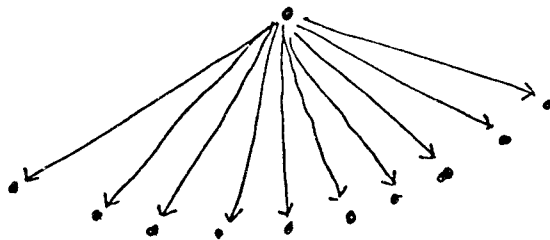
The principle of critical groupsize thus implies very serious and unavoidable consequences for any society. These consequences are inevitable because one of the factors defining critical sizes is the biological constraints to which the species is submitted.

One of the most important consequences is the impossibility of planetary communication for mankind, as mankind, by its sheer number, is more numerous than any critical groupsize value could admit. This consequence might be the end of many political utopias.

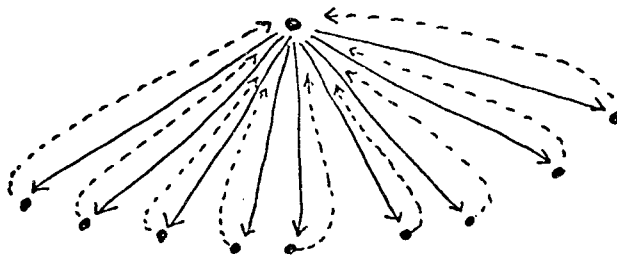
Considering the actual dimensions of many human organizations which outgrew any admissible critical groupsize within the limits of a reasonable reaction speed, any attempt at communication within these organizations gets "self-blocked." We thus cannot hope to be able to bypass this blockage by using sophisticated technology, because the

blockage does not originate from the deficiencies of some technical setup but from those of the human brain, and we cannot bypass the human brain in communication processes concerning humans and taking place among humans.

Let us take for example an everyday feature: a central television transmitter which, by hypothesis, could transmit influences to a quasi-unlimited number of receivers.



Here is the problem: this process does not really represent a communication system, as (for example) all receivers could switch off their sets or pay no attention to the message transmitted, or even completely misinterpret it. In order to make this process an efficient communication system, it would be necessary to make it contain some apparatus which could facilitate feedback towards the centre (i.e. channelling the set's answers or sending questions to the central transmitter).



But, whichever way the centre might be organized, feedback coming in from several million sources could not be assimilated: the feedback mass arriving into the centre would be larger than any specific valence. Even if we conceded that the valence of a machine receiving the feedback could be larger than the feedback mass, the humans who had to programme the machine could not do it properly. (In other words, the Orwellian Big Brother can, technically speaking, not function.)

In my personal language I call this limitation of planetary communication (limitation resulting from the numerical constraint implied by critical groupsize) the "Babel Tower syndrome." The biblical image is perfect: an organization (the builders of the tower) grows, and when growing, it menaces God. God does not react: He simply waits till the critical groupsize effect manifests itself. This happens inevitably, and the builders' organization gets automatically blocked by the "noise" in communication, as the organization grew too large.



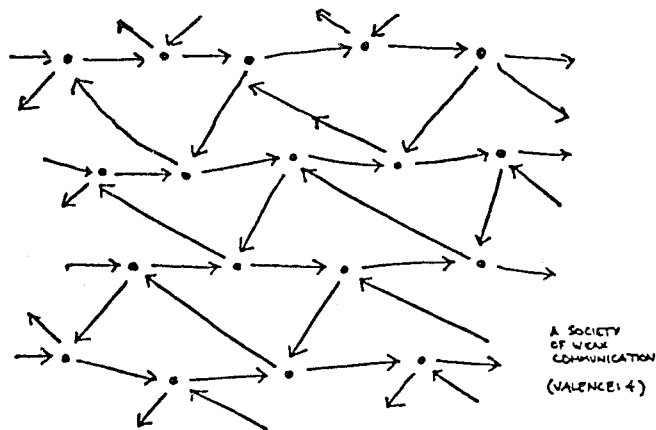
## VI. CRITICAL GROUPSIZE AND BEYOND

The principle of the critical groupsize has several interesting consequences in sociology and politics. The first of such consequences is the emergence of a new social structure: what I call a society with "weak communication." Let us explain this structure.

When we investigated the idea of critical groupsize, we saw that the decisive factors were invariants of biological character (valence and channel capacity), and that these factors have relatively small numeric values when the reference period is considered quite short (that which has to be done if we want to be realistic). Critical groups were thus very small groups with a very reduced amount of internal communication, as most communications could not reach persons situated far from the source ("far" means that the distance is measured by the number of transmissions necessary to convey influence).

We considered this critical group as an "island" with a zone of non-communication surrounding it. But conditions for the critical group could be interpreted otherwise: in a communication network containing a number of persons and objects there can exist a critical group around each person (or object) in the society, considered as the "centre" of this group. Such an interpretation is possible if the links composing the network are arranged in such a way that the number of links relating a particular person to the others does not exceed the number admitted by valence.

This society, even though it contains a very large number of individuals, contains a relatively small number of links: it is based on "weak communication."



The other new social concept, which I call a "non-geographical" organization, can be explained by the effects of modern communication technology coupled with the critical group effect.

If a communication network cannot pass beyond critical group size in its functioning (such as we saw in the last paragraph), there is no constraint which would indicate, on the other hand, that all members of an organization or group should effectively live in physical proximity to each other. Communication technology (beginning with writing) introduces the "non-geographical" organization, but till the development of modern communication techniques the reaction speed of such an organization was necessarily very slow, so that the corresponding critical group size could thus be relatively large. Modern communication technology changes this limitation, and the non-geographical group becomes "on-line"; its reaction speed thus becomes practically as fast as in territorial groups. As a direct consequence of this improvement, the on-line non-geographical group has to reduce its size to one below the same critical group sizes as do classical groups.

Both these new models of society, the one with weak communication and the non-geographical on-line society, can be considered as of great importance in politics. Among other consequences, these models might show the size-limits of nations in a new light.

I will consider here the term "nation" as meaning a set of people

having some organization which maintains an order accepted by convention. We call such an organization a "government." The conventional order manifests itself in some preset pattern of "influences" among persons and/or objects belonging to the nation. Such patterns are those concerning status, property, decisionmaking, etc.

We will try to consider size-limits of nations on the basis of the critical groupsize corresponding to the reaction speed determined by events coming from the exterior. Obviously, the critical size of organizations within the nation, or of the nation as a whole considered as one organization, will be different according to the special concerns these organizations have to deal with, and according to how much such concerns can be regulated by sheer routine, without the organization having to intervene. (For example, "property" is regulated everywhere by routine, the organization not intervening except in cases of abuse against this routine.)

These reflexions imply that in nearly all domains the size-limit of a nation will be determined by the size-limit of the executive organization whose concern the said limit will be; thus a loosely governed nation can be far larger than a strictly governed one, as a loose governing style necessitates smaller organizations than a strict one, and these smaller governing organizations can be nearer to critical groupsize than the larger ones. Thus internal policy, or economic policy, can be implemented by the government of a large nation only if such a policy is a "loose" one (i.e. admitting existing routine and minimum law enforcement), or if it is implemented on a very much decentralized basis, by law enforcement organizations which are extremely independent in regard to the centre. Both cases might be excellent political principles, but both become inefficient in a crisis. This statement is very much corresponding to our actual everyday experience: large nation-states have governments which become more fragile in crisis than those of smaller ones.

The fact that the governing organizations of a nation can become

fragile makes important the system of international relations for such governments. International relations mean, for fragile governments, a means to slow down the rhythm of impulses coming from the outside, and thus a way to keep a relatively slow reaction speed in the face of such impulses. As we saw earlier, this means that the reference duration is considerably increased and the corresponding critical size along with it.

It is evident that international relations do not radically improve the fragility of governments, as they do not reduce the size of a nation under critical size, but clearly reduce the size of law-enforcing organizations to below critical groupsize.

Besides, international relations themselves result from operations performed by a very much reduced group of persons who assume the function of "mouthpieces": i.e. who speak in the name of a nation. As these are not very numerous, international relations between "mouthpieces" work generally well: foreign policy is made within a sort of exclusive club, whose members are sufficiently few for the "club" to stay under critical groupsize.

Hence the preference of all fragile governments for making foreign rather than domestic policy.

But the problem of governmental fragility is not settled so simply, and the question of the "credibility of the mouthpieces" arises. Indeed, we stated above that a communication system within a nation surpassing a certain critical size cannot work; it follows from this that there is often no guarantee that the promises of a "mouthpiece," promises made in international agreements, will be effectively kept. This simple fact is a major difficulty in making international relations: governments have to be sure that the nation which is represented by the mouthpiece will really endorse what the mouthpiece promised. As we saw before, when talking about the TV system, it is not easy to get feedback to a message emitted by a central transmitter, so it is very difficult to keep up the credibility of a government's

mouthpiece.

All these consequences of the critical group size principle make large state organizations appear increasingly fragile. This growing fragility is simultaneous with a growing stability of international organizations (composed of the mouthpieces of the increasingly fragile governments), as these organizations are under critical group size (non-geographic on-line organizations). (The much-discussed multinational corporations are but one example of this trend, exactly as are the more and more numerous agencies of the United Nations.)

These developments can be considered in a new manner, once we look at them as manifestations of an emerging society with "weak communication" which can be a "non-geographical" one. Like any other trend, it has both good and deleterious aspects, and the comprehension of the fact that they are, in a way, the results of the regulating effect of the critical size principle, might help to find some leverage on it. But defining a principle and recognition of its effects is still far from finding the "levers" for steering (this might perhaps be our luck).

I think, personally, that a "centreless" network, a society with "weak communication" might be a goal worth striving for, as they might be better tools for survival than is our actual society. I also think that the effects of critical sizes drive us in this direction, but much more study is necessary before we are able to speak out with certitude.

## VII. CONCLUSION

We were during this study first explaining the term "critical group-size," the manner in which practical numerical values can be obtained, then considering some of the sociological and political effects of the critical group principle. I would like to close this paper by some conjectures belonging to futurology: what might be the influence of this principle on our near future?

We are at present living in a world which is going to get poorer, as compared to the image earlier decades had of the future. Resources are diminishing faster than science and political organizations could invent alternative methods to replace them or use them differently. Thus the industrialized world gets poor because its development depends upon the abundance of such resources, and the non-industrialized world impoverishes even more rapidly, as it was counting on industrialization to escape from poverty, thus losing the routine (non-industrial) which ensured its survival in the past.

I have here no space to detail the image of a "poor world" (I have done so in several other papers), but this summary description of the trend might suffice to characterize the general situation, which leads necessarily to the emergence of new attitudes towards poverty, whatever these new attitudes might be.

Such new attitudes towards increasing poverty are actually the main topic of all "wise men's councils" all around the world, and "wise men" everywhere have very clever recommendations showing how such a new attitude could be achieved. There is but one problem left: how could these recommendations be diffused to, digested by and

implemented by those whom they concern, i.e. the "man in the street"? And, besides, how could this be done sufficiently fast, faster than the "evolution of the context"?

If the hypothesis about the critical group effect is true, the implementation of the recommendations by the "wise men" simply cannot be done. The structure of communication in actual society, valence and channel capacity as it is with our species, the number of people supposed to be involved in the recommended operations, and finally the reference period admitted by the context, cannot be reconciled with the constraint of critical group size. Thus the organization of "wise men's councils," producing recommendations to be diffused by governments, does not seem the appropriate strategy.

Getting poor has its specific speed, and governments are helpless in the face of phenomena accompanying it (unemployment, inflation, etc.). As a result, the man in the street feels himself abandoned by the institutions he relied on. As he is fundamentally interested in his own survival, he starts to invent particular solutions to assure it; as he has no diffusing organization at his disposal, his particular inventions are not largely known: they are known generally in his particular community alone, in full accordance with the critical group principle.

Thus, one alternative of human survival might be based on the simultaneous invention of survival techniques (i.e. new attitudes in face of poverty), implemented within small communities with weak communication among them. Barter economy versus money-based economy, subsistence economy versus employment, etc., might be such attitudes, which cannot be recommended from the "outside" but have to be invented by each group in its turn. These attitudes might seem similar to the recommendations of the "wise," but — and here is the difference — they cannot be propagated; they have to be invented by those whom they concern.

Thus, in the face of survival in a world which gets poor, humanity

might invent the society with "weak communication," as an effect of the critical group principle.

The other alternative is a tragic one: I am thinking of genocide, which became implementable with progress in military technology. "Clean" genocide (destruction of large groups of people in a region without destroying all resources at the same time) has today become possible. People sticking to the status quo (a large number of people today) who want to stop the impoverishment process might prefer this act, which could be implemented without the collaboration of a large number of people as in the last world wars (and thus does not imply the mobilization of gigantic armies who could revolt). Avoiding mobilization and use of other tools for a "clean genocide" is no less vulnerable to the critical group size constraint than the first alternative, and I do not see how this planetary piracy could easily be prevented.

Obviously, both scenarios have been explained in an utterly simplified manner, and there are many other which remain possible. Being an optimist, I think that the first scenario might be much the more probable one (the simultaneous invention of the "lifeboat" organizations), which does not mean that the other one could not happen at least locally. There are some political organizations on earth which established themselves by practising genocide.

In conclusion, I think that "wise men's councils" actual role should be to see how to assure that our future should follow the first scenario instead of the second one, and I think as well that more study of and knowledge about the critical group size phenomenon might help us in this aim. No doubt such knowledge will not lead us to find the "levers" permitting the manipulation of human society, but if we can find ways how to avoid at least the worst developments, it is worthwhile to make some efforts to obtain such knowledge.

Critical group size might be one of our number-one problems.