Do the images of neuronal pathways in the human central nervous system show or not feed-back ? A comparative study in 15 countries.

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Résumé

Dans le cerveau humain, tous les trajets nerveux forment des réseaux (supports des apprentissages) et fonctionnent avec de multiples régulations. Cependant, l'analyse des images de trajets nerveux dans les manuels scolaires de 15 pays montre que moins du quart d'entre elles illustrent des régulations. Près de la moitié de ces régulations concernent le contrôle neuro-hormonal des fonctions reproductrices, certaines le rythme cardiaque ou la respiration. Très peu de pays enseignent la double innervation (gamma et alpha) de tout muscle, et moins encore illustrent des réseaux de neurones dans le cerveau. La majorité de ces enseignements reste fortement influencée par le behaviorisme.

Abstract

In the human brain, the neuronal pathways are networks (which support learning) and work with permanent regulations (feedbacks). However, less than ¼ of illustrations in the analysed school textbooks of 15 countries is showing such regulations. Half of them are concerning the neuro-hormonal control of the reproduction; some are related to the control of the heart rhythm or breathing. Only in some countries the double innervations (gamma and alpha) of striated muscle is taught, and only a few countries are illustrating the neuronal networks in the brain. Most of these teachings are strongly under the influence of behaviourism.

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Synopsis

Introduction: theoretical background and question of research.

The scientific content of Neurosciences is evolving very fast, especially during these last 20 years with the emergence of cognitive sciences and of the cerebral imagery. The concepts of cerebral plasticity and epigenesis are now central in the research field (Changeux 1983, 2002, Edelman 2000), as well as the connexionnism and the concepts of emergence, enaction and umwelt (Varela 1989, Stengers 1997, Stewart et al 1997, Buisseret 1999). We know that our leaning and of our memory are configured in our neuronal networks (Changeux & Ricoeur 1998). We know also that any process in our central nervous system is controlled by several regulations, with neuronal feed-back.

In France, a recent president of the National Committee of Programmes for the Life and Earth Sciences, was claiming that *"the cybernetic approach can be an extraordinary pedagogical tool, offering us a language and a formalism very easy to use"* (Calvino, in an interview by the SNES[1]), and proposed to introduce in the syllabuses the concepts of homeostasis and of servomechanims.

In 1984, Carpenter developed in his book on Neurophysiology a simple formalism of cybernetics, particularly to illustrate the control of any movement by the double innervations (gamma and alpha) of every striated muscle. He insisted on the importance of this control, indicating that, for instance, the solear muscle of the cat is innervated by 150 motoneurones **α** and 100 motoneurones **γ** (from Matthews 1972).

How are these perspectives introduced in the biology syllabuses?

A first survey has been done recently by Clément, Mouelhi & Abrougui (2006) to analyse the French and Tunisian syllabuses and textbooks, showing a strong influence of behaviourism and hereditarism, nevertheless with a recent evolution in France (introduction of the concepts of cerebral plasticity).

We enlarge here this survey to 15 countries, with the analysis of the current syllabuses and textbooks.

We use some concepts of Didactics of Biology. The didactical transposition, defined by Chevallard (1985) in didactics of Mathematics, has been yet adapted to Biology Education (Clément 1998, 2004, 2006). The main change is to enlarge the scientific knowledge at each level of the transposition, considering interactions KVP between scientific knowledge (K), values (V) and social practices (P).

For instance, the reduction of neuronal pathway to linear transmission, without any regulation from stimuli to responses, illustrates the influence of behaviourism (Clément et al 2006) as well as the reductionnist ideology (Canguilhem 1982). The reduction to reflexes is probably also a sign of the influence of hereditarism. And the separation between brain and body, the former controlling the latter, could be a new way to express the Cartesian dualism with the separation soul / body.

Material and methods

Table 1 - Part of the grid used to analyse the chapters dealing with Human Brain

C-2. Grid - Analysis of the images with (neuronal) pathway for Human Brain

See the annex for more information on the definition of the ten categories used below.
CNS = Central Nervous System, including spinal cord and / or brain. One image by box : just indicate the page number (e.g. p.23). In the column at right, indicate the total number of images of each category.

Image on pages						Total
Categ 1 : only Stimulus → CNS (Central Nervous System)						
Categ. 2 : only CNS → Response						
Categ. 3 : Stimulus → Spinal Cord → Response						
Categ 4 : Stimulus → Brain → Response						
Categ. 5 : Several stimuli, and / or several Responses						
Categ. 6 : with feedback(s) Brain → Response → Brain						
Categ. 7 : muscle double innervation gamma + alpha						
Categ.8 : other voluntary movements or sensori-motor coordination with feedbacks						
Categ. 9 : Neuro-hormonal regulation						
Categ.10 : other examples of regulation						

[1] SNES = Syndicat National de l'Enseignement Secondaire

We have analysed 55 school textbooks currently used in 15 countries. Table 2 lists the countries, and the number of textbook analysed in each country. The analysis of these chapters have been done by the team of each country (see Acknowledgements and the list of co-authors of the present work). We have used the same grid, elaborated collectively within the Biohead-Citizen project, under the responsibility of P.Clément. We analyse here the answers of the question reproduced in the table 1 (above).

Results and discussion

Most of the books were Biology textbooks, but some were dealing with Psychology at the end of secondary school (Portugal), or more generally with Science in the Primary School.

Most of the chapters related to Human Brain are developed at the end of the secondary School, the last year and/ or the year before, depending of the country. The situation is very diverse for the precedent years, with or without teaching the human brain. In most of the countries, this topic is totally absent in the Primary School. Due to this diversity, the Table 2 (next page) has grouped in the same column the results obtained from the two last scholar years together, and in an other column all the other school levels.

Results are summarised in the Table 2 and Figure 1 (next page). In Estonia, there is no image whatsoever with a neuronal pathway, and there is only one in Lithuania. In the other countries, there are important variations but, in all the cases, the linear pathways with no feed-back at all are the majority of images (81%), showing a strong influence of the behaviourism. The example of the reflex is always present, with a pedagogical goal but with also carrying hereditarist and behaviourist implicit messages when the only explained movements are innate or conditioned reflexes. The nervous control of any movement by the innervation gamma is illustrated by one image only in Lebanon, as well as in Tunisia and in Romania.

Two third of the images with feed-back are related to the neuro-hormonal control of reproduction (figure 1). Some of them are related to the sensori-motor control of the movements or of the heart rhythm or breathing. Very few countries are illustrating the neuronal networks in the brain (e.g. an image in a Senegal textbook published in 2005); the other feedbacks inside the brain (figure 1) are just joining different cerebral areas.

In conclusion, most of these teachings are still under the influence of behaviourism, and only some countries started to introduce images related to the constructivist or the cognitivist approach.

These results will be presented and discussed with more details during the communication.

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Table 2 - Occurrences of images showing neuronal pathways, only linear ("linear") or with feedbacks ("feedback") in the analysed textbooks, for each country.

Participant Country	**Number of textbooks**	before 16 years		17-19 years		**TOTAL**	
		linear	feedback	linear	feedback	**linear**	**feedback**
P1 - Portugal	**3**	7	3	3	0	**10**	**3**
P2 - France	**16**	23	0	72	19	**95**	**19**
P3 - Germany	**3**	5	2	4	1	**9**	**3**
P5 - Italy	**8**	11	0	1	0	**12**	**0**
P6 - Cyprus	**1**	15	0	-	-	**15**	**0**
P7 - Estonia	**2**	0	0	0	0	**0**	**0**
P8 - Lebanon	**4**	26	2	10	6	**36**	**8**
P9 - Tunisia	**4**	5	0	17	5	**22**	**5**
P10 - Finland	**2**	5	1	4	2	**9**	**3**
P12 - Hungary	**4**	0	0	7	3	**7**	**3**
P13 - Lithuania	**1**	1	0	-	-	**1**	**0**
P14 - Malta	**2**	7	2	-	-	**7**	**2**
P16 - Romania	**1**	-	-	32	10	**32**	**10**
P18 - Morocco	**2**	9	0	2	5	**11**	**5**
P20 - Senegal	**2**	5	0	6	4	**9**	**4**
TOTAL	**55**	119 (92 %)	10 (08 %)	158 (74 %)	55 (26 %)	**277 (81 %)**	**65 (19 %)**

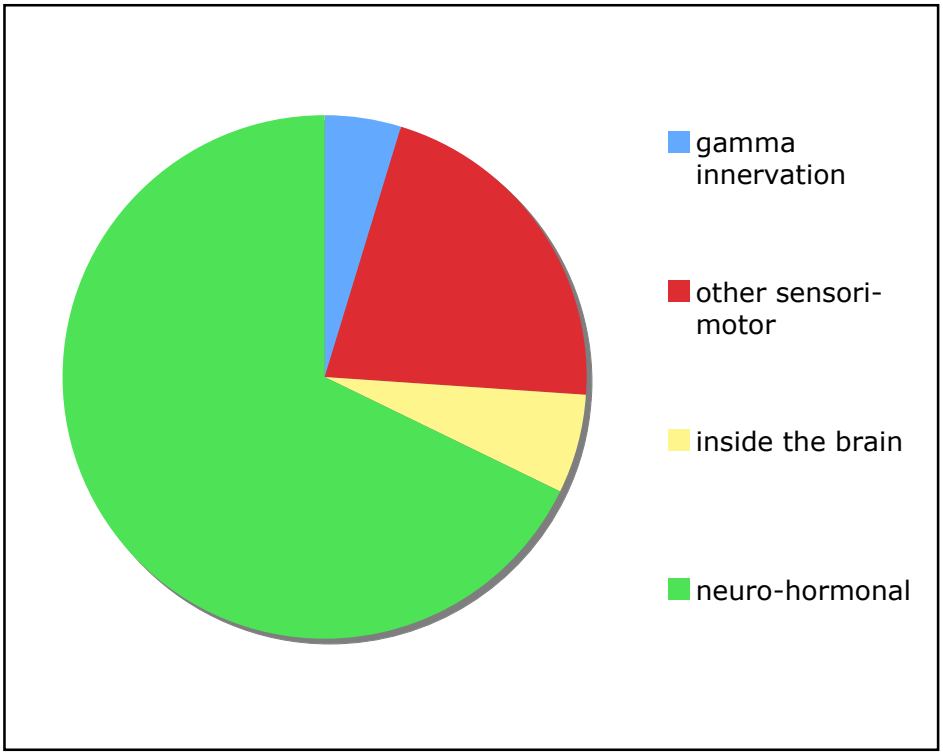

Figure 1 - Repartition by topics of the 65 images presenting feedback, in all analysed textbooks (see also right column of Table 1 for their occurrence by country).