

## Briefing 46

## Neuroscience in Education



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### Summary

- Neuroscience emerged concurrently with the rise of brain imaging in the 1970s and its aim is to better understand how the brain works; its development has been the source of great hopes.
- However, it has struggled to prove its worth in the field of education. Far from bringing clarity to teaching methods or helping teachers, systematic reference to brain mechanisms instead creates the risk of bypassing critical thinking and legitimising a certain social Darwinism.
- The recent popularity of neuroscience risks creating a discontinuity in educational policies. Actually, neuroscience cannot simply sweep away all the existing scientific heritage and establish a new "science of teaching" on its own.

Arnaud Saint-Martin, Member of the National Assembly

Florence Lassarade, Senator

### ■ From Neuronal Man to neuronal child?<sup>1</sup>

The debate about man's dual nature as both body and soul is a very old one. Very early on the question arose as to whether it would be possible to define the terms in a completely scientific manner. Shortly before the start of our era, the poet Lucretius described the destiny of souls without any experimental data to rely upon, and developed his atomic theory without the necessary means of observation either.<sup>2</sup>

With their encyclopaedists' vision of knowledge, Enlightenment thinkers also avoided making too rigid a distinction between the humanities and life sciences - in spite of their attraction to experimental approaches - and often distinguished themselves in both fields, as was the case of La Mettrie (1709-1751), the theoretician of man as a machine.

The obstacles prevailing to this day in such regard<sup>3</sup> are nevertheless not insurmountable, as molecular neurobiology specialist Jean-Pierre Changeux showed with the publication of his 1983 essay, *L'Homme neuronal*, (Neuronal Man) written for a general audience but with a philosophical bent.<sup>4</sup> The work attracted both praise and criticism. While the *Journal de Genève* found that the reductionism of the explanatory model used in the work "gives readers a cut-rate illusion of profound insight into the world",<sup>5</sup> a festschrift published in 2016 asserted that "*L'Homme neuronal is still unsurpassed as a scientific panorama of our times.*"<sup>6</sup>

Logically, the first stage in the construction of a person would be the "neuronal child." It would doubtless be possible to use this term to refer to all the tests performed to explain a child's psychic and intellectual functioning by

means of an analysis of the physicochemical mechanisms at work in their brain.

Nevertheless, this briefing has no pretension of settling the debate on the epistemological assumptions underlying the basis of what we now refer to as neuroscience. Its aim is simply to evaluate **the extent to which neuroscience might be used to contribute to the success of learning in children and adolescents.**

### ■ Neuroscience in the disciplinary landscape

Neuroscience is not the only discipline used to understand learning processes. But where should it be situated within the disciplinary landscape, relative to **the line of demarcation that is traditionally drawn between the life sciences and the humanities and social sciences?** And in what light does the construction of such a delimitation emerge from this examination?

#### ➤ What does neuroscience do?

"The term neuroscience has come into accepted use over the last decade to refer to various disciplines, united in their pursuit of a shared objective: an understanding of the nervous system, the way it operates, and the phenomena arising from its operation," explained the *Courrier du CNRS* in 1984.<sup>7</sup> Upon reading this very comprehensive definition, and in light of the various current understandings of the term, one might posit that the use of the term has remained quite fluctuating to this day,<sup>8</sup> though the emphasis now falls more clearly on a distinctive anchoring of neuroscience in medicine and biology.

In this regard, the use of functional magnetic resonance imaging (MRI) is frequently cited as one of the usual experimental protocols in neuroscience. Advances in

brain imaging have made it possible to observe which areas of the brain are more specifically activated in a given patient when they have to **read a word** or **recognise an image**, which suggests the possibility of linking a specific brain activity to certain knowledge acquisition behaviours.<sup>9</sup> To interpret this neurobiological data, neuroscientists use both analogies and explanatory metaphors: **the brain wave triggered by the recognition of a familiar word** would seem to follow a neuronal movement comparable to that of a tidal bore, a natural phenomenon of a sudden water rise occurring in some estuaries, such as in the Gironde during high tides in the Bay of Biscay.<sup>10</sup>

#### ➤ *A possible parallel with linguistics*

Linguistics is another field that is referred to in seeking to shed light on knowledge acquisition processes such as learning to read, and had its moment in the limelight in the 1960s, at a time when structuralism was the order of the day. At the time, it was very common to locate this discipline at the intersection of life sciences and the humanities. In some respects, it is indeed a "hard" science: acoustic phonetics classifies and analyses sounds on the basis of spectrograms, while articulatory phonetics is based on the anatomical study of the production of sounds by the phonatory apparatus; it is also an essential discipline for refining the diagnoses of language disorders such as aphasia.

Even in other sub-fields such as grammar or semantics, with the support of theorists such as Noam Chomsky, linguistics aspired to become an exact science like mathematics, by seeking out innate structures of language competence. The underlying premise of this generative linguistics was that by pushing structural analysis far enough, it should be possible, by means of progressive abstraction, to identify an ultimate phonetic code and morphosyntactic code for each language, which could in turn achieve the precision of a computer language once sufficiently formalised, thus preparing the ground for nothing less than... a universal grammar.

This movement was reflected at an institutional level. Linguistics departments, which have now been reintegrated into the faculties of letters, were attached to schools of medicine for a time.<sup>11</sup> Such restructuring, moreover, not only varies from time to time, but also from country to country: the dominant configuration of the academic field in the United States may not necessarily prevail in France or elsewhere in Europe.

Ultimately, the example of linguistics – which does not in itself constitute a homogeneous block in any way – mainly shows that the strict division of knowledge between the "hard" sciences and the humanities, despite any intrinsic validity it may have, does not necessarily account for all the variety in the field of knowledge, which undoubtedly manifests itself more often than is commonly accepted as a **continuum of knowledge**, with

patterns far removed from the categorical thinking inherited from Aristotle.

The positioning of a discipline will also depend, in part, on the approach adopted by its advocates.<sup>12</sup> **For neuroscience, as for any other science, it is therefore important above all to consider, on a study by study basis, how far the technical-experimental approach can be taken** – and at what point interpretative work on the results of this approach must begin. No less importantly, while this work must be subject to necessarily different criteria of verifiability,<sup>13</sup> it must also demonstrate the reproducibility of its results.

#### ■ **Reading, an example of the contribution of neuroscience**

Mastery of written language traditionally serves as a touchstone of teaching methods. In the French-speaking world, as in the English-speaking world, learning to read is a major challenge for all children starting school. In this regard, it could be said that one of the great merits of neuroscience is that it provided a scientific basis for the refutation of the so called 'global method'.<sup>14 15</sup>

#### ➤ *The global method refuted by MRI?*

As early as 1967, neuropsychiatrist Pierre Debray called for children with learning difficulties *"to be quickly removed from reading instruction using the global method."*<sup>16</sup> Debray was a hospital practitioner and his statement was based on observations, but it would take the work of neuroscience to provide more comprehensive evidence to support it. Studies performed on the cerebral bases of reading have given proof that global reading and syllabic reading do not activate the same areas of the brain; the **first** activates the right hemisphere and the **second** activates the left ventral occipito-temporal region.<sup>17</sup> These results were interpreted as demonstrating that *"the global method mobilises an inappropriate circuit, diametrically opposed to that of expert reading."*<sup>18</sup>

Nevertheless, one of the achievements of brain imaging is that it has demonstrated the great plasticity of the brain: if a given neural pathway is inhibited, the synaptic connections can be remodelled. Stanislas Dehaene reports the case of a four-year-old girl who underwent surgical removal of the left occipito-temporal region, which is considered the key brain region associated with reading: *"the region that we all use to recognise written words was completely missing,"* he writes. *"Yet, she had learned to read in an essentially normal way: only very fine chronometric measurements showed that her reading was a little slowed down, by only a few tens of milliseconds."*

*"When we scanned her, at the age of eleven,"* he continues, *"we understood how she managed to read so well. Although her spoken language areas remained strongly lateralised to the left hemisphere, she recognised written words using her right visual areas."*<sup>19</sup>

We can therefore ask ourselves whether this argument might not be partly reversible. Firstly, the observed

difference from "normal" – a few hundredths of a second – appears minuscule. More generally, this evidence of **cerebral plasticity** would appear to disprove any theory positing too categorical an equivalence between a given intellectual activity and the activation of a given part of the brain. One must be prudent in taking the leap from brain mapping to deriving axioms from its findings. Furthermore, in the leap from those axioms to practical applications that one might be tempted to derive from them, this principle of prudence applies all the more.<sup>20</sup>

As far back as 2004, Régine Plas stated that *"cerebral imaging has incontestably made progress, but it is not absolutely certain that it has resolved the question of the relationship between the soul and the body or, if you prefer, the brain and thought."*<sup>21</sup> Rather than placing brain imaging at the centre of its efforts to rationalise educational approaches, the Scientific Council of National Education as a body instead prefers "randomised controlled experiments in classes". These experiments make very traditional comparisons between the results of cohorts of students using different learning methods... **The epistemological shift that was sometimes expected did not take place.**<sup>22</sup>

#### ➤ *The biases of brain invocation*

Such changes in doctrine are highly instructive. Basically, they demonstrate the inevitable failure of any attempt to impose a single model of truth. But in this specific case, it also manifests a salutary reaction against the **lure** of what some have called **neuroenchantment**.<sup>23</sup>

Studies have shown that arguments based on visual representations of the brain have more chance of gaining support for this reason alone, regardless of how rational the thesis put forth actually is. Neuroscience researchers are certainly not to blame for this phenomenon, but the reception of their work undoubtedly suffers from it: in common belief, an assertion referring to the involvement of neural mechanisms will often have **apodictic value**, even if in the eyes of the scientists themselves it lacks sufficient evidence to be considered true.<sup>24</sup>

More broadly, the interest aroused by the applications of neuroscience is not unrelated to a certain **fascination with technology**, as an object of fantasy presenting itself as something both unavoidable and marvellous, but also as a token of social distinction,<sup>25</sup> like the flying cars of Silicon Valley dreamed up by *"engineering entrepreneurs (... mostly wanting to escape the traffic jams of the California coast."* The parallel is not far removed from parents of students anxious to find a scientifically proven miracle formula capable of getting their children to the top of the class.

#### ■ **The meanest role of neuroscience in schools**

Learning to read in fact stands as an example of a problem that needs to be examined more broadly than from the simple perspective of neuronal activity. To support this examination, one must also try to clearly

discern the specific contribution of each discipline to the development of learning.

#### ➤ *Misunderstandings about its didactic value*

As collections of raw observations, neuroscience experiment reports are unusable by teachers, who are still – and always – working *with the child*, not *on their brain*. Therefore it appears *a priori* very difficult to build a bridge between these analyses and pedagogical practice. In this regard one might simply consider the experiments conducted by Chomsky, which are poorly suited to providing exercises for language teaching.<sup>26</sup> Actually, neuroscience itself is only the experimental component of a cognitive psychology, which, like linguistics,<sup>27</sup> constitutes a disparate set of disciplines.<sup>28</sup> It is in fact the branch that is by nature the least likely to give rise to concrete applications, just as neurophysiology was in the past.

At best, it confirms information<sup>29</sup> that was already known beforehand; thus, when brain imaging allows:

*(...) an answer to one of the fundamental questions of the psychology of reading: must one always sound words out in one's mind before being able to understand them? Or can we go directly from the letters to the meaning of words without having to retrieve their pronunciation?*

*Answer: these two reading pathways coexist and compete with one another. Depending on the words one is reading, the cerebral tidal bore [mascaret] opts to take one or the other of these routes.*<sup>30</sup>

Is this just a banal truism?<sup>31</sup> Attempts to assimilate neuroscience into the National Education system have in any case met with indifference and even outright failure. By admission of the central administrative departments, neuroscience has been watered down and dissolved in practice, within teaching programmes, as well as in the continuing training of teachers, who shun the corresponding modules. Because it inspires so little interest, **neuroscience would seem to have all but failed, as a result, to rescue the global method from the discredit into which it has fallen.** Far from contributing certainties, the emphasis it was given in the early days has now given way to a feeling of dizzying discontinuity, since after all, pedagogy is more than just a **science**, and is still, first and foremost, **an art**.

#### ➤ *The illusory erasure of disciplinary boundaries*<sup>32</sup>

In modern societies, the transition from spoken to written language is experienced as the foundational moment in language learning. Yet the first lesson of linguistics is, on the contrary, that language is fundamentally a correspondence between sound and meaning. Writing plays no role here and is not taken into account at all.<sup>33</sup>

This universally relevant insight was long distorted by the influence of writing, which is always grounded in a given culture.<sup>34</sup> It is thus no exaggeration to claim that learning to read must first and foremost be grounded in an examination of the conventions of written representation

in the language being taught. Why can't the child read? Neuroscience books for a general audience all too often jump from reports of experiments conducted with electrodes flashing on a skull to considerations which, while not entirely irrelevant, no longer fall within the same scientific field, but rather within other disciplines.

In French, the purely phonetic spelling adopted in medieval manuscripts was "enriched" with stray letters during the Renaissance by scholars keen to bring French writing closer to the presumed sources of our language in Latin or Greek. At first sight, one can only be confused by these numerous silent letters - which, over time, have sometimes ended up being pronounced (precisely because of the importance attached to writing), such as the *p* in "*abrupt*" or the *s* in "*fil*s" [son] (but not the *!*). It is thus necessary to pick words that have remained "untouched" in order to introduce children to the principles of **phonic reading**. But, in other cases, **visual reading** exercises, when used sparingly, can help learners recognise the word as a whole, by associating it directly with a unit of meaning. This alone will allow them to make the distinction between *vers*, *verre*, *vert* and *ver*. [*towards*, *glass*, *green* and *worm*]

#### ➤ Collateral misuses of neuroscience

In this context, the invocation of neuroscience proves at best useless, at worst counterproductive. When faced with a child's difficulties in learning to read, a neuroscience-based approach would seem to quickly provide a clear answer: **if the problem is of a cerebral nature, the cause must lie in genetics!** But in an educational context, this reasoning borders on tautology - and may also be seen as deriving from a risky **social Darwinism**,<sup>35</sup> since only doctors are qualified to detect pathologies in children. What's more, in the context of schooling, this approach ultimately leads to an interpretive **dead end**.<sup>36</sup>

But would a diagnosis inspired by linguistics not give rise to the same feeling of helplessness? Unless there is a radical spelling reform in French, a French-speaking child would seem to be doomed to wander forever in an inescapable labyrinth... But fortunately, there are indeed ways to intervene. Starting from the objective difficulties encountered in reading, **alfonic writing** [phonic writing] for example, offers one solution: the **transitional** use of a simple, purely phonetic alphabet.

This classic tool is designed for everyone and has the advantage of immediate availability. It is intended equally for "*dyslexic children, deaf and hard of hearing French speakers, or immigrants with a native language other than French*"<sup>37</sup> Such methods are persuasive due not only to their low cost, but to their elegant simplicity as well. This can certainly be seen as a concrete pedagogical achievement.

#### ■ The problem of pedagogical discontinuity

Lastly, it is appropriate to locate the recent neuroscience trend within the broader context of **scientific fads**. Structuralism, sociological studies, child psychoanalysis... All these theories have fallen one after the other into the graveyard of fine educational ideas – victims of the **myth of the *tabula rasa***, which they themselves had first promoted.<sup>38</sup>

"In my view, science should be **cumulative** rather than constantly revolutionary," said Stanislas Morel to the rapporteurs, also highlighting the difficult position in which this instability in educational discourse places teachers.<sup>39</sup> It would indeed seem more rational to build upon the existing scientific heritage, not by concealing or excessively emphasising our debt to previous generations, but rather by grounding current research more firmly within long-term historical trends.

Additionally, several contemporary works address the **mastery of handwriting** as a challenge involving fine psychomotor skills.<sup>40</sup> Bearing in mind the long history of reflections on the role of spatial orientation in cognitive processes would in no way detract from this discovery. In ancient Rome, the method of *loci* was used to memorise long lists of ordered items, relying on the memory of well-known places connected by a route frequently travelled on foot.<sup>41</sup> Building broader representations based on this mnemonic technique, in late antiquity Saint Augustine developed the concept of the **memory palace**.<sup>42</sup> This notion already contained the seeds of the discourse of contemporary cognitive psychology, conceiving of memory as a **repository of consciousness**.

Certainly, these bodily activities, or the memories thereof, involve neuronal activity. But what is it that fixes in the brain the movement of writing, or the memory of it, if not the movement of the body and the hand?

Drawing upon advancements in brain imaging, neuroscience sought in its time to establish itself in a manner completely breaking with the history of the discipline. Although those times are still linked to our own in many ways,<sup>43</sup> it remains to be seen **what the future will hold for this approach, which claimed to be of such radical novelty**.

The OPECST's websites:

<http://www.assemblee-nationale.fr/commissions/opecst-index.asp>  
<http://www.senat.fr/opecst>



## Persons consulted

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- Stanislas Dehaene, professor at the Collège de France, holder of the Chair in Experimental Cognitive Psychology, president of the Scientific Council of National Education, and author of *Les Neurones de la lecture* [The Neurons of reading] (Odile Jacob, 2007);
- Édouard Gentaz, professor of Developmental Psychology at the University of Geneva and author of *Neurosciences à l'école: leur véritable apport* [Neuroscience at school: its real contribution] (Odile Jacob, 2022);
- Jean Hubac, head of the Educational Policy Support department at the General Directorate of School Education for the National Education Ministry (DGESCO);
- Adriano Linzarini, from the OECD Directorate for Education and Skills (PISA surveys and other indicators) – Centre for Educational Research and Innovation (CERI);
- Stanislas Morel, associate professor of Educational Sciences at Sorbonne Paris-Nord University and author of *La Médicalisation de l'échec scolaire* [The medicalisation of school failure] (La Dispute, 2014).

## References

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<sup>1</sup> Jean-Pierre Changeux, author of *L'Homme neuronal* [Neuronal Man], wrote a preface for the book *Les Neurones de la lecture* [The neurons of reading] by neuroscience specialist Stanislas Dehaene (see list of persons consulted), published by Odile Jacob in 2007.

<sup>2</sup> The first two books of the first century BC work *De rerum natura* are devoted first to various theories about atoms and the existence of the void (Book I), and then to their properties and secondary qualities when they combine with one another (Book II). Books III and IV deal respectively with the material nature of the soul (Book III) and with thought and sensations (Book IV). Jean-Marc Lévy-Leblond, physicist and philosopher of science, makes this contemporary assessment of the work: "what is really of great interest to the contemporary physicist in Lucretius is his remarkable foresight about modern ideas and concepts." It is with these words on page 149 that the author opens the chapter "Lucretius, vingt siècles après" [Lucretius, twenty centuries later] of his work *Le Tube à essais, Effervescences* [The Test Tube, Effervescence], Paris, Le Seuil, "Science ouverte" collection, 2020. <https://stm.cairn.info/le-tube-a-essais-effervescences--9782021425086-page-149?lang=fr>

<sup>3</sup> Meanwhile, the historical links between dialectical materialism and brain research were pushed to the extremes in Soviet Russia in the 1920s. From 1925 to 1927, neurobiologist Oskar Vogt (1870-1959) performed a dissection of Lenin's brain, seeking the cause of his great genius. "He reported that his analysis of some 30,000 paraffin-embedded sections of brain tissue showed some clear structural peculiarities, including, among other things, highly active pyramidal cells in the cortex and an exceptional number of nerve fibres (referred to as 'associative' fibres) connecting them. According to the Pravda report, it was to this richness of the material substance of his brain that the German neurologist attributed Lenin's 'genius, ability to quickly find his bearings in complex situations and problems, and capacity for immediate action.' In the first official report of the new [Brain] Institute two years later, Vogt confirmed that Lenin's brain anatomy demonstrated that he was an "athlete of association," gifted with quick understanding and an exceptional sense of reality," writes Brigitte Schroeder-Gudehus in *Relations Internationales*, No. 106, Summer 2001, pg. 273-275. <https://www.jstor.org/stable/45344193> The author's "lecture notes" are a report on the most complete work on the subject: Jochen Richter, *Rasse, Elite, Pathos. Eine Chronik zur medizinischen Biographie Lenins und zur Geschichte der Elitegehirnforschung in Dokumenten* [Race, elite, pathos – A chronicle of the medical biography of Lenin and the history of elite brain research based on documentary evidence], Herboisheim, Centaurus, 2000, 334 p.

<sup>4</sup> *L'Homme neuronal* sold more than 200,000 copies, according to Olivier Houdé. "L'Homme neuronal, trente ans après", Michel Morange et al. (dir.), Éditions Rue d'Ulm" [*Neuronal man*], thirty years on, edited by Michel Morange et al.], figure cited in his review of the 30th anniversary book published in *Cerveau & Psycho*, 2016/5 N° 77, 2016, p.93b. <https://doi.org/10.3917/cerpsy.077.0093b> A year after its publication, *L'Homme neuronal* was given a very negative review that cast doubt on its possible application to teaching: Jean-Claude Filloux, "Le pédagogue et l' 'homme neuronal'" [The teacher and the 'neuronal man'], *Revue française de pédagogie*, volume 70, 1985, pg. 51-57 <https://doi.org/10.3406/rfp.1985.1552>

<sup>5</sup> "L'homme neuronal: un cerveau sans tête" [Neuronal man: a brain without a head], an article by Jacques Vonèche, *Le Journal de Genève*, 7 January 1984. Jacques Vonèche, who concluded by citing the example of Trissotin, was a professor at the Faculty of Psychology and Educational Sciences at the University of Geneva. [https://www.letempsarchives.ch/page/JDG\\_1984\\_01\\_07/16/article/8890725/von%C3%A8che%20%22homme%20neuronal%22](https://www.letempsarchives.ch/page/JDG_1984_01_07/16/article/8890725/von%C3%A8che%20%22homme%20neuronal%22)

<sup>6</sup> Francis Wolff, "Ce que *L'Homme neuronal* nous a fait penser" [What *Neuronal man* made us think about] in Michel Morange, Francis Wolff and Frédéric Worms (dir.), *L'Homme neuronal, trente ans après*, Paris, Rue d'Ulm, 2016, p. 41-52, and for this assessment, pg. 52.

<sup>7</sup> This is the source used by the Computerised Treasury of the French Language (TLFi), specifically *Le Courrier du CNRS* for April-June 1984, pg.12. <https://www.cnrtl.fr/definition/neurosciences> It should be noted that the TLFi was completed in 1994 and has not been updated since that time. For the current period, it is possible to rely on the raw data provided by Gallicagram, a lexicometric software program developed by Benjamin Azoulay and Benoît de Courson (<https://doi.org/10.31235/osf.io/84bf3>). This tool found that the number of occurrences of the morpheme "neuroscience" in daily newspapers like *Le Monde* peaked in 2018; it appeared 228 times that year, although its first appearance was in 1980, when it had appeared only once. Following the graph of interest in the topic – probably with some slight time-lag – one can then observe a rapid decrease in the frequency of use of the word. By 2024, occurrences had fallen back to 64, which was the average level in the early 2010s.

<sup>8</sup> There are other examples of similar terminological (and perhaps conceptual) instability; for example, in a completely different field, but to designate a phenomenon which also originated in the United States of America, the use of the word "start-up." See Maxime Quijoux and Arnaud Saint-Martin, "Start-up : avènement d'un mot d'ordre" [Start-up: the advent of a slogan] in *Savoir/Agir*, 2020/1 no. 51, 2020. p.15-22,

where the authors warn: "In preparing our review, we observed a relative degree of variability in how the expression 'start-up' is used. This illustrates the semantic instability of an imported category." <https://shs.cairn.info/revue-savoir-agir-2020-1-page-15?lang=fr>.

<sup>9</sup> In her work at OPECST, co-rapporteur Florence Lassarade has already highlighted the role of medical imaging as a tool for detecting neurodegenerative diseases, alongside cognitive tests and blood biomarker detection. Yet this tool is only used at the diagnostic stage of these diseases, not when determining a treatment strategy for them. See OPECST scientific briefing no. 38, *Avancées thérapeutiques dans la prise en charge des maladies neurodégénératives* [Therapeutic advances in the management of neurodegenerative diseases], footnote no. 34 [https://www.assemblee-nationale.fr/dyn/16/organes/delegations-comites-offices/opepst/publications/notes\\_scientifiques\\_opepst/avancees-therapeutiques-dans-la-prise-en-charge-des-maladies-neurodegeneratives-note-scientifique-n-38-juin-2023](https://www.assemblee-nationale.fr/dyn/16/organes/delegations-comites-offices/opepst/publications/notes_scientifiques_opepst/avancees-therapeutiques-dans-la-prise-en-charge-des-maladies-neurodegeneratives-note-scientifique-n-38-juin-2023)

<sup>10</sup> This example is taken from *Neurones de la lecture* (cited in note 1), pg. 158-159. This work was of course written for a general audience, but the image chosen, as such, speaks to certain preconceived notions about how science should be popularised. The metaphor used here is of a dual nature. The tidal bore is of course a natural phenomenon, but the example would only really make sense to people who live near the Gironde and are familiar with the way that river moves. The approach therefore compares this neuronal movement not so much to a familiar reality as to the scientific descriptions made of that reality, as seen for example in the Wikipedia article about this unique hydrographic phenomenon (article "mascaret": <https://fr.wikipedia.org/wiki/Mascaret>). To discuss the matter in this way is basically to use these hydrographic descriptions as a *figurative* scientific description of a neuronal movement that it would have been appropriate to simply explain in the first place.

<sup>11</sup> In 1971, in the wake of the post-May 1968 reorganisation of the University of Paris, the University of Paris V-René Descartes was created, bringing together the Faculty of Medicine, the Faculty of Pharmaceutical and Biological Sciences, the Institute of Psychology and the Faculty of Humanities and Social Sciences. Within this new group, the field of linguistics sought an unprecedented proximity with the life sciences.

<sup>12</sup> With regard to experimental psychology, in the wake of which neuroscience was born, its generic ambiguity is nothing new, since even as far back as 1945 the discipline was attached to the life sciences at the CNRS, and was taught at the faculties of letters in the universities. "In 2011, at the CNRS, psychology was attached to the Institute of Biological Sciences, and was allocated to department 27, entitled 'Behaviour, Cognition, Brain.' No clinical psychologists work in this department. At the university however, since the time of their creation, the UFRs [training and research units] and departments of psychology have always been part of the colleges of letters," writes Régine Plas, in the work "La psychologie cognitive française dans ses relations avec les neurosciences. Histoire, enjeux et conséquences d'une alliance" [French cognitive psychology in its relations with neuroscience. The history, challenges and consequences of an alliance], in: *Revue d'Histoire des Sciences Humaines*, 2011/2 no. 25, 2011. pg.125-142. <https://doi.org/10.3917/rhsh.025.0125>

<sup>13</sup> A theorist of the refutability of scientific theses, Karl Popper was also far from excluding the possibility of the non-materiality of the soul. On this subject, see Thomas Chabin, "Popper et le problème du corps et de l'âme" [Popper and the question of the body and soul], *Philosophia Scientiæ*, 11-1, 2007, 159-193. <https://doi.org/10.4000/philosophiascientiae.325>

<sup>14</sup> The "global method" could be defined as one which aims to "teach children to identify whole words, before moving on to breaking them down into syllables and then into isolated letters." Such is the definition used by the Computerised Treasury of the French Language, which gives its source, rather elliptically, as: "Revue psychol., May 1976, no. 76, pg. 19-20." It was not possible to locate the source in question.

<sup>15</sup> In his memoirs about his recent stint as head of the Ministry of National Education from 2017 to 2022, Jean-Michel Blanquer writes: "I also took advantage of this period [summer 2017] to set up a completely new entity: the Scientific Council of National Education. I felt it was essential to provide a rational basis for the public policies that we were going to pursue. [...] Over several years, I had come to know and appreciate Stanislas Dehaene, professor at the Collège de France, recognised worldwide as one of the greatest experts in the field of cognitive science. Through studies based particularly on brain imaging, he was able to demonstrate some fundamental pathways for the learning of subjects such as reading or mathematics. His demonstration of the mechanisms involved in a child learning to read is so enlightening that one wonders why it is so difficult for some to accept his conclusions. [...] In the National Education system, the challenge we face is just as much to create a clear and lasting body of thought for the benefit of children as it is to implement diverse and concrete technical measures." From *La Citadelle* [The Citadel], Paris, Albin Michel, August 28, 2024.

<sup>16</sup> These reflections on learning to read by Doctor Pierre Debray can be found in the 16 and 23 November 1967 issues of *L'Éducation*. Although the hospital practitioner made undeniable advances in the treatment of dyslexia (from 1972 to 1988 he headed the Child Psychiatry department at the Necker Enfants-malades hospital in Paris), his thinking on educational problems was controversial from the start; see in particular Paule Maninchelli, *L'Éducation* no. 846, Opinions et Expériences, 11 January 1968. Ironically, the "global method" is widely considered to have been invented by Ovide Decroly (1871-1932), a Belgian educator who was himself a trained neuropsychiatrist.

<sup>17</sup> Yoncheva Y. N., Blau V. C., Maurer U. and McCandliss B. D. (2006), *Strategic Focus During Learning Impacts the Neural Basis of Expertise in Reading*. Paper presented at the Association for Psychological Science Meeting Convention, New York. This study is presented in Dehaene, *Les Neurones de la lecture*, pg. 298 et seq., cited in note 1.

<sup>18</sup> *Les Neurones de la lecture*, pg. 299.

<sup>19</sup> *Les Neurones de la lecture*, pg. 225.

<sup>20</sup> During his hearing by the rapporteurs on March 12, 2025, Scientific Council of National Education president Stanislas Dehaene agreed that "there is a long way from the synapses to education."

<sup>21</sup> Such was the conclusion of his article, "Comment la psychologie expérimentale française est-elle devenue cognitive ?" [How did French experimental psychology become cognitive?], in *La revue pour l'histoire du CNRS*, 5 May 2004 <http://journals.openedition.org/histoire-cnrs/586>

<sup>22</sup> Other scientific and technological assessment bodies abroad have performed reviews of brain research already. In Germany, the Bundestag Committee on Education, Research and Scientific Evaluation commissioned a study on the subject. It was conducted by the *Büro für Technikfolgenabschätzung* (Office of Technology Assessment, TAB), and was published on January 22, 2008. It reads in particular: "The example of the learning process shows the possibilities and practical limits of neuroscientific research, as far as the higher functions of consciousness (and therefore also cultural phenomena) are concerned. Despite significant progress in understanding the physiological basis of memory

performance and learning processes, **it is evident that neuroscience has not yet revolutionised methodology and didactics.**" Bundestag print document 16/7821, p. 87 <https://dserver.bundestag.de/btd/16/078/1607821.pdf>

<sup>23</sup> See Franck Ramus, "Neuroéducation et neuropsychanalyse : du neuroenchantement aux neurofoutaises", [Neuroeducation and neuropsychanalysis: from neuroenchantment to neurononsense] *Intellectica*, 2018, no. 69, pg. 289-301. The article is part of a themed issue of the journal entitled: "Les neurosciences au sein des sciences de la cognition entre neuroenthousiasme et neuroscepticisme." [Neuroscience amongst the cognitive sciences, between neuroenthusiasm and neuroscepticism] In a book written in collaboration with Annick Ohayon, Régine Plas also presents a catalogue of preconceived ideas about psychology, and includes in particular the following assertion among the various prejudices that she believes should be eliminated: "When we know everything about the brain, we will no longer need psychology." in *La psychologie en questions : idées reçues sur la psychologie* [Psychology in questions: preconceived ideas about psychology], Le Cavalier bleu, 2011.

<sup>24</sup> There is no shortage of warnings about the errors and mistakes into which one can fall by reference to the functioning of the brain. At the beginning of *Neurosciences à l'école: leur véritable apport* [Neuroscience at school: its real contribution], a book published in November 2022, Édouard Gentaz (see list of persons consulted) cites in particular: Elena Pasquinelli, "Neuromyths: Why do they exist and persist?", *Mind, Brain, and Education*, 2021, no. 6, pg. 89-96; Sébastien Lemerle, *Le Cerveau reptilien. Sur la popularité d'une erreur scientifique* [The reptilian brain. On the popularity of a scientific error], CNRS, 2020; Yves Rossetti, "Des (neuro)sciences à l'école? Mythologies et réalités" [(neuro)science in school? Mythologies and realities], *La Revue de santé scolaire et universitaire*, 2018, 9 (54), pg. 12-16.

<sup>25</sup> Daniel Compagnon and Arnaud Saint-Martin, "La technique : promesse, mirage et fatalité" [Technology: promise, mirage, and inevitability], *Socio*, 12 | 2019, 7-25. The following quote is taken from paragraph 5. <https://journals.openedition.org/socio/4401> The authors explicitly include the "applications of neuroscience" among the "discourses and (...) prophecies of technological innovation that promise a better world," invoking the enthusiasm that it enjoyed, particularly among the post-war generations, in their reference to the "ideology of progress that triumphed during the Trente Glorieuses [1945-1975]".

<sup>26</sup> "Chomsky emphasised in the late sixties that generative theory was not a theory of learning foreign or second languages, and that its vocation was not didactic," in Jean-Michel Robert, "Lexicologie et français langue étrangère – Linguistique appliquée et didactique des langues" [Lexicology and French as a foreign language - applied linguistics and language teaching], *Études de linguistique appliquée*, Paris, volume 75, July 1989, pg. 114-123.

<sup>27</sup> In terms of content, there is no shortage of analyses on the institutional and theoretical concordance between neuroscience and Chomskyan linguistics; see, for example, the observations on psycholinguistics in the article cited in note 21.

<sup>28</sup> The official title of the chair created in 2005 at the Collège de France is "Chair in Experimental Cognitive Psychology," though it is commonly referred to as a chair in neuroscience.

<sup>29</sup> It really is exclusively about confirming information: "Neuroscience does not provide proof of the effectiveness of one method over another on the basis of brain imaging," according to Stanislas Morel, who spoke to the rapporteurs (see list of persons consulted).

<sup>30</sup> This example is drawn from *Neurones de la lecture*, pg. 161-162. On the "cerebral tidal bore", see above.

<sup>31</sup> Aware of this potential criticism, the author of the citation seeks to preempt it by pushing the argument further: "Many teachers will see this as obvious fact, applied in pedagogy for decades already." (pg. 303) He then adds: "Nevertheless experience shows that making it explicit can only be of help to teachers." (*ibid.*)

<sup>32</sup> Some sociologists have analysed the abolition of disciplinary boundaries as a new phase of technological development; see, in this regard, the article cited in note 25 (in its preliminary summary). This mixing of fields should not be confused with the multidisciplinary educational approach, whose specific legitimacy lies in the need to consider the child as a whole.

<sup>33</sup> In his *Course in General Linguistics*, published by his students in 1916 based on their own notes, Ferdinand de Saussure (1857-1913) states, on this subject: "The spoken word is so intimately bound to its written image that the latter manages to usurp the main role. People attach even more importance to the written image of a vocal sign than to the sign itself. A similar mistake would be in thinking that more can be learned about someone by looking at his photograph than by viewing him directly." A modern language such as Lithuanian was able to exist for more than a millennium without written evidence, until the 15<sup>th</sup> century, like all other languages in this regard prior to the invention of writing. Saussure thus concludes: *This one example is enough to show the extent to which language is independent of writing.*

<sup>34</sup> On the prestige of writing and its deceptive ascendancy over the spoken form, Saussure warns: *This illusion, which has always existed, is reflected in many of the notions that are currently bandied about on the subject of language.*

<sup>35</sup> The daily national press regularly echoes this danger of a Darwinist drift in neuroscience; for instance, upon the publication of François Gonon's book, *Neurosciences : un discours néo-libéral* [Neuroscience: a neoliberal narrative] (Champ social), there appeared Stéphane Foucart's article, "Quand la science du cerveau légitime des choix politiques" [When brain science legitimises political choices] in *Le Monde* of 6 December 2024, and an interview with the author entitled "Le discours des neurosciences justifie implicitement les inégalités sociales" [The neuroscience narrative implicitly justifies social inequalities], published in *L'Humanité* of 6 January 2025.

<sup>36</sup> Co-rapporteur Arnaud Saint-Martin recalls having attended a presentation sometime in the 2000s by molecular biology specialist Jean-Pierre Changeux, who said that he found the teachings of Pierre Bourdieu, a sociologist famous for his theory of social reproduction, to be fully consistent with his own. The co-rapporteur, while acknowledging this scientific parallel, nevertheless emphasises that Bourdieu's thought is, in his view, less rigid and deterministic than may sometimes be suggested by certain simplifications of his work, and by Jean-Pierre Changeux's remarks here. On this subject, see Ronan Le Roux and Arnaud Saint-Martin, "Situations du déterminisme en sciences humaines et sociales" [Situations of determinism in the human and social sciences], *Socio*, 6 | 2016, posted 11 May 2016, consulted 15 April 2025, <https://doi.org/10.4000/socio.2130>

<sup>37</sup> François-Xavier Nève, *Alfonic, Écrire sans panique, Le français sans orthographe*, [Alfonics: Writing without panic - French without orthography] Now future, Liège, 2019, pg. 29. Developed in the 1970s by the linguist André Martinet (1908-1999), this system of notation is also used by associations such as ATD Quart Monde; see *Vaincre l'illettrisme* [Beating illiteracy] Claire Fondet, Quart Monde, January 1990.

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<sup>38</sup> In an interview with Claire Benveniste, associate professor in Educational and Training Science, Stanislas Morel (see list of persons consulted) declares: "We absolutely need highly specialised disciplinary research that isolates specific topics and follows through on them in depth; it's essential. But I feel that mutual ignorance and the tendency towards disciplinary hegemony has very harmful effects, both socially and in the schools. For example, in the case of dyslexia, teachers have for decades been at the mercy of ever-changing scientific fads. First it was sociology, then it was psychoanalysis for a while, now it's neuroscience, in twenty years maybe something else... And the same goes for all the quarreling over reading methods. From a scientific standpoint it is uninteresting, and it is also highly detrimental to the meaningful use of scientific knowledge in schools." See *Carnets rouges* no. 29, 16 January 2024. <https://carnetsrouges.fr/se-confronter-au-probleme-de-compatibilite-entre-sciences-sociales-et-sciences-cognitives-pour-le-depasser-entretien-avec-stanislas-morel/>

<sup>39</sup> For several years, Peter Lang Publishing has planned the release of a book on the subject, edited by Stanislas Morel, Jean-Paul Payet and Emmanuel Sander, entitled *Théories explicites et implicites de l'apprentissage chez les enseignants : questionnements croisés de chercheurs en éducation*. [Explicit and implicit theories of learning among teachers: cross-disciplinary inquiries by educational researchers.]

<sup>40</sup> Here we must cite the exemplary approach of Danièle Dumont. A teacher, she offered activities designed to introduce the movements involved in writing as early as nursery school, such as having children move along a path while twirling a scarf; this is the first step in discovering the sequential movements of cursive writing and the fluidity of writing gestures. See *Le Geste d'écriture* [The gestures of writing] Hatier, March 2020, pg. 79-82.

<sup>41</sup> See the article "Method of loci" from the online encyclopedia Wikipedia: [https://fr.wikipedia.org/wiki/M%C3%A9thode\\_des\\_loci](https://fr.wikipedia.org/wiki/M%C3%A9thode_des_loci).

<sup>42</sup> See *Confessions*, book X, chapters VIII to XXI. Alain Lieury (1946-2015), who was a professor of Cognitive Psychology at the University of Rennes II, wrote: "Saint Augustine was (...) a great precursor of the latest concepts in cognitive psychology." See *Psychologie de la mémoire. Histoire, théories et expériences*, [Psychology of memory. History, theories, and experiments] Dunod, 2021, chapter one, pg. 5-32.

<sup>43</sup> One can track the frequency with which the term "neuroscience" has appeared in the media over time by using software like "Gallicagram" (see note 7). The values obtained may be considered as a summary indicator of the strong public interest in this topic.