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CHAPTER 3. ORGANIZATIONAL CONSCIOUSNESS *VERSUS* ARTIFICIAL CONSCIOUSNESS

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Abstract. What is the capacity of an informal network of organizations to produce answers in response to complex tasks requiring the integration of masses of information designed as a high-level cognitive and collective activity? Are some network configurations more favourable than others to accomplish these tasks? We present a method to make these assessments, inspired by the Information Integration Theory issued from the modelling of consciousness. First we evaluate the informational network created by the sharing of information between organizations for the realization of a given task. Then we assess the natural network ability to integrate information, a capacity determined by the partition of its members whose information links are less efficient. We illustrate the method by the analysis of various functional integrations of Southeast Asian organizations, creating a spontaneous network participating in the study and management of interactions between health and environment. Several guidelines are then proposed to continue the development of this fruitful analogy between artificial and organizational consciousness (refraining ourselves from assuming that one or the other exists).

Keywords. Organization, consciousness, environment, health, network, information, public policies, text mining.

3.1 “HOW DO ORGANIZATIONS THINK?”

At first, it seems an awkward question. How can we assume that organizations think? Why would we push this incongruity to the point to ask ourselves how a network of organizations thinks? In a first place, let us justify the legitimacy, then the consistency of the question. If consensual uses of the notion of thought exist, there is in contrast no consensus about the concept itself. There are, of course, different neighbouring conceptions of what thought is, co-evolving with our practices, knowledge and more generally, according to the cultural (and thus historical) contexts among which they are called for³⁷. A priori, it is not ruled out that thought itself can be considered in respect with a certain conception of organization's functioning.

³⁷ We can quote here the conclusion to the Section entitled “conceptual stability and change” in the article (p.1522) written by Hjørland (2009): “*Concepts are dynamically constructed and collectively negotiated*”

The issue can be tamed if we assess it slightly differently, considering on an interrogative form the statement contained into the title of Mary Douglas's book, published in 1986 *"How institutions think"*. Numerous are the institutions³⁸ which, through the cultural immersion we experience, are constituting the common environment of our subjective thoughts, the cognitive reference framework within which we are evolving, as individual or social groups, often without being aware of its impregnation. M. Douglas traces the genealogy of this corpus of ideas back to E. Durkheim: those ideas receiving a lukewarm or sometimes hostile³⁹ welcome, they almost fell into oblivion. Nevertheless, some authors followed up the development of the elements presented by Durkheim. But above all, the book of Mancur Olson (1965), reformulating the analysis of collective action for public goods production grounded on the rational (individual) behaviour theory, shed new light on the question of whether and to which extent thought depends on institutions. In response, this new formulation led to various critiques, especially those developed by M. Douglas: she essentially insists on the fact that Olson's theory, discounting small groups, cannot apply to all levels of social organization (without being able to explain it); she also observes that other factors of co-operation exist and cannot be captured by an utilitarian approach.

Of course, the scientific fame of those authors itself does not confirm the relevance of our initial question. But as works on the rational choice theory, works developed in Artificial Intelligence and even more those focusing on the conditions to be met in order to build an artifact endowed with consciousness (Cardon, 2000) allow us to renew the context of these studies. More precisely, our approach intends to explore an analogy with computational models of artificial consciousness (for a recent review, cf. Reggia, 2013). Specific cerebral cortex regions are dedicated to specialized functions⁴⁰. Several brain regions are simultaneously challenged and co-operate with each other in a network in order to generate sophisticated processes—particularly cognitive processes—of a higher level. Considered from in a general and abstract sense, those processes relate to an information integration process. Tononi (2008) developed a theory stating that the emergence of integrated information from the cerebral regions' network constituted a fact of consciousness; the diversity of processes operating is much like the observed diversity of consciousness experiences. The analogy between the functioning of organizations and of cerebral regions is extremely tempting and we chose to explore it further.

Indeed, the information integration is more than a simple juxtaposition or collection of information but it develops a synthesis at the level of the considered entities' network, the network thus functioning as a system. We interpret the various solutions generated by organizations networks responding to global as well as local changes (environment, health, economy...) as the result of the systemic process of the information integration. Section 3.2 presents a limited group of organizations dealing with health and environmental challenges in Southeast Asia in order to illustrate our approach. Transposing Tononi's (2004) consciousness model, in Section 3.3 we examine informational networks linking those organizations according to several functions they perform; then we evaluate their theoretical limits to function as an information integration system induced by the efficiency of the underlying informational networks. We also assess how the consideration of a corpus describing the entire network impacts the informational networks between organizations and their information integration capacity. Some options stemming from this analogy between artificial consciousness and artificial consciousness are presented in Section 3.4. Section 3.5 discusses the

meanings that classify the world according to interests and theories. Concepts and their development cannot be understood in isolation from the interests and theories that motivated their construction, and, in general, we should expect competing conceptions and concepts to be at play in all domains at all times."

³⁸ For example, the categories of time, space, causality, but also the grammatical forms of the language...

³⁹ Douglas (1986) op. cit., p. 11.

⁴⁰ Objects or people recognition, motor control systems, vision, audition, etc.

assumptions and limitations of the model we propose, before presenting our conclusions in Section 3.6.

3.2 ORGANIZATIONS NETWORKS “HEALTH-ENVIRONMENT” IN SOUTHEAST ASIA

Our research about organizational networks on health and environment in Southeast Asia, has been conducted within the framework of an international research project entitled BiodivHealthSEA. That project aimed at investigating the local impacts of global changes on zoonotic diseases (as those diseases constitute more than 60% of emerging diseases), focusing on rodent-borne diseases, in relation to biodiversity changes. The project analyses the local perception of biodiversity loss and their links to health through global governance, national public policies and the actions of NGOs in the sectoral domains of health, environment, conservation and development.

In the context of the regional economic integration with the opening, by the end of 2015 of the ASEAN (Association of Southeast Asian Nations) Economic Community, the free movement of goods, services and persons will accelerate the pace of changes within the region. Indeed, Southeast Asia is a hotspot of biodiversity at threat subject to important environmental changes (land use changes, deforestation, and erosion of biodiversity) in relation to fast socio-economic changes (economic growth, migration, and wildlife and livestock trade). Those changes in turn cause the infectious diseases' emergence of potential global pandemics (Morand et al. 2014) that must be acknowledged at the regional level as well as the national level.

In that respect, our research led to review policies, agendas, or various kinds of initiatives on biodiversity or health at the regional level and to assess how health and biodiversity are connected in formal or informal settings. To take into account the diversity of actors and the way they try to coordinate their strength and goals (the goals themselves may be driven by international or regional policies), we identified different networks and initiatives. We have chosen those born from health and environmental considerations in general or those that were more specific (geographical area in Southeast Asia, topics, actors involved).

Since its creation, ASEAN has been characterized by its minimal institutional organization, a limited use of formal rules or the principle of non-interference in each other's domestic affairs. The so-called “ASEAN Way” favours national implementation and cooperative programmes and dialogues among members (Robinson and Koh, 2002). The traditional “ASEAN Way” together with the realization that States actors have a limited ability to deal with global, regional and national challenges, led to the elaboration of regional programmes by States actors as well as other stakeholders. This “alternative regionalism” in the regional context is referred to “as a spontaneous, bottom-up process that recognizes the importance of a wide range of stakeholders in the making of regional systems and institutions” (Chandra, 2009, p. 4). Thus we can affirm with Lallana that ASEAN as an institution is a network organization or we could consider it as a network of networks. Lallana adds an interesting comparison stating that “ASEAN operates much like the Internet” (Lallana, 2012).

Our research interest here is to study how networks dedicated to health or environment in Southeast Asia interact, produce and share information but it is also to evaluate the ability to integrate information within a network of networks of organizations. As many networks related to the health or the environment exist in Southeast Asia (on environmental networks, cf. Elliott, 2011), we decided to focus on some in order to illustrate our work.

We consider a regional organization which gathers all the ASEAN member states plus Timor Leste. The choice has been guided by the fact that this organization called SEAMEO (Southeast Asian Ministers of Education Organization) is an established organization celebrating its 50th anniversary in

2015. It is itself divided into 21 institutions specialized in different research and education areas, all producing knowledge and information. Within SEAMEO, we chose the institutions whose activities among the network are directly linked with issues regarding health and environment (agriculture, food and nutrition, history and tradition, cultural diversity, tropical medicine, tropical biology and public health).

The study of this network will allow us to determine the capacity of a network of organizations to produce answers in response to complex tasks that require the integration of masses of information designed as a high-level cognitive and collective activity. We examine if some network configurations are more favourable than others to accomplish these tasks. In this respect, we use the analogy between artificial consciousness and organizational consciousness presented Section 3.1, selecting some SEAMEO institutions to develop methodology and explore the potential of the analogy.

3.3 MULTIFUNCTIONAL ORGANIZATION NETWORK

Mathematically, the number of networks created on the basis of a group of objects is indeterminate: it is the specific kind of link considered between these objects which generate a specific network. Thus, the network is not necessarily a priori or intentionally thought about or created, but it can be structured by the existence of the various entities forming the network. It is particularly true with social networks (family or neighbourhood ties, professional links...) and organization networks whether they are formal or not. We consider here three types of functions generating as many networks: 1) missions of the organizations previously described; 2) their governing board composition; 3) content of their training programmes.

How do we proceed⁴¹ ? For each organization, we gather information publicly available regarding one of those functions (information obtained through their websites). Each organization has an associated text corpus from which we can extract a list of keywords or key expressions⁴² (and if necessary, to each keyword we associate a list of similar expressions). The keyword extraction step is optional. We use it here to reduce the information management load while giving the possibility to direct the informational network building to a specifically targeted research topic. A link is created between two organizations A and B if a least one pair of keywords⁴³—respectively coming from A and B's corpus—appears in the corpus of the organization C (C being distinct or not from A and B). This link is weighted by the function of average mutual information $I_{AMI}[A, B]$ ⁴⁴ evaluated through corpus analysis, as described in the Annex (gathering all the equations). The auto information associated to an organization $I_{AMI}[A, A]$ is assessed in the same way (with $C \neq A$ otherwise no auto information will result from network affiliation). Taking account of all pairs of organizations, we create a network induced by the considered function, network represented by a graph which vertices are organizations and links are weighted by the values of average mutual information functions (or auto information). A null value indicates that there is no link.

The capacity Φ_{IS} of the entities network (cerebral cortical regions in the case of Tononi (2004, 2008), organizations here) to behave as an information integration system is limited by the weakest informational link between entities groups within the network. As such, Φ_{IS} is theoretically evaluated

⁴¹ The method is described in detail and commented in Lajaunie and Mazzega (2016a).

⁴² By keyword we mean a noun phrase, a word or even a word root: e.g. the root "agri" identifies all occurrences of themes related to agriculture in the corpus we use here.

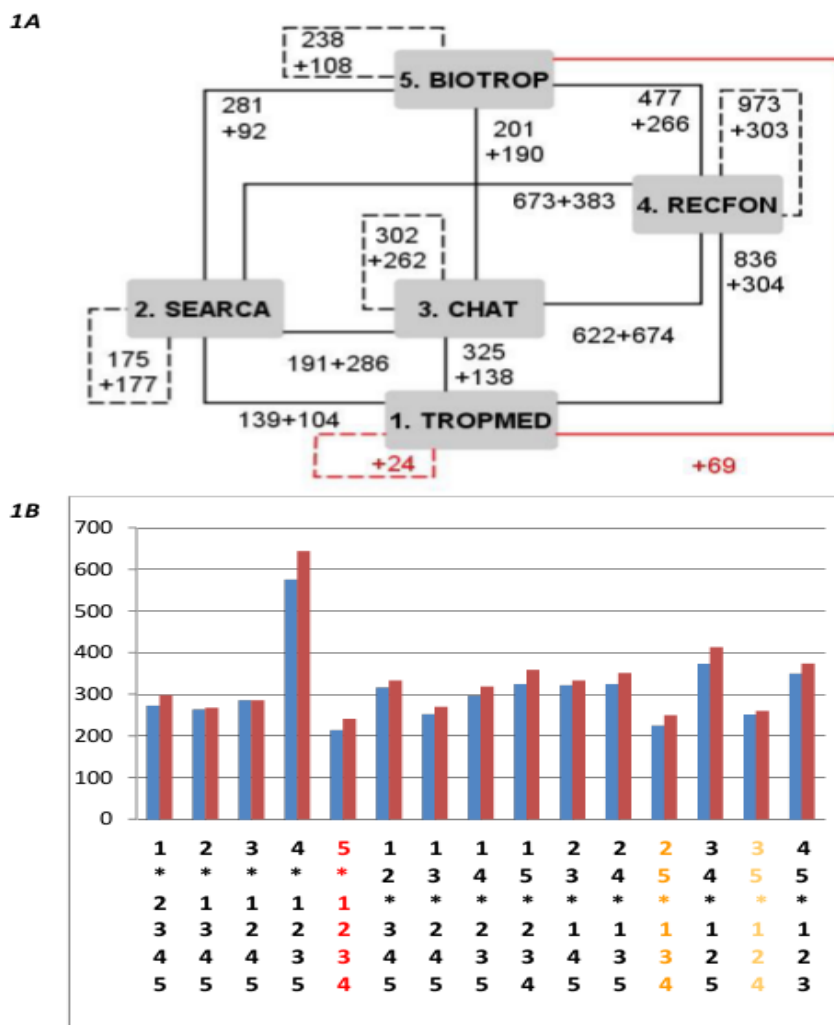
⁴³ Note that in a pair of keywords (t_j, t_k) (tn, tm) we can have $t_j = t_k$.

⁴⁴ Note that $I_{AMI}[A, B] = I_{AMI}[B, A]$ and $I_{AMI}[A, B] \geq 0$.

considering all possible partitions of the entities set⁴⁵, when calculating for each of them average mutual information values and determining the minimal value. Without going into details, this approach is proposed by Tononi (2004) on a neuro-physio-pathological basis. For instance, it is observed that patients with cortex lesions may have cortex regions isolated one from the other and thus are deprived from some consciousness experiences⁴⁶. In extreme cases, such injury can lead to the total absence of informational link between two groups of entities.

4.3.1 Network induced by the role and missions of organizations

Similarly, two organizations dedicated to completely disparate missions, without any link between one another, are not prone to work together and even less to conjointly conduct complex tasks. **Figure 3.1A** shows the informational network induced by the description of the role and missions of each of the five SEAMEO's organizations considered. Other texts that form an additional corpus can be added to the original corpus and considered in the analysis (e. g. a text describing the roles and missions of SEAMEO, see below).



⁴⁵ In theory only because the number of partitions of a set S of N elements very quickly increasing with N , we only consider the set of all bipartitions of S .

⁴⁶O. Sacks' book (1998) describes such cases. Brain's plasticity allows reducing at least partially the incidences of those injuries.

Fig.3.1 (A) Informational network of roles and missions of the 5 organizations of SEAMEO considered (vertices in grey). Information function's values I_{AMI} are indicated on the links using the form “x+y” according to the following convention: x is I_{AMI} value without taking account of the additional corpus C_+ , +y the information input induced by the adjunction of this corpus. When $[x = 0; y \neq 0]$ the link is indicated in red; (B) $I_{AMI}[S_{\kappa}, S_{\pi}]$ values (y-axis) associated to each bipartition (S_{κ}, S_{π}) of the organization network (x-axis). The minimal value indicates the capacity Φ_{IIS} of information integration of the network

We observe that RECFON presents strong informational links with the 4 other organizations. It also has the highest auto information rate: it means that RECFON's role within the network is understood only in regard with the roles and chores of other organizations in the network. Indeed, RECFON's missions are encompassing research, education and information in food and nutrition: thus, they can overlap BIOTROP's missions in biology, TROPMED's missions regarding public health or even those of SEARCA in agricultural research. In contrast, TROPMED's missions (null auto information) are defined only by self-reference, and the affiliation to the network does not change its extent.

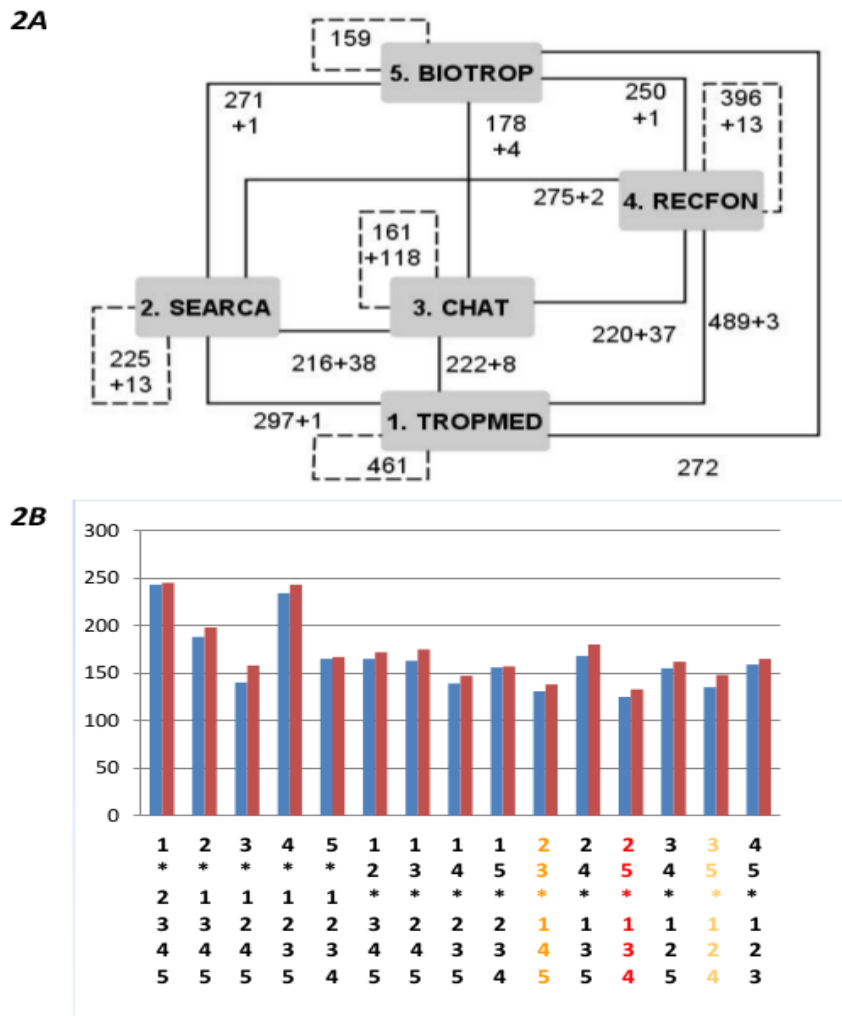


Fig. 3.2 (A) Informational network of the governing boards of the 5 organizations of SEAMEO (vertices in grey); (B) Values $I_{AMI}[S_{\kappa}, S_{\pi}]$ (y-axis) associated to each bipartition of the governing boards' network (x-axis). The minimal value indicates the capacity Φ_{IIS} of information integration of the network. For representation conventions, cf. Fig. 3.1

TROPMED and BIOTROP are not linked through their respective tasks. If we take account of the additional corpus describing SEAMEO's roles and charges as such, most of the informational links are strengthened, sometimes considerably (e.g. the link RECFON-SEARCA) and induce a link between TROPMED and BIOTROP.

Nevertheless, the adjunction of that corpus is very marginal regarding the change of the theoretical capacity of an organization network to integrate information and process complex collective tasks (Figure 3.1B). It can be explained by the fact that if the network formalization may strengthen the informational flow between affiliated organizations, the organizations are not endowed with additional missions or competences. The partition limiting the network capacity to act as an information integration system split BIOTROP on one side and the four other organizations on the other side. A way to improve the network capacity to accomplish collective missions, while minimizing organizational changes, would probably go through a new definition of the role and missions of BIOTROP.

4.3.2 Network Induced by the Organization's Governance

To which extent the composition of the governing boards is improving (albeit to a various extent) the information flows between organizations? In order to answer, the corpus associated to each organization is now composed with the names of each member and their affiliations—department or agency (e.g. ministry) or faculty and university in the case of academic staff. The informational network induced by the composition of the governing boards is presented in Figure 3.2A. Here the additional corpus is formed by the composition of the governing board of SEAMEO.

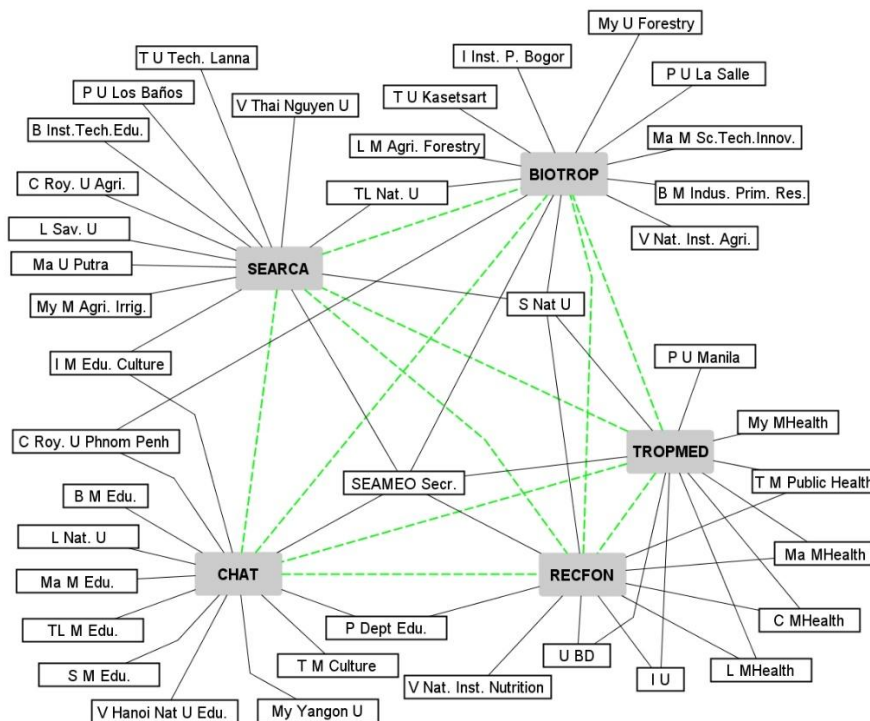


Fig.3.3 Informational network of the governing boards of the 5 organizations of SEAMEO (vertices in grey; links in green dotted lines) and of organizations taking part to their respective boards. The Secretary General of SEAMEO is an ex-officio member of all the different boards. 1st Letter {B : Brunei Darussalam ; C : Cambodia ; I : Indonesia ; L : Laos ; Ma : Malaysia ; My : Myanmar ; P :

Philippines ; S : Singapore ; T : Thailand ; TL : Timor Leste ; V : Vietnam} ; 2nd letter : {M : Ministry ; U : University}

The network obtained is a complete graph. The fact that the Secretary General of SEAMEO is an *ex-officio* member of each board contributes to this result. Almost all link weightings have very close values one another, board compositions having a very similar shape. The adjunction of an additional corpus, here the composition of SEAMEO's Council changes very slightly the strength of informational links and the network's capacity to function as an information integration system through the functioning of its governing board (Figure 3.2B). This last result reflects the fact that the Council of SEAMEO's network organizations is not the board of one network's organization. The bipartition limiting this capacity split SEARCA and BIOTROP on one side and the three other organizations on the other side.

Each board being composed of around 13 members, it is difficult to understand those results by a simple observation of the organization boards' composition. Actually, the informational network (Fig. 3.2A) incorporates much information. Figure 3.3 unfolds the entire network of institutions taking part to various governing boards (those taking part to SEAMEO's Council are not represented, this Council operating at another level). The strong visible symmetry of the graph is probably the reason of the homogeneity of information function's values of Figure 3.2A (with one exception: the participation of 8 organizations to the governing boards of TROPMED and RECFON induce a high mutual information value between those two organizations). We can notice the centrality (Freeman, 1979) of SEAMEO's Secretariat as well as of the National University of Singapore (cf. Table 3.1). Nevertheless, it is a closeness centrality degree (in average SEAMEO's Secretariat is the closest from other organizations, it can be seen as the "centre" of the network). The strongest betweenness centrality degrees are associated to CHAT, BIOTROP and SEARCA: those organizations are linking together groups of institutions that would otherwise be relatively disconnected from one another.

Table 3.1 List of 10 organizations with the highest centrality degrees among the 5 SEAMEO's organizations or of organizations affiliated to their governing board (cf. graph, Fig. 3.3 without informational links in green: 44 vertices, 56 links). N_e : number of links (or centrality degree, normalized by the higher centrality degree found in the graph); B_{cent} : betweenness centrality degree; C_{cent} : closeness centrality measure

N_e		B_{cent}		C_{cent}	
Org. Name	Value	Org. Name	Value	Org. Name	Value
BIOTROP	1.00	CHAT	1.00	SEAMEO Secr.	1.00
CHAT	1.00	BIOTROP	0.99	BIOTROP	0.80
SEARCA	1.00	SEARCA	0.99	S Nat. U	0.80
RECFON	0.83	SEAMEO Secr.	0.96	CHAT	0.80
TROPMED	0.83	RECFON	0.53	SEARCA	0.80
SEAMEO Secr.	0.42	TROPMED	0.53	RECFON	0.77
S Nat. U	0.33	S Nat. U	0.44	TROPMED	0.77
10 ex-æquos	0.17	IM Edu. Culture	0.14	P Dept. Edu	0.67
		C Roy.U Phnom Peh	0.14	TL Nat. U	0.67
		TL Nat. U	0.09	C Roy.U Phnom Penh	0.67
		P Dept. Edu.	0.09	IM Edu. Culture	0.67

4.3.3 Network induced by the organization's training courses they provide

As all the organizations studied depend on SEAMEO (regional inter-governmental organization established among governments of Southeast Asian countries to promote regional co-operation in education, science and culture in the region), they all offer training courses detailed on their website. The corpus used here is the description of the course offers. The informational network induced by

these offers is presented **Figure 3.4A**. The SEAMEO network also promotes these courses on its website. The additional corpus is the description of the course offer as presented at the SEAMEO level. When this additional corpus is not taken into account, CHAT is apart from the other organizations (the network is not fully connected, CHAT is an isolated vertex). CHAT is indeed focusing on the promotion of co-operation regarding the study of history and traditions among SEAMEO's members, through research, human resource development, education and networking. The courses currently offered do not fit in the general line of courses proposed by the other organizations and regarding various aspects of their missions (agriculture, nutrition, health...).

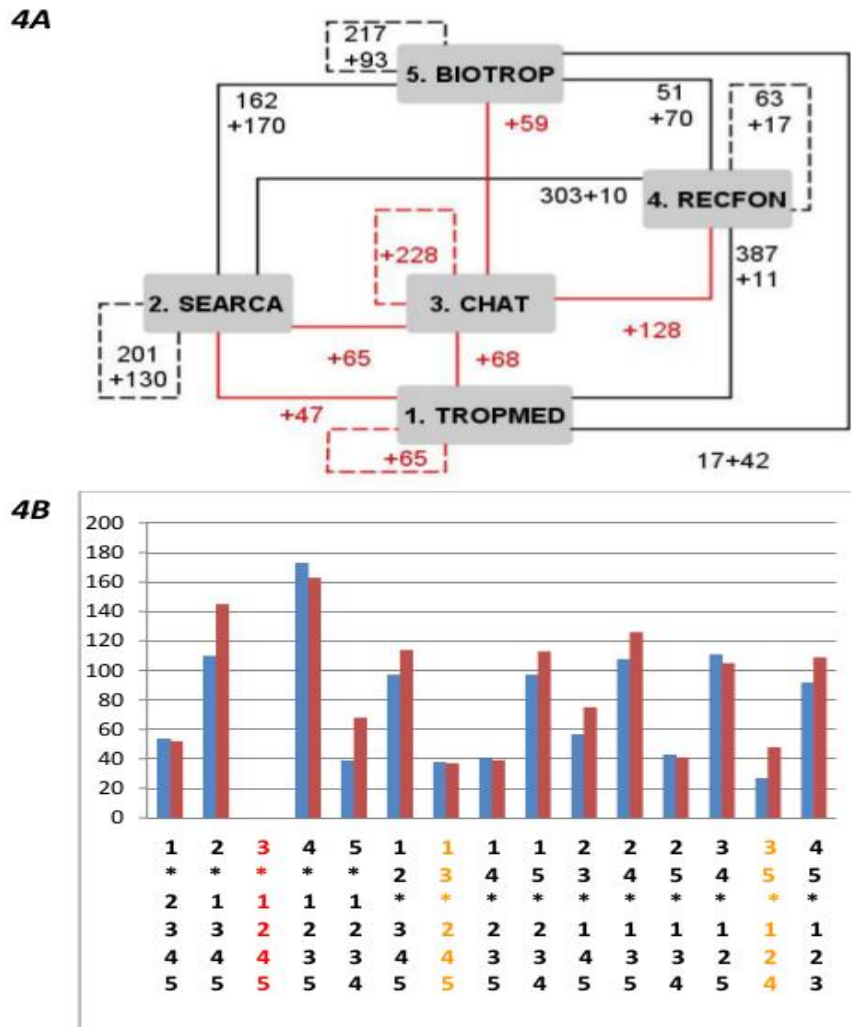


Fig.3.4 (A) Informational network of the training courses proposed by the 5 organizations of SEAMEO (vertices in grey); (B) Values $I_{AMI}[S_k, S_\pi]$ (y-axis) associated to each bipartition of the network of training courses (x-axis). The minimal value indicates the capacity Φ_{IIS} of information integration of the network. For representation conventions, cf. Fig. 3.1

Of course, SEAMEO's description of training courses (additional corpus) allows linking offers from the affiliated organizations (links in red, Fig. 3.4A) but does not change the incapacity ($\Phi_{IIS} = 0$) of organizations to propose courses that would integrate (not simply overlap) all the areas covered (bipartition of CHAT on one side versus the 4 other organizations on the other side, Fig. 3.4B). The additional corpus is not associated with a vertex of the graph (SEAMEO member organizations offer

courses but not SEAMEO as such). Hence the bipartite summit that minimizes the information is the same: CHAT is an isolated organization on one side and the other organizations are on the other side.

3.3.4 Assessment of SEAMEO's organizations

Although the five organizations we are considering here are members of a formalized network, SEAMEO, the informational links between them should be analysed under a specific perspective of characteristics (role and missions) or functions (administration and governance, courses) of affiliated members. The quality and structure of each network depends of the considered function. The formal network is efficient to process complex information integration tasks (that we relate to a form of organizational consciousness) in terms of governance (through governing boards) but are *a priori* unable to offer courses integrating in a synthetic way all the knowledge disseminated by its members (Table 3.2).

Table 3.2 For each type of functioning of the organization network, the elements of the smallest part of the bipartition minimizing the average mutual information are shaded in grey. The value corresponding to the capacity of information integration Φ_{IIS} is indicated in the last column (and between brackets the gain of information obtained by the adjunction of the additional corpus)

Linking Functions	Organization					Φ_{IIS}
	TROPMED	SEARCA	CHAT	RECFON	BIOTROP	
Missions	TROPMED	SEARCA	CHAT	RECFON	BIOTROP	215 (+26)
Governance	TROPMED	SEARCA	CHAT	RECFON	BIOTROP	128 (+8)
Training	TROPMED	SEARCA	CHAT	RECFON	BIOTROP	0 (+0)

The information produced at the level of SEAMO's network allows a better link between organizations and modify their respective positions for the process of given functions. However, it cannot replace the role of organizations and thus cannot reinforce the network capacity to function like an information integration system that is to say to realize collectively high level cognitive tasks.

In a previous article (Lajaunie and Mazzega, 2016a), we also studied the impact of the adjunction of a new organization C in the network. We notably observed that the entrance of C into the network can modify the intensity of informational link between organization A and B already in the network, or create an auto information on A, as C's functions lead to reconsider A's functions. On another hand, the information integration capacity being assessed *a priori*, it is possible to evaluate different scenarios. It can be done by adding organizations and depending on each considered function (mission, governance, courses), to choose the organization that will maximize the capacity of the extended network to process integrative collective tasks.

3.4 ORGANIZATIONAL VERSUS ARTIFICIAL CONSCIOUSNESS: OPEN DEBATE

So far, we have shown that the transposition of Tononi's model (2004, 2008) allows considering various organizations as components of several informational networks, corresponding to functions performed by those organizations, and evaluating *ex ante* their theoretical capacity to collectively conduct the integration of a large amount of information. The method gives the possibility to assess the impact of an additional organization or of an additional corpus describing the whole network on those informational networks and on their integration capacity. But those are only beginnings: the study must be completed aligning the idea of organizational consciousness to the theory of consciousness as an information integration system. The most interesting point is that diverse theoretical predictions on the emergence of consciousness - differentiated participation of some cerebral cortical regions to this emergence, the existence of connectivity patterns favouring more or

less the integration of information, etc. - are significant regarding organization networks, and can be assessed. In the following sections, we present those predictions (many are relying on neuropsychiatric observations) as conjectures to explore in the case of organizations.

As for cerebral regions (CR), all the organizations of the network are not necessarily involved into the emergence of an organizational consciousness—or let us say to the information integration at the network's level. Moreover, the organizations involved in this process can participate only temporarily. According to the collective task to accomplish, some organizations will be activated while others will not⁴⁷, following complex processes (not very predictable, nonlinear, or each time depending on different variables, or on unstable configurations of actors' relationships). At a lower systemic scale, the internal functioning processes of each organization (respectively AC) are likely to modify the quality of experience of consciousness by the network. Here, "quality of experience of consciousness" means type of actions that the organizations of the network are able to undertake collectively. At a superior systemic scale, networks of networks of organizations (or AC) exist and create other information integration structures and thus other experiences of consciousness.

It has also been demonstrated that the informational network connectivity of cerebral regions (and thus the capacity of Φ_{IS}) evolves over time, for instance in response to a solicitation from the environment. There is a continuous rearranging in the case of organizations or at least in the case of SEAMEO (which we consider only partially here) and of its international or regional partners. Those solicitations come from the adaptation of regional strategic positioning vis-à-vis the emergence of economic or political challenges, shifting alliances, changes in the legal, political or economic context of international co-operation. This adaptation capacity is corresponding to the "ASEAN's way", flexible and adaptive way of decision-making. As underlined by Ellen Frost (2008), environmental, health, and human rights groups are forming information networks and uneven cross-border coalitions.

Various neuro- and physio-pathological works are also showing that learning processes induce a modification of physical substrate of cerebral areas (mainly through a rearranging and improvement of the inter-connectivity patterns) which in turn leads to an extension of the consciousness experience range. The input of information technology to the functioning of organizations' network offers a trivial analogy of this phenomenon (e. g. Scott, 2000). Moreover, organizations are developing in collaboration a broad spectrum of activities resulting in co-learning processes (multilateral meetings, co-organizations of events, common synthesis or strategic reports, collaborative projects, creation of new governing boards, involvement into participatory management processes...). We should underline the fact that each of those activities can be seen as a specialized informational network involving the organization's members.

The field of possible analogies between dysfunction of the brain, on the one hand, and of organizations, on the other hand, is wide open. Works in this area are numerous whether it is in neuropsychiatry, administrative science or science of organizations. The flexibility and the genericity of our model should allow deepening and renewing the exploring of those useful analogies. Some cortex injuries are going with the loss of determined consciousness experiences⁴⁸. The dissolution of an organization, its withdrawal from a collective project (or to a lesser extent its potential weaknesses) can be considered as an "organizational injury". According to our simulations, such a withdrawal

⁴⁷ It will be necessary to specify how to define and observe the network's state at a determined moment: the informational networks previously presented are creating the structure of informational exchanges (an equivalent to anatomic constraints of the brain); the network's state would correspond to the real functioning state of the network when realizing a specific collective task. To various activity patterns would correspond diverse consciousness experiences.

⁴⁸ After the brain's corpus callosum cut off, each hemisphere of the brain develops its proper experience of "private" consciousness, but only the left hemisphere can express its states of mind (Sperry, 1984).

induces a repositioning of each organization within the network relatively to the others, whatever the function considered. The organizations also show various forms of resilience overcoming some dysfunctioning through a coordinated and negotiated redefinition of their own prerogatives or even through collective activities based on the integration of numerous information sources (e.g. by being proactive for the conception and implementation of inter-sectoral or inter-agencies projects to address the dynamic of emergence of new risks regarding health and environment). At the regional or international level, this resilience is generally translated by the integration of new partners or the creation of institutions favouring various actors' commitment at different levels of governance (for instance the creation of a virtuous circle between international coordination and national public policies⁴⁹).

Practically we will pay attention to other theoretical inputs, relying particularly on two of them. Tononi's model (2004, 2008) is strongly grounded on the notion of a "complex", defined as a subset of elements (AC) that does not belong to a subset whose capacity Φ_{IIS} of information integration is higher. The accessible range of consciousness experiences is determined by static (anatomy, informational network a priori) and dynamic characteristics (functional states, patterns, processes, and activating parameters of network's components) of complexes (one AC can be part of one or more complexes, thus partial overlap are possible). Considering the very limited number of organizations used to develop our examples, we did not try to identify those complexes among the combinatorics of possible merging of organizations. Nevertheless, this step, for each informational network, does not present any difficulty. Other works also offer interesting perspectives; particularly the analogy with the theory stating that consciousness depends on the existence of a top-down synergy of AC activities via a global neuronal workplace (Dehaene and Naccache, 2000) remains to explore. Those authors start with the observation that the treatment of an enormous amount of information by the brain is possible without consciousness but that there is a prerequisite: the attention. Furthermore, consciousness itself is required for the realization of specific tasks like the sustainability of information, the realization of new operation combinations or the spontaneous generation of intentional behaviours. We will test the hypothesis that this role is assigned to international organizations.

3.5 DISCUSSION

Modelling the structuring and functioning of organizations and groups of organizations is an active field of research. Many ongoing works propose to reproduce and integrate in a coherent way the most salient properties of organizations in generic representations, kinds of meta-models adaptable to many contexts via their instantiation. For example, Diaconescu and Pitt (2015) rely on the ideas developed by A. Koestler in the 1960s (Koestler, 1969; see also Calabrese et al., 2010) on so-called "holonic" systems to account for the relative autonomy of organizations (internal structuring, roles, own resources, internal rules, choice of shared objectives) and for their successive interlocking in more integrative hierarchical structures of polycentric governance. They continue the study by Pitt et al. (2011), which explores via a logical formalization one of the principles exhumed by E. Ostrom and her colleagues (Ostrom, 1991; Andersson and Ostrom, 2008) concerning the conditions for the success of autonomous institutions of sustainable management of common goods. This "nested enterprises" principle is concerned with the efficiency of a system of systems ordering this management in layers and encapsulations of institutions starting from the local level. We note that at this level of abstraction,

⁴⁹ Substituting an analysis based on the notion of influence for analyses regarding effectiveness and compliance, Bernstein and Cashore (2012) propose an approach of the link between global governance (e.g. international environmental regimes) and public policies closer to the bases of our model.

the modelling of organizations involved in the governance of common natural resources exploits an analogy with the conception of self-managing systems in the domain of autonomic computing (Lalanda et al., 2013). Noriega et al. (2014) propose a modelling of socio-cognitive systems that can combine human and artificial agents interacting via a web-mediated social space. This approach emphasizes the interactions between participants' behavioural norms, their implementation and the overall performance of the system. This very limited overview is quite representative of a rapidly expanding field, many other works underway on this topic developing innovative approaches (see e. g. Ghose et al., 2014, Aldewereld et al., 2016).

The approach presented here focuses on assessing effective (e. g. through the composition of governing boards, the institutionalized partnerships) or potential governance (partial recoveries of roles, missions, or training offers) of themes offered by a group of organizations. No prior condition constrains the type of organizations (organization in the common sense, network or network of networks of organizations, technical platforms, multi-agency initiatives, etc.), their legal status (public, private, mixed, governmental or not, etc.), the fact of being localized or geographically distributed, or their institutional arrangements (networks, encapsulations, hierarchies, etc.). The model is based on the empirical data produced by the organizations themselves. This is an advantage because it reduces the projection of an *a priori* view of the structure and functioning of organizations onto a reality where collaborations, management and assessment, influences and powers intertwine more than they obey a hierarchy⁵⁰. But it also has its weakness since the analysis remains dependent on the information produced and updated by organizations, according to non-standardized templates. We overcome these limitations in part by analysing - when they exist - the joint productions of organizations, in particular with text mining and the analysis of the evolution of the terminology associated with a topic of interest⁵¹. Of course, the effective functioning of organizational networks depends on power relationship, strategic positioning or resources control, following changing configurations. Ideally, the assessment of concrete patterns of collaborations should be supplemented by sociological surveys in the field. However, in networks counting several tens or hundreds of organizations, this expectation seems out of reach. Nevertheless, the model presented here is also able to highlight the underlying informational networks and the collective capacities of actors on the basis of the analysis of surveys and interviews.

If the analogy between a possible organizational consciousness and artificial consciousness seems fruitful, it is not pursued without critical thinking. In fact our preliminary results can be used just as well as arguments going against the theory considering the complex process of information integration as artificial consciousness. The existence of that complex process is enough to develop our study without stating the hypothesis of a consciousness form, which is still lacking a consensual concept. At that stage, everything depends actually on a prerequisite acknowledging or not the possibility of an artificial consciousness.

Overall, our conviction is growing that the institutional sphere of governance is sufficiently complex and rapidly evolving to require the simultaneous use of several approaches⁵², each of which nourishes the analysis from a specific perspective and in mutually complementary ways.

⁵⁰ In addition, even though the neuronal network exists *a priori*, the consciousness experiences may modify its functioning and reciprocally: we observe the same for organizations.

⁵¹ E. g. for the analysis of "health and environment" terminology in international biodiversity conventions see Lajaunie and Mazzega, 2016b, 2017; Lajaunie et al., 2017.

⁵² See Mazzega and Lajaunie, 2017 for an approach of governance modeling relying on Galois lattices, and Mazzega et al., 2018 for the introduction of the notions of dimensionality and conjugacy in governance modeling using simplicial complexes.

3.6 CONCLUSION

The need for inter-sectoral public policies, mainly in environment (considered in a broad sense) is already showing collective awareness regarding challenges and the necessity to consider simultaneously and conciliate different point of view. The difficulties resulting from their conception and implementation are acknowledged and lead to examine both the co-operation process between actors and the cognitive basis of the collective action (Funtowicz and Ravetz, 1993; Head and Alford, 2015). Indeed, their conception ideally requires processing a massive integration of information (data, knowledge, institutional constraints, arbitration between divergent interests...). Their implementation requires collaboration between many organizations with various and complementary competences in order to reach common objectives (e.g. creation of a public good). In this respect, recalling Tononi's perspective (2004, 2008) as well as the perspective adopted in this study, the developed activities are expressing a form of an organizational consciousness emerging at the organization network's level. This is an interesting point of view: it leads to view the need for inter-sectoral policies as the product of an "augmented" consciousness. It also encourages scrutinizing it as the stimulus favouring the development of such an organizational consciousness, and to consider public policies as the expression of that consciousness. To come back to a conception in line with the one developed by M. Douglas (1986), those organizational systems are also stimulating individual awareness. It can happen regarding the importance of specific issues (e.g. ecological awareness) and, to a higher level of organization, the production of *artifacts* such as public policies, judicial norms, some events (e.g. Conference of the Parties to various conventions) or associations⁵³.

Inspired by Tononi's theory of consciousness (2004, 2008), we are building a model of functioning of a group of organizations, proceeding in two steps: using a description of a function ensured by each organization member, we set an informational network which vertices are organizations and links are weighted by mutual information functions. The weakest informational link between subsets of organizations expresses the capacity of the network to produce complex cognitive operations, the integration of information loads at the network level. We have thus analysed the three informational networks respectively induced by the mission, the governance and the training offers of a group of five organizations belonging to SEAMEO's network in Southeast Asia. We estimated a priori their capacity to accomplish in an integrative and collective way their mission, to act according to an integrated governance (e.g. strategic decision-making) or to propose training synthesizing their own knowledge.

On the basis of those results, we pursue the analogy between artificial consciousness and the possibility of a form of organizational consciousness—perceptible and that can be modelled. Indeed, it opens a research field: on the analysis of public policies as consciousness experiences, on the involvement of some organizations in the realization of specific collective tasks (which leads to the notion of network state or the notion of contingent activation of its members), on the nature of dysfunctioning of organizational networks and their resilience modes or even on the impact of the

⁵³ We can broaden that perspective. A rich literature, at the confluence of various academic areas, proposes criteria in order to define or characterize the complexity of judicial, socio-environmental or political systems [e.g. Bourcier et al., 2012; Squazzoni, 2014]. Nevertheless, our experience leads us to consider a subjective aspect of complexity: can be qualified as complex any system that cannot be comprehended by an individual understanding: "comprehension" and not "analysis" because if analysis can be broken down into different elements, comprehension targets more precisely information and knowledge integration processes which is not the result of a simple juxtaposition of preset results. In other words, the understanding of complex systems requires the creation of the conditions of an organizational consciousness (and the development of tools and methodologies coming for computer science and artificial intelligence can contribute to developing organizational consciousness).

formalization of a network or entrance of new members on the organizations' capacity to function as information integration systems.

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3.7 ANNEX

The corpus C_S associated with a network S composed of M organizations is built as the concatenation of the individual corpora C_m associated with each organization, symbolically:

$$C_S = \cup_{m=1}^M C_m \quad (1)$$

The *posterior*⁵⁴ probability of occurrence of the term t_n^j associated with organization X_j in the corpus C_m is given by

$$P[t_n^j(C_m)] = F_{oc}[t_n^j(C_m)] / F_{oc}[t_n^j(C_S)] \quad (2)$$

where $F_{oc}[x]$ is the number of occurrences of event x . The *posterior* probability of joint occurrence of two terms, t_n^j of X_j and $t_{n'}^l$ of X_l , in the corpus C_m is:

$$P[t_n^j(C_m), t_{n'}^l(C_m)] = F_{oc}[t_n^j(C_m) \wedge t_{n'}^l(C_m)] / F_{oc}[t_n^j(C_S) \wedge t_{n'}^l(C_S)] \quad (3)$$

The average mutual information between organizations X_j and X_l in the network S is estimated as:

$$I_{AMI}[X_j, X_l]_{C_S} = (N_j \times N_l)^{-1} \sum_{m=1}^{M+} \sum_{n=1}^{N_j} \sum_{n'=1}^{N_l} e_{nn'}^{jl}(m) \quad (4)$$

N_j (resp. N_l) being the number of terms in X_j (resp. X_l). If we consider an additional corpus C^+ then $M += M + 1$ (otherwise $M += M$). The elementary information $e_{nn'}^{jl}(m)$ between terms t_n^j and $t_{n'}^l$ on corpus C_m is given by:

$$e_{nn'}^{jl}(m) = P[t_n^j(C_m), t_{n'}^l(C_m)] \ln \left\{ \frac{P[t_n^j(C_m), t_{n'}^l(C_m)]}{P[t_n^j(C_m)]P[t_{n'}^l(C_m)]} \right\} \quad (5)$$

The elementary information $e_{nn'}^{jl}(m)$ is not zero (and therefore $I_{AMI}[X_j, X_l]_{C_S} \neq 0$) if term t_n^j of X_j and term $t_{n'}^l$ of X_l are both occurring in the same corpus C_m (whatever the value of m). The auto information $I_{AMI}[X_j, X_j]_{C_S}$ is not zero (self-loop on the graph) if at least one key term of X_j appears at least in one other corpus C_l , with $l \neq j$. The average mutual information between components S_κ and S_π of the S network bipartition is

$$I_{AMI}[S_\kappa, S_\pi]_{C_S} = N_{\kappa\pi}^{-1} \sum_{m=1}^{M+} \sum_{n=1}^{N_\kappa} \sum_{n'=1}^{N_\pi} e_{nn'}^{\kappa\pi}(m) \quad (6)$$

the elementary information $e_{nn'}^{\kappa\pi}(m)$ being given by an equation similar to (5) except that term t_n^κ (resp. $t_{n'}^\pi$) is taken in the list (composed of $N_{\kappa\pi}$ term pairs $[t_n^\kappa, t_{n'}^\pi]$) of formed by all key terms of organizations belonging to the bipartition component S_κ (resp. S_π), no term appearing twice in the list.

⁵⁴ We could *a priori* postulate a uniform distribution of occurrence of a given term between the various corpora. The posterior probability is here based on the analysis of the empirical texts.

The capacity $\Phi_{IIS}[S]$ of network S to function as an Information Integrative System (IIS) is the amount of effective information that can be integrated across the informational weakest link of a subset of organizations. Limiting the search for this weakest link between bipartition components S_κ and S_π , we have:

$$\Phi_{IIS}[S] = \min_{[S_\kappa, S_\pi] \in \Pi_2(S)} \{I_{AMI}[S_\kappa, S_\pi]_{C_S}\} \quad (7)$$

$\Pi_2(S)$ being the set of all bipartitions of S .

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