Addendum on Entropy to the Exploratory Study on Group Unconscious at the Basque Foundation for the Investigation of Mental Health Group Training for Therapists

Begona Trojaola Zapirain*‡, Federico Carminati†, Miguel Angel Gonzalez Torres*‡§, Ernesto Gonzalez de Mendivil*, Claire Fouassier||, François Martin, José Labarere††, Jacques Demongeot§§, Erika Nora Lorincz||, Giuliana Galli Carminati||**

ABSTRACT

The present paper is an addendum to a previous study on the work that has been conducted during the eleven sessions of a group analysis training at the Basque Foundation for the Investigation of Mental Health at Bilbao. The participants were presented with an "absurd questionnaire" proposing 50 pairs of images, in each of which one image had to be chosen. The results of the previous study were in favors of the influence of group dynamics on individual choices of the images proposed in the questionnaire. Our present analysis complements the previous work with the exploration of the relations between the orientation of the answers in the groups as results of multiple variable analysis and the distribution of Bernoulli's Entropy. Consistently with the conclusions of the previous paper, we interpret these correlations as group effects in the light of Bion's view of group dynamics, which postulates an immediate onset of a group unconscious and its evolution during the group activity.

Key Words: group dynamics, entropy, quantum entanglement, basic assumptions, group orientation

DOI Number: 10.14704/nq.2015.13.1.780 **NeuroQuantology 2015; 1:49-56**

1. Introduction

"I thought of calling it *information*, but the word was overly used, so I decided to call it uncertainty. [...] Von Neumann told me, 'You should call it entropy, for two reasons. In the first place your uncertainty function has been used in statistical mechanics under that name, so it already has a name. In the second place, and more important, nobody knows what entropy really is, so in a debate you will always have the advantage.'" Excerpt from a conversation between Claude Shannon and John von Neumann regarding what name to give to the attenuation in phone-line signals (Tribus & McIrvine, 1971; Sommaruga, 2009).

The present papers extends a previous work (Trojaola-Zapirain *et al.,* 2014) on Group unconscious common orientation based on an exploratory study at the Basque Foundation for the Investigation of Mental Health group training for therapists. In this work we presented evidence of the effects of the group situation on the behaviour of the group

Corresponding author: Giuliana Galli Carminati
Address: *OMIE, Fundación Vasca para la Investigación en Salud Mental / Osasun Mentalaren Ikerketarako Ezarkundea, Bilbao, Spain. †Physicist at CERN, 1211 Geneva 23, Switzerland; email: Federico.Carminati@gmail.com. ‡Psychiatry Service, Basurto Hospital, Bilbao, Spain. §Basque Country University, Bilbao. **Association pour le Travail Groupal thérapeutique et social (ASTRAG) and Simposietto. Honorary research fellow at CNRS; e-mail: martin@lpthe.jussieu.fr ††TIMC-IMAG, UMR CNRS 5525, Faculté de Médecine, Université J. Fourier of Grenoble, 38700 La Tronche. §§AGIM, FRE CNRS 3405, Faculté de Médecine, Université J. Fourier of Grenoble, 38700 La Tronche.
e-mail giulianagallicarminati@hotmail.com
Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.
Received: 12 September 2014; **Revised:** 27 November 2014; **Accepted:** 21 February 2015.

members in terms of their choices when confronted with a questionnaire proposing the choice of pictures in pairs.

The correlations that appear between the groups and members of a group during group analysis sessions seem comparable in nature to the remote correlations that appear between two related quantum systems (Einstein, Podolsky & Rosen, 1935; Schrödinger & Born, 1935; Schrödinger & Dirac, 1936; Bell, 1964; 1966; Aspect, Grangier & Roger, 1982). This phenomenon is called quantum entanglement: two entangled quantum particles can be separated by thousands of kilometres and nevertheless form a single (whole) non-separable system, as long as no measurements are performed on one of the two particles. Since the discovery of quantum mechanics, similarities have been observed between the quantum description of the world and the functioning of our psyche. In this perspective we decided to investigate the similar entanglements between individuals, and tried to generalize these correlations to individuals belonging to a group.

According to Bion, the evolution of the group is governed both by universal principles he calls "basic assumptions" and by the conflicts that are rooted in the contingent reality of each specific group (Bion, 1961; Vergopoulo, 1983; Foulkes, 1964). Mediated by the "basic assumptions", group dynamics is similar to individual dynamics, in particular if one considers the loss of the ideal group leader.

Table 1. Demographic, socio-economical and group composition of the participant sample expressed in numbers and percentages for Staff, Trainees, and for the overall participants. Quantities reported are: the number of participants in each age class, the median age with the interquartile range (Q1 and Q3: 25th and 75th percentiles respectively), the sex distribution expressed as numbers and percentages of female subjects, the number of participants in each socio-economic subcategory, the number of participants in each enrolment year and in each of the sub-groups of the training. Groups from A to D were the four "small groups". Group E was the conductors of the "large group" and group F was the organizing staff.

	Subcategories	*Staff*		*Trainees*		*All*	
		(n = 14)		(n = 31)		(n = 45)	
Age (years)	20-30	1	7.1%	21	67.7%	22	48.9%
	31-40	5	35.7%	8	25.8%	13	28.9%
	41-50	4	28.6%	2	6.5%	6	13.3%
	>50	4	28.6%	0		4	8.9%
	Median (Q1-Q3)	42.5	(33-50.5)	29	(27-32.5)	31	(28-38)
Sex	Female	7	50.0%	24	77.4%	31	68.9%
Marital status	Married	4	28.6%	29	93.5%	33	73.3%
	Divorced/widowed	3	21.4%	0		3	6.7%
	Single	7	50.0%	2	6.5%	9	20.0%
Professional status	Psychologist	13	92.9%	17	54.8%	30	66.7%
	Psychiatrist	1	7.1%	4	12.9%	5	11.1%
	Social worker	0		4	12.9%	4	8.9%
	Nurse	0		3	9.7%	3	6.7%
	MD	0		2	6.5%	2	4.4%
	Public servant	0		1	3.2%	1	2.2%
Enrolment year	1	0		10	32.2%	10	22.2%
	2	0		14	45.2%	14	31.1%
	3	0		7	22.6%	7	15.6%
	4	8	57.1%	0		8	1.8%
	5	6	42.9%	0		6	13.3%
Sub-groups	A	2	14.3%	8	25.8%	10	22.2%
	B	2	14.3%	9	29.0%	11	24.4%
	C	2	14.3%	6	19.4%	8	17.8%
	D	2	14.3%	8	25.8%	10	22.2%
	E	2	14.3%	0		2	4.4%
	F	4	28.6%	0		4	8.9%

As explained in the previous paper, our assumption is that the correlations between individual unconscious form a single entangled (non-separable) quantum system where they lose their individuality in favour of a single collective behaviour.

The objective of the present work is to investigate further evidence that group analysis situations can lead the unconscious of the participants to adopt a common orientation in the choice of pictures. In other words, we would like to test whether the presence of an orientation of the group unconscious has a measurable effect on the real world.

As described in the our previous paper (Trojaola-Zapirain *et al.,* 2014) we try minimising biases that can be introduced by common cultural background such as news, politics, arts, and so forth, we designed an "absurdum" questionnaire so that answers would rely as little as possible on logical thinking and acquired knowledge, using pictures as unrelated as possible to each other (Figure 1).

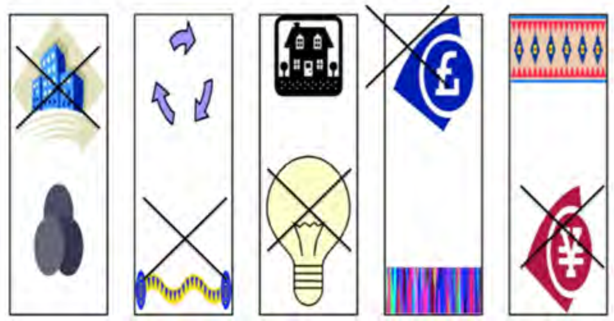

Figure 1. A page from the questionnaire with "fake" answers.

The goal of the current study is to consider here the evolution of entropy in groups, studying the possible orientation of answers and the corresponding trend of the entropy. In the mid of the 19th century, Rudolf Clausius (1850) introduced the concept of entropy, which was reinterpreted in terms of statistical mechanics by Ludwig Boltzman (1886) toward the end of the century. Entropy has often been loosely associated with the concepts of order, disorder and chaos. One of the more powerful (and confusing) aspects of the concept of entropy is that it provides a powerful abstract link between thermodynamics, statistical mechanisms, information theory and quantum mechanics (Balian, 2004). Although the concept of entropy was originally a thermodynamic construct, it has been adapted in other fields of study, including information theory, psychodynamics, thermo- and ecological economics, and evolution (Brooks & Wiley, 1988; Avery, 2003; Yockey, 2005).

In this work, we are mainly interested in the interpretation of entropy as measure of information and, implicitly, a measure of order and disorder.

In this context we can think of entropy as the amount of information needed to fully define the microscopic state of the system, which is otherwise left unspecified by the macroscopic description. The first to notice the connection between entropy and information was Claude Shannon (Shannon & Weaver, 1949). In information theory, entropy is the measure of the amount of information in a transmitted message and is sometimes referred to as Shannon entropy. In this context, the definition of entropy is expressed as the sum of terms depending on a set of discrete probabilities:

$$H(X) = -\sum_{i=1}^{n} p(x_i)\log p(x_i)$$

where $p(x_i)$ is the probability that a particular message x_i is actually transmitted. We note here that the question of the relation between information and thermodynamic entropy has been, and still is, subject to controversy (Brillouin, 1956; Georgescu-Roegen, 1971; Tribus & McIrvine, 1971; Balian, 2004; Chen, 2005; Frigg & Werndl, 2010).

In case all probabilities are equal, the formula for the information entropy reduces to:

$$H = -k\log(p)$$

where k is the unit of entropy. It is interesting to note that, in these cases, the Shannon entropy (in bits) is the number of yes/no questions needed to determine the content of the message. It is also instructive to note that this expression of the entropy is identical to the Boltzmann (Boltzmann, 1896) formula based on statistical mechanical considerations. Although the equivalence between Shannon and Boltzmann entropy can be demonstrated in several ways, some authors argue that the use of the name entropy for the former is arbitrary and should be dropped in favour of *uncertainty.*

In our case, the choice of one of the two pictures can be described as a binary process whose outcome can be either 1 (upper picture) or 0 (lower picture). This kind of process is also called a Bernoulli process. In a Bernoulli process there can be only two outcomes (1 or 0), mutually exclusive and exhaustive: success with a probability of p and failure with a probability of (1-p). If X denotes a random variable, we have:

$$\Pr(X = 1) = 1 - \Pr(X = 0) = 1 - q = p.$$

with Pr being the probability of the outcome. A classical Bernoulli process is a single toss of a coin, and is defined fair if p=1/2. The Bernoulli distribution is a special case of a binomial distribution with *n=1,* hence we have:

$$f(k;p) = p^k(1-p)^k \text{ for } k \in \{0,1\}.$$
$$E(X) = p \text{ and } Var(X) = p(1-p)$$

In information theory, the entropy of a Bernoulli process is called Bernoulli entropy (H_b) and is defined as

$$H(X) = H_b(p) = -p\log(p) - (1-p)\log(1-p).$$

When p=1/2, the binary entropy function attains its maximum value. This is the case of the unbiased bit, the most common unit of information entropy.

2. Materials and methods

2.1 Participants

For this study we used forty-five adult participants (31 women and 14 men) involved in the group analysis training given by the Basque Foundation for the Investigation of Mental Health (OMIE). This group was composed by 31 people attending the training, 10 members of the training staff and 4 members of the organizing staff. Two participants of this training were excluded from the study because they did not complete the experiment. The training consisted of 10 sessions. At the beginning of the first session and at the end of each session, the participants were asked to fill the questionnaire. Demographic data and socio-economic characteristics of participants have been reported in the previous study and are presented here in Table 1 for completeness.

The Ethics Committee of Geneva University Hospitals approved the experimental protocol, in adherence to the Helsinki Declaration for research with human subjects, and approval was also granted by the OMIE foundation. All participants gave written informed consent after receiving oral and written information about the experiment. All participant data were coded so that they were completely anonymous, including for the researchers analysing the data.

2.2 Questionnaire

To evaluate to what extent participants could act according to a common group unconscious, we used an "absurdum questionnaire" of 50 pairs of pictures (Trojaola-Zapirain *et al.,* 2014). For each of the fifty pairs, participants were asked to choose one of the two pictures. A typical page with hypothetical answers can be seen in Figure 1. The questionnaire had to be filled within 3 minutes and no correction was allowed. The pictures were colour or black and white drawings and photographs selected from the Web, so that the choice could have minimal correlation either with common cultural background or knowledge or else logical thinking. This method aims at avoiding multiplier effects that a classical word questionnaire (Zanello *et al.,* 2004) can introduce, because the latter requires conscious reflection peculiar to one's own unconscious.

The one hundred images chosen for the questionnaire were randomized to form 50 pairs presented on 10 A4 format landscape oriented sheets with 5 pairs per page. Each pair occupied about 4 cm (horizontal) by 11.5 cm (vertical). For the 11 testing sessions, the pairs were randomly ordered on the 10 sheets to avoid mnemonic or learning effects.

2.3 Procedure

OMIE's teaching is a 5-year program to train group therapists for group analysis. Trainees follow courses on group analysis theory, methods and applications, and they also participate in analytical groups to gain practical experience with group dynamics. Practical training is based on 10 modules per year, each one lasting one day and a half. Participants of different years are divided into groups of 8 to 10 people including a conductor (group leader) and an observer, who are members of staff. In the case under study there were four such groups (A to D, Table 1). These groups meet 3 times for 1h30 in the course of a module. At the end of each day, the four groups gather for 1h30 in a "large group" that also includes the "large group" leaders (group E in our Table). Finally, group F is composed by the members of the directing committee, which includes the remaining staff and meets during the course of the module.

During the first test session, participants filled the socio-demographic form indexed with a code to render data anonymous. The same code was used to mark the "absurdum questionnaires". The overall experiment includes 11 tests, in which participants had to select one picture for each of the 50 pairs of the questionnaire. The first test was taken the first day before the training actually started. The remaining 10 tests were given at the end of the second day (Saturday) of each module. For administrative reason, the staff did not pass the second test at the end of the first module.

2.4 Data Analysis

To analyse the data, the most frequently selected picture of each pair during the first test will be indicated as picture A (A_i, i=1, 50), while the other picture will be designed as B (B_i, i=1, 50). Frequency tables were computed for each pair of pictures and each one of the 11 sessions (see Figure 2) and a detailed analysis has been reported in the previous work.

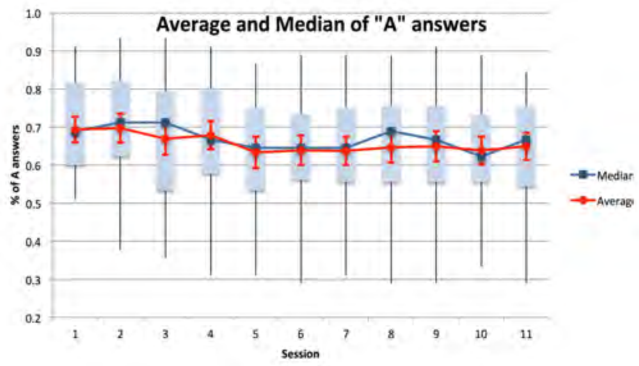

Figure 2. Evolution of the average proportions of the pictures the most selected initially (picture A). The proportions of participants (± 95% confidence interval shown on average points, red vertical lines), who chose the initially preferred pictures (A), are averaged over the 50 questions for each of the 11 sessions (abscissa). The figure also shows the median (blue line) and interquartile (blue boxes and black lines) evolutions.

a) For each of the 11 time-points, we performed separate exploratory multiple correspondence analyses (Le Roux & Rouanet, 2004; Greenacre & Blasius, 2006) to describe participant behaviour toward the 50 pairs of pictures. Multiple correspondence analysis is a generalization of principal component analysis, where the variables to be analysed are categorical (Jolliffe, 2002). To explore the relationships among participants within the 50 pairs of pictures at a time-point, we analysed an indicator matrix, with columns corresponding to the pairs of pictures and rows to participants. A value of one indicates that the participant selected the A picture of the corresponding pair, while a value of zero indicates they selected B. Then, we derived the Burt matrix (Greenacre, 2007), which is a cross-tabulation of all pairs of pictures among participants, and performed correspondence analysis in order to obtain the decomposition of total inertia in orthogonal dimensions, in a way analogous to the decomposition of variance in principal component analysis. We estimated the total inertia explained by the first six dimensions, and the coordinates for each pair of pictures on these first six dimensions. To investigate changes in behaviour toward pictures, we compared graphically picture projection plots of column coordinates after principal normalization across time-points.

   We calculated the average for each of the six projections (p_1, p_2, p_3, p_4, p_5, p_6), and the global average of these averages (p_{ave}).

b) We calculated the Bernoulli entropy as the sum of the entropy of the answers to the 50 questions for each of the session:

$$H_j = \sum_{i=1}^{50} -p_{ij}\log(p_{ij}) - (1-p_{ij})\log(1-p_{ij})$$

where p_{ij} is the observed probability (frequency) of obtaining answer A for the i^{th} question ($i \in [1, 50]$) at the j^{th} session ($j \in [1, 11]$). We compared the trends of multiple components analysis and the one of Bernoulli entropy over the 11 sessions. The objective was to observe the coherence between the evolution of the choices expressed by the multiple components method (the average for each of the six projections (p_1, p_2, p_3, p_4, p_5, p_6) and the global average of these averages (p_{ave}) with the evolution of entropy. We underline that this comparison is only qualitative.

3. Results

In the overall data set we found 2,143 missing data points out of 24,750, which were filled in using the last observation, carried forward approach (LOCF) as detailed in the previous study. We recall that the staff (14 members) did not complete the second questionnaire, which represents a total of 700 (i.e., 50 x 14) missing data.

a. Orientation of the choices

To explore the relationships within the 50 pairs of pictures among participants at each time-point, we performed separate exploratory multiple correspondence. The results are reported in

Figure 3. The change in choices is signalled by a sudden variation of the values of the projections and their average. An increase in the value of the projections is associated with a greater coherence in the answers (orientation of the group), while a decrease is associated with a loss of coherence in the answers of the group. We observe a first large increase of p_1, p_2 and p_3 at the 4th test administration (3rd week of training). The first visible change for p_4, p_5 and p_6 appears instead at the 5th test administration (4th week of training). The projection average (p_{ave}) shows a first positive fluctuation at the 4th test administration (3rd week of training). We observe a second large increase for the projections p_1, p_4, p_5, p_6 and p_{ave} at the 9th test administration (8th week of training). p_1 shows an important decrease the 7th test administration (6th week of training), accompanied by a less marked decrease of p_2 and p_3.

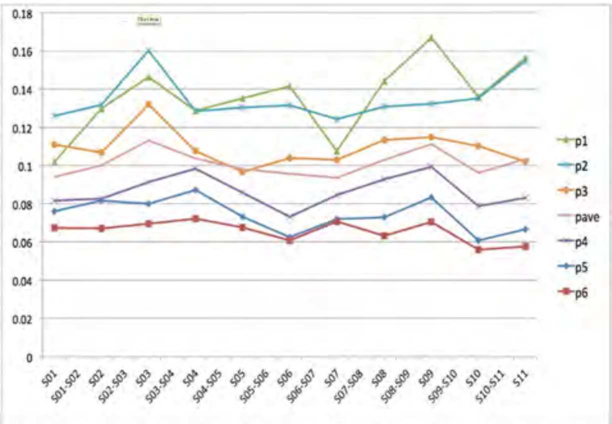

Figure 3. Evolution of the projections of the multiple correspondence analysis (p_1, p_2, p_3, p_4, p_5, p_6) and of their average (p_{ave}) during the 11 tests.

b. Entropy of the choices

The entropy (reported in Figure 4, green line) shows an increase from the beginning to the end of the experience, which is the expected behaviour in an isolated system, with a slight decrease at the 2nd test administration (1st week of training) and at the 9th test administration (8th week of training). The diminution at the 1st week is not coincident with the trend of p_{ave}, as we could expect, under the hypothesis of an inverse relationship between the orientation of the choices and the value of entropy. By contrast, the diminution of the entropy at the 8th week of training is coincident with the second larger change of p_{ave}, which happens at the same week of training.

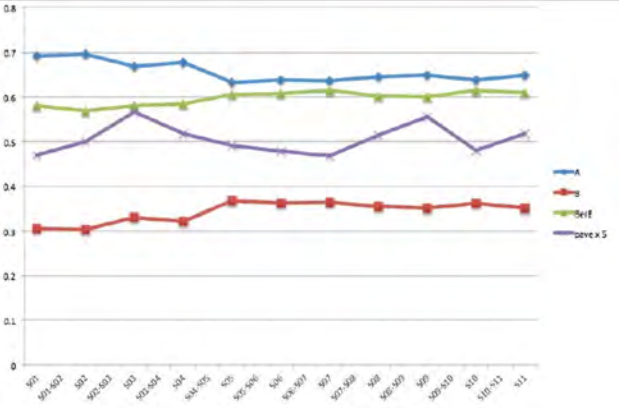

Figure 4. Evolution of the Bernoulli entropy during the 11 sessions (BerE, green line). We have also reported the trend of the A and B responses during the sessions (blue and red lines, see text for explanation) and the average projection (p_{ave}, purple line), multiplied by five to facilitate visual comparison.

4. Discussion

As reported in the previous study, the initial answers to the test are not a 50%-50% random choice between the two pictures of each pair, despite the fact that the pairs of pictures were chosen trying not to induce social or cultural biases. As discussed, this initial bias could be, at least in part, the reflection of some shortcoming of our protocol or a genuine group effect.

Indeed, according to Bion, group effects could be seen as soon as people are actually put together. They do not even need to interact actively, and the mere assembly of individuals should be enough to connect unconscious and to provoke group phenomena.

A future version of such a protocol will include the demand for prospect participants to fill the questionnaire before they actually meet for the first session. In practice it is not easy to obtain a questionnaire filled before the beginning of the training above all because during the first evaluation meeting the candidate is not yet chosen for the training. In other hand, sending the questionnaire after the selection exposes the study to the danger of copies with possible memorisation of the images. To propose a second meeting for the purpose of the research is very demanding in organisation and expensive.

4.1 Orientation and Entropy of Choices

We observe some changes in the trend of the orientation of choices at the 3rd and 9th test administrations, i.e., during the 2nd and 8th weekends of training, corresponding respectively to the phases of group idealisation at the beginning, and of group disillusion that occurs before the mourning of the group.

"Honey moon" (dependence from the leader), and the successive "fight-flight" attitudes (reaction against the dependence from the leader) could be represented by an increase in the joint orientation of the choices.

The Entropy increases during the experience as in a closed system, with a slight diminution at the 2nd test administration (1st week of training), i.e. very early in the training (before the "honey moon"), and at the 9th test administration (8th week of training). The trend of average projection and Entropy seem reciprocally inversed starting from the 4th test administration. We can postulate that the "honey moon" and the successive "fight-flight" attitudes influence the orientation of choices and the Entropy, but that only "fight-flight" attitudes influence Entropy.

5. Conclusions

The present work has been conducted during group analysis training at the Basque Foundation for the Investigation of Mental Health (OMIE) at Bilbao. The objective is to look for evidence in favour of the influence of group dynamics on individual choices of images in a questionnaire aimed at minimising, or at least reducing, cognitive and social bias.

Globally the Entropy shows the typical behaviour of a closed system. It is interesting to notice that the orientation of choices as described by the exploratory multiple correspondence analysis is not similar to the trend of the Entropy in the three first test administrations. Subsequently the trend of choices and the trend of the Entropy become inversely correlated from the 4th test administration. The orientation of choices seems to change the trend of the Entropy only in the second part of the experience, during the "fight-flight" (reaction against the dependence from the leader) attitudes

If we consider that entropy links the concepts of order and information, we could consider that it is an expression of a more fundamental archetype, which otherwise has been expressed as *Chaos and Cosmos, Eros and Thanatos* and so on. In this interpretation entropy, as all archetypes, has two faces, the creative order (how much order is there) and the destructive disorder (how much disorder is there), but also the destructive order (there is no more information to obtain) and the creative disorder (there is still information to obtain).

We could then propose the following interpretation. When entropy increases in groups, both creative and destructive, this is due to the "work group". According to Bion (1961) is the aspect of the group that does "keep the group anchored to a sophisticated and rational level of behaviour". The activity of the work group increases order but reduces the amount of information that can be extracted. At the same time the disorder, both creative and destructive decreases, and this is a sign of a reduction of the effect of the basic assumptions. The action of the basic assumptions is to increase the disorder, but also to increase the amount of information that can be extracted from the group.

In this sense the observed evolution of entropy indicates that the work group progressively, but not monotonically, supersedes the action of the basic assumptions, once the information available is extracted and made explicit. Consequently order is brought into the group, while creativity and disorder are reduced. This again is in accordance with Bion's view of the group dynamics, as he maintains that the action of the "work group" tends to eventually prevail.

Because of the postulated early group orientation of the unconscious it will be important in following studies to test the group of participants with an absurd test before personal interactions in group experience take place.

References

Aspect A, Grangier P & Roger G. Experimental Realization of Einstein- Podolsky- Rosen- Bohm Gedankenexperiment: A New Violation of Bell's Inequalities. Physical Review Letters 1982; 49(2):91–94. doi: 10.1103/PhysRevLett.49.91.

Avery J. Information Theory and Evolution. World Scientific, 2003.

Balian R. Entropy, a protean concept. In Dalibard, J, Poincaré Seminar 2003: Bose-Einstein condensation – entropy. Birkhäuser, Basel, 2004. p. 119–144.

Bell J. On the Einstein- Poldolsky-Rosen paradox. Physics 1964; 1:195-200.

Bell J. On the problem of hidden variables in quantum mechanics. Rev Mod Phys 1966; 38: 447.

Bion W. Experiences in groups and other papers, Tavistock Publications Ltd, 1961.

Boltzmann L. The second law of thermodynamics. Populare Schriften, Essay 3, address to a formal meeting of the Imperial Academy of Science, 29 May 1886. Ludwig Boltzmann, Theoretical physics and philosophical problem. Boston: Reidel. Reprinted in Bush, SG, 1974

Brillouin L. Science and Information Theory. New York : Academic Press, 1956.

Brooks DR & Wiley EO. Evolution as Entropy – Towards a Unified Theory of Biology, University of Chicago Press, 1989.

Chen J. The Physical Foundation of Economics – an Analytical Thermodynamic Theory. World Scientific. 2005.

Clausius R. On the Motive Power of Heat, and on the Laws which can be deduced from it for the Theory of Heat. Poggendorff's Annalen der Physick, Vol LXXIX, Dover Reprint. 1850.

Einstein A, Podolsky B & Rosen N. Can Quantum-Mechanical Description of Physical Reality Be Considered Complete? Phys Rev 1935; 47(10): 777–780. doi:10.1103/PhysRev.47.777.

Foulkes SH. Therapeutic Group Analysis, International Universities Press. New York, 1964.

Frigg R & Werndl C. Entropy – A Guide for the Perplexed', in Beisbart, C & Hartmann, S, Eds 2010, Probabilities in Physics, Oxford University Press, Oxford, 2010.

Georgescu-Roegen N. The Entropy Law and the Economic Process. Harvard University Press, 1971.

Greenacre M. Correspondence Analysis in Practice, Second Edition. London: Chapman & Hall/CRC, 2007.

Greenacre M & Blasius J. Eds. Multiple Correspondence Analysis and Related Methods, London: Chapman & Hall/CRC, 2006.

Jolliffe IT. Principal Component Analysis, Series: Springer Series in Statistics, 2nd ed., Springer, NY, 2002.

Le Roux B & Rouanet H. Geometric Data Analysis, From Correspondence Analysis to Structured Data Analysis. Dordrecht. Kluwer, 2004, p.180.

Schrödinger E & Born M. Discussion of probability relations between separated systems. Mathematical Proceedings of the Cambridge Philosophical Society 1935; 31(4):555–563. doi:10.1017/S0305004100013554.

Schrödinger E & Dirac P. Probability relations between separated systems. Mathematical Proceedings of the Cambridge Philosophical Society 1936; 32(3):446–452. doi:10.1017/S0305004100019137.

Shannon CE, Weaver W. The Mathematical Theory of Communication. Univ of Illinois Press, 1949.

Sommaruga G (Editor). Formal Theories of Information: From Shannon to Semantic Information Theory and General Concepts of Information (Lecture Notes in Computer Science / Theoretical Computer Science and General Issues) Paperback, Springer, 2009.

Tribus M & McIrvine EC. Energy and information', Scientific American 1971; 224:178–184.

Trojaola-Zapirain B, Carminati F, Gonzalez Torres A, Gonzales de Mendivil E, Fouassier C, Gex-Fabry M, Martin F, Labarere J, Demongeot J, Lorincz EN & Galli Carminati G. Group unconscious common orientation: exploratory study at the Basque Foundation for the Investigation of Mental Health group training for therapists. NeuroQuantology 2014; 12(1): 139-150.

Vergopoulo T. La sensibilisation à la dynamique de groupe d'après W.R. Bion et S.H. Foulkes, Médecine et Hygiène 1983 ; 3149-3155.

Yockey HP. Information Theory, Evolution, and the Origin of Life, Cambridge University Press, 2005.

Zanello A, Rouget-Weber B, Gex-Fabry MG, Maercker A & Guimon J. New instrument to assess social functioning in mental health settings. European Journal of Psychiatry 2004; 18:76—8.