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Fifty years of research

FIFTY YEARS OF RESEARCH

by Andrée C. EHRESMANN

RESUME. Liste de mes publications dont les premières datent juste de 50 ans, suivie d'un diagramme indiquant comment les principales idées se relient, ce qui permet de dégager des lignes essentielles partant de mes premiers travaux et s'entremêlant au cours des ans.

To mark the fiftieth anniversary of my first research papers, I have established a list of my publications. A brief look at it shows that I have worked on very different domains, from my first studies on functional analysis and differential equations, to pure category theory, and then applications to model biological and cognitive systems. However all these domains have been approached from the angle of category theory that gives an underlying coherence and continuity to my research during this half century. The large diagram given at the end of this paper stresses the connections between the various notions I have dealt with, and locates three main threads running through my work. It is not the place here to go further into this matter. It will be dealt with on the site

http://perso.orange.fr/vbm-ehr/ACE/ehr.htm

which already contains various information and a brief summary of my work; it will soon be expanded with reprints and/or refunding using modern tools of former out of print papers.

1. The list of my publications

In the following table, two different increasing chronological numberings are used, the first one for research publications, the other one for lecture notes and editorial works The older publications (up to the seven-

ties) appeared under my maiden name Bastiani. When available, I have given an electronic address, except for the several papers published in the "Cahiers"; these papers can all be freely downloaded from the NUMDAM site

http://www.numdam.org/numdam-bin/feuilleter?j=CTGDC

	Books
72	*Memory Evolutive Systems: Hierarchy, Emergence, Cognition,* (with J.-P. Vanbremeersch), Studies in Multidisciplinarity Vol. 4, Elsevier, 2007 (389 pages).
18	*Théorie des Ensembles*, Centre de Documentation Universitaire SEDES, Paris, 1970 (350 pages).
	Research papers
71	How Charles Ehresmann's vision of Geometry developed with time, in *Geometry and Topology of manifolds*, Banach Center Publications Vol. 76, Varsovie, 2007, 29-34.
70	Sur Paulette Liberman (1919-2007), *Cahiers Top. et Geom. Dif. Cat.* XLVIII-4 (2007), 270-274.
69	The memory evolutive systems as a model of Rosen's organisms (with J.-P. Vanbremeersch), *Axiomathes* 16 (2006), Springer, 165-214. Online: www. springerlink.com/index/Y538783R8N35KM26.pdf
68	A mathematician's itinerary, Abstract, *Cahiers Top. et Geom. Dif. Cat.* XLVI-3 (2005), 170-171.
67	*A mathematician's itinerary*, in "Charles Ehresmann : 100 ans". Online presentation in http://perso.wanadoo.fr/vbm-ehr/ChEh/
66	Emergence, Cognition, Consciousness (with J.-P. Vanbremeersch), *Cahiers Top. et Geom. Diff. Cat.* XLVI-3 (2005), 221-222.
65	Hyperstructures and Memory Evolutive Systems (with N. Baas et

	J.-P. Vanbremeersch), *Intern. J. Gen. Sys.* 33 (5) (2004). 553-568. Online: www. ingentaconnect.com/content/tandf/ggen/2004/ 00000033/00000005/art00006
64	A categorical model for cognitive systems up to consciousness (with J.-P. Vanbremeersch), in *Proc. Intern. Conference on theoretical Neurobiology* (Ed. N.C. Singh), NBRC New Delhi, 2003, 50-61.
63	Knowledge in Memory Evolutive Systems (with J.-P. Vanbremeersch), *Theoria et Historia Scientiarum* VI-2 (2002), 15-37.
62	Emergence Processes up to Consciousness Using the Multiplicity Principle and Quantum Physics (with J.-P. Vanbremeersch), ALP. *Conference Proceedings* (CASYS, 2001, ed. D. Dubois) 627 (2002), 221-233.
61	Localization of universal problems; local colimits, *Applied Categorical Structures* 10 (2002), 157-172.
60	How to model consciousness in a Memory Evolutive System? (with J.-P. Vanbremeersch), 1999, Online *http://perso.orange.fr/vbm-ehr/*
59	Colimits in free categories, *Diagrammes* 37 (1997), Paris, 1-12.
58	Information processing and symmetry-breaking in MES (with J.-P. Vanbremeersch), *Biosystems* 43 (1997), 25-40. Online: linkinghub.elsevier.com/retrieve/pii/S0303264797016900
57	Multiplicity Principle and emergence in MES (with J.-P. Vanbremeersch), *SAMS* **26** (1996), 81-117.
56	Are interactions between different time-scales a characteristic of complexity? (with J. Chandler and J.-P. Vanbremeersch) in *Actes du Symposium ECHO,* Amiens 1996, 162-167.
55	Contrasting two representations of emergence of cellular dynamics (with J. Chandler and J.-P. Vanbremeersch), in *Proc. Symposium on Emergence, Inter'Symp'95 Baden-Baden* (Ed. G. Farre), International Institute for advanced studies in Systems Research and Cybernetics, University of Windsor, 1996.
54	Emergent properties for complex systems (with J.-P. Vanbremeersch), in *Advances in Synergetics* (Ed. E. Laskeri & G. Farre), International Institute for advanced studies in Systems Research

	and Cybernetics, Univ. Windsor, 1994, 73-78.
53	*Emergence et Téléologie,* Rapport 94-1, Publications Univ. Picardie, Amiens 1994 (1er prix concours AFCET "Systémique et Cognition").
52	Emergence and causality in evolutionary systems, in *Advances in Synergetics* (Ed. E. Lasker & G. Farre); International Institute for advanced studies in Systems Research and Cybernetics, Univ. Windsor 1994, 22-26.
51	Rôle des contraintes structurales temporelles dans les systèmes complexes (with J.-P. Vanbremeersch), in *AFCET 93,* Vol. 8 "Systémique et Cognition" 1993, 103-112.
50	Memory Evolutive Systems: An application to an aging theory (with J.-P. Vanbremeersch), in *Cybernetics and Systems,* Tata McGraw Hill Pub., New Delhi, 1993, 190-192.
49	Outils mathématiques utilisés pour modéliser les systèmes complexes MES (with J.-P. Vanbremeersch), *Cahiers Top. et Géom. Diff. Cat.* XXXIII-3 (1992), 225-236.
48	Semantics and Communication. for Memory Evolutive Systems (with J.-P. Vanbremeersch, in *Proc. 6th Intern. Conf. on Systems Research* (Ed. Lasker), International Institute for advanced studies in Systems Research and Cybernetics, University of Windsor, 1992.
47	How do heterogeneous levels with hierarchical modulation interact on a system's learning process? (with J.-P. Vanbremeersch), in *Advances in Human Systems and Information Technologies* (Ed. E. Lasker, T. Koizumi & J. Pohl); International Institute for advanced studies in Systems Research and Cybernetics, Univ. Windsor, 1992, 181-186.
46	Un modèle pour des systèmes évolutifs avec mémoire, basé sur la théorie des catégories (with J.-P. Vanbremeersch), *Revue Intern. de Systémique* 5-1 (1991), 5-25.
45	Hierarchical Evolutive Systems (with J.-P. Vanbremeersch), *Proc. 8th International Conference of Cybernetics and Systems,* Vol. 1 (Ed. Manikopoulos), New York, The NIJT Press, Newark 1990, 320-327.
44	Modèle d'interaction dynamique entre un système complexe et des

	agents (with J.-P. Vanbremeersch), *Revue Intern. de Systémique* 3-3 (1989), 315-341.
43	A model for a neural system based on category theory (with J.-P. Vanbremeersch), in *Advances in Support Systems Research* (Ed. E. Lasker & R.R. Hough), The International Institute for advanced studies in Systems Research and Cybernetics, Univ. Windsor, 1990, 316-320.
42	A learning model for complex systems based on category theory (with J.-P. Vanbremeersch), in *Advances in Systems Research and Cybernetics* (Ed. E. Lasker); The International Institute for advanced studies in Systems Research and Cybernetics, University of Windsor, 1988, 546-558.
41	Hierarchical Evolutive Systems: a mathematical model for complex systems (with J.-P. Vanbremeersch), *Bull. Math. Biol.* 49 (1987), 13-50..
40	Un modèle mathématique pour les systèmes vivants, basé sur la Théorie des Catégories, *Compte-Rendus Acad. Sc. Paris*, Section III, 302 (1986), 475-478.
39	Approche catégorique de la complexification et du choix pour les systèmes vivants (with J.-P. Vanbremeersch), *Sém. de Philosophie et Math.*, Ecole Normale Sup. Paris, 1986.
38	From fibre bundles to categories, *Cahiers Top. et Geom. Diff.* XXV-1 (1984), 15-36.
37	Comments on Part IV-2 and Synopsis, in *Charles Ehresmann: Œuvres complètes et commentées*, Part IV, 1982, 775-815.
36	Sur le plongement d'un prototype dans un type (with C.,Ehresmann, polycopié Univ. Paris VII, 1972), in *Charles Ehresmann, Oeuvres Complètes et Commentées*, Part IV-1, Amiens 1982, 293-306.
35	Comments on Part II-2 and Synopsis, in *Charles Ehresmann: Œuvres complètes et commentées*, Part II, 1982, 705-769..
34	Catégories localement triviales, catégories microtransitives, *Cahiers Top. et Geom. Dif.* XXIII-4 (1982), 379-388,
33	Comments on Part II-1 and Synopsis, in *Charles Ehresmann: Œuvres complètes et commentées*, Part II, 1982, 333-425.
32	Comments on Part IV-1 and Synopsis, in *Charles Ehresmann:*

	Œuvres complètes et commentées, Part IV, 1981, 323-397.
31	Comments on Part III-2 and Synopsis, in *Charles Ehresmann: Œuvres complètes et commentées*, Part III, 1981, 767-861.
30	Partial completions of concrete functors, *Cahiers Top. et Geom. Diff.* XXII-3 (1981), 315-328.
29	Etude des catégories dans une catégorie (with C. Ehresmann, Poly-copié Univ. Paris VII, 1973); in *Charles Ehresmann; Oeuvres Complètes et Commentées*, III-2, Amiens 1981, 707-757.
28	Comments on Part III-1 and Synopsis, in *Charles Ehresmann: Œuvres complètes et commentées*, Part III, 1980, 33?-421.
27	Charles Ehresmann (Conf. Coll. Arnsberg 1979), *Seminarberichte Fernuniv, Hagen* 6 (1980).
26	Liste des publications de Charles Ehresmann, *Cahiers Top. et Geom. Diff.* XX-3 (1979), 221-229.
25	Multiple functors, IV (with C. Ehresmann), *Cahiers Top. et Geom. Diff.* XX-1 (1979), 3-49.
24	Multiple functors, III (with C, Ehresmann), *Cahiers Top. et Geom. Diff.* XIX-4 (1978), 387-444,
23	Multiple functors, II (with C. Ehresmann), *Cahiers Top. et Geom. Diff.* XIX-3 (1978), 295-334
22	Tensor products of topological ringoids (with C. Ehresmann), *Cahiers Top. et Geom. Diff.* XIX-1 (1978), 78-112.
21	Multiple functors, I (with C, Ehresmann), *Cahiers Top. et Geom. Diff.* XV-3 (1974), 215-292
20	Sketched structures and completions, *Cahiers Top. et Geom. Diff.* XIV-2 (1973), 158,
19	Categories of sketched structures (with C. Ehresmann), *Cahiers Top. et Geom. Diff.* XIII-2 (1972), 105-214.
17	Catégories de foncteurs structurés (with C. Ehresmann), *Cahiers Top. et Geom. Diff.* XI-3 (1969), 329-384.
16	Systèmes guidables et problèmes et problèmes d'optimisation. Compléments et errata, *Pub. Labo.. Automatique Théor.* Univ. Caen (1966), 13 p.
15	Sur le problème général d'optimisation, in *Actes Congrès d'Auto-matique Théorique*, Dunod, Paris (1965), 125-136.
14	Systèmes guidables et problèmes d'optimisation IV, *Pub. Labo..*

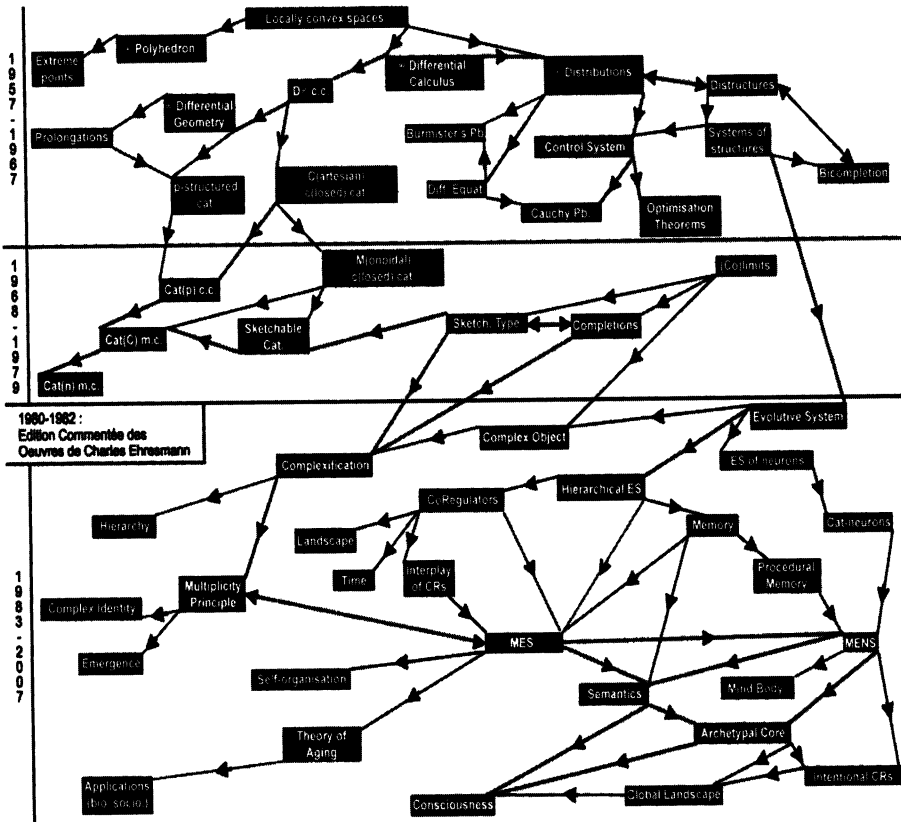|	
	Automatique Théor. Univ. Caen (1965), 62 p.
13	Systèmes guidables et problèmes d'optimisation III, *Pub. Labo.. Automatique Théor.* Univ. Caen (1965), 30 p.
12	Systèmes guidables et problèmes d'optimisation II, *Pub. Labo.. Automatique Théor.* Univ. Caen (1964), 47 p.
11	Applications différentiables et variétés différentiables de dimension infinie, *J. Analyse Math.* Jérusalem XIII (1964), 1-114. On-line: http://www.springerlink.com/content/120600/?k=bastiani
10	Sur les distributions vectorielles, *Pub. Labo.. Automatique Théor.* Univ. Caen (1964), 32 pages.
9	Systèmes guidables et problèmes d'optimisation I, *Pub. Labo.. Automatique Théor.* Univ. Caen (1963), 31 p.
8	The explicit solution of the equations of the elastic deformations for a stratified road under given stresses in the dynamic case, in *Proc.Intern. Conf, on Structural design of Asphalt pavements,* University of Michigan, 1962, 394-402. Online : www.asphalt.org/Pubs/1stconf.html
7	*Différentiabilité dans les espaces localement convexes - Distructures,* Thèse d'Etat, Univ, Paris (1962).
6	Méthode pratique de résolution du problème de Cauchy mixte, *Compte-Rendus Acad. Sc. Paris* 250 (1960), 260,
5	Cônes convexes et pyramides convexes, *Ann. Inst. Fourier,* Grenoble IX (1959), 249-292. Online: www.numdam.org/numdam-bin/fitem?id=AIF_1959__9__249_
4	Sur les appuis d'une. pyramide convexe et sur les polyèdres convexes sans sommet (with C, Ehresmann), *Compte-Rendus Acad. Sc. Paris* 249 (1959), 2895-2898.
3	Pyramides topologiques, Applications à l'Analyse, *Compte-Rendus Acad. Sc. Paris* 249 (1959), 175-178.
2	Polyèdres convexes de dimension infinie, *Compte-Rendus Acad. Sc. Paris* 247 (1958), 1943-1946.
1	Polyèdres convexes dans les espaces vectoriels topologiques, *Cahiers Top. et Geom. Diff.* I (1957-58), 47 pages. (Thèse 3ème cycle, Paris 1959).

	Lecture Notes
5'	*Topologie Algébrique*, Cours 3° cycle (with C. Ehresmann), Polycopié Amiens 1975, 166 pages.
3'	*Topologie et Calcul Différentiel*, Cours polycopié, Amiens 1972, 214 pages.
2'	*Algèbre MP1 et MP2*, Cours polycopié, Amiens 1970-72, 353 pages.
1'	*Algèbre et Topologie*, Cours Licence, Polycopié Amiens 1968-69, 360 pages.
	Editorial work
14'	Fiftieth anniversary of the "Cahiers" and Index of the "Cahiers" I to XLVIII, *Cahiers Top. et Geom. Dif. Cat.* XLVIII-4 (2007), 275-316.
13'	Introduction and Edition of the Abstracts of the International Conference "Charles Ehresmann : 100 ans" (Amiens 2005), *Cahiers Top. et Géom. Dif. Cat.* XLVI-3 (2005). And (with J.-P. Vanbremeersch) posting of developed lectures on the site: http://perso.wanadoo.fr/vbm-ehr/ChEh
9'	Edition (with G. Farre and J.-P. Vanbremeersch) of the Proceedings of "*Symposium ECHO*", Amiens (August 1996).
8'	Edition, publication and biographical notices of the 7 volumes de "*Charles Ehresmann; Oeuvres Complètes et Commentées*", Amiens, 1980-82.
7'	Introduction and Edition of the Abstracts of the "*3ème Colloque sur l'Algèbre des Catégories, dédié à Charles Ehresmann*", Amiens 1980, CTGD XXI-4 (1980), 347-352; and of the Proceedings of this Conference in *Cahiers Top. et Géom. Diff.* XXI-4, (1980), XXII (1981) and XXIII-1 (1982).
6'	Introduction and Edition (with C. Ehresmann) of the Abstracts of the "*2ème Colloque sur l'Algèbre des Catégories*" (Amiens 1975 and Chantilly 1975), *Cahiers Top. et Géom. Diff.* XVI-3 (1975).

4'	Introduction and Edition (with C. Ehresmann) of the Abstracts of the "*Colloque sur l'Algèbre des Catégories*", Amiens 1973, *Cahiers Top. et Géom. Diff.* XIV-2 (1973); and of its Proceedings in *Cahiers Top. et Géom. Diff.* XIV-4 (1973), XV-2 et XV-4 (1974).
	Internet sites (with Jean-Paul Vanbremeersch)
10'	Création in 1999 of a site on our joint research work on Memory Evolutive Systems : http://perso.orange.fr/vbm-ehr/ Il contains a list of our papers on the subject, several of these papers, and a sketch of our recent book: *Memory Evolutive Systems: Hierarchy, Emergence, Cognition* (2007). The 3 following sites are sub-sites of it.
11'	The site http://perso.orange.fr/vbm-ehr/CT is devoted to the journal *Cahiers de Topologie et Géométrie Différentielle Catégoriques.*
12'	The site http://perso.orange.fr/vbm-ehr/ChEh/ contains the Proceedings of the international Conference « *Charles Ehresmann : 100 ans* » (Amiens, 2005); as well as information (and photos) on Charles Ehresmann.
13'	The site http://perso.orange.fr/vbm-ehr/ACE/ehr.htm (in development) contains the list of the publications of Andrée Ehresmann and a brief summary of her research works.

2. Diagram of my research interests

The following diagram mentions the main notions I have introduced and/or extensively used, with their connections. It reproduces a

much clearer color diagram which can be found on the Internet site cited above. Here the important links appear in grey (they are in red on the original figure).

The notions appearing in the first part (from 1957 to 1967) can be classified as analysis (even if categorical notions are introduced in their treatment), those in the second part (from 1968 to 1979) as 'pure' category theory, and the third part concerns applications of the preceding parts to a categorical model for biological and cognitive systems.

This diagram makes explicit three interrelated main threads, all deriving from the initial problem that is raised in my thesis: to unify the various notions of 'generalized functions' and adapt them to the infinite dimensional case, the basic idea under the categorical notion of 'distructure' thus obtained being to extend the differential operators to continuous functions.

1. Infinite dimensional differential calculus and differential geometry, later leading to the study of internal categories and cartesian closed structures.

2. Enrichment and (pre)sheafification of partial category actions (systems of structures in the later terminology of C. Ehresmann), leading to the theory of distructures generalizing Schwartz distributions; their application to model and solve control problems (Control Systems) and, later, to model living systems (Memory Evolutive Systems, with J.-P. Vanbremeersch).

3. Completion problems: bicompletion for distructures, theory associated to a sketch, cartesian and monoidal closed structures on sketchable categories (in particular on the category of multiple categories), complexification process to model the development of Memory Evolutive Systems and the formation of higher cognitive processes up to consciousness for cognitive systems.

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