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Discussion forum

Theories on mind, not on brain, are relevant for education

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The debate on the relationship between neuroscience and education implies two different questions: (1) Are all goals in neuroscience equally relevant for educational purposes? (2) Do neuroscientific theories and empirical data have the same impact on educational theory and practice? I think the answer to both questions is no.

The aims of neuroscience are threefold: The endeavour of neuroscientists is to investigate (i) the working brain; (ii) the functional architecture of the mind; (iii) the mapping between brain and mind. In my view, only the second aim is relevant for education. For teachers in primary schools or professors in universities, knowing the chemical processes underlying neuronal communication, identifying the anatomical basis of the cognitive operations or understanding the functional role of the cerebral hemispheres is not useful for planning and conducting courses and lectures. In contrasts, psychological theories depicting processing levels and computational mechanisms involved in learning and in accomplishing specific cognitive tasks (such as reading, reasoning or calculating) can enlighten motivated teaching programmes and strategies.

Let us consider two examples, one on reading and one on memory.

Psycholinguistic (e.g., Rayner et al., 1980; Finkbeiner et al., 2006), neuroimaging (e.g., Dehaene et al., 2001) and neuropsychological (e.g., Miozzo and Caramazza, 1998) data show that reading words requires transforming visually presented letter strings in abstract orthographic information before accessing semantic and phonological knowledge (i.e., the meaning and pronunciation of the written words). Prominent cognitive models of word reading (e.g., Caramazza and Hillis, 1990; Coltheart et al., 2001) share the assumption that orthographic representation mediates between visual processing and lexical access. Therefore, any educational approach should be based on the assumption that reading ability does not rely on associating the visual shapes of letter strings with the meaning of known words, but depends on the ability to recognize individual letters as orthographic symbols and to identify them independent of the actual format and style. It follows that teaching to read should be centred on acquiring alphabetic signs and their phonological correspondence, and that the so-called ‘‘global methods’’ should be discouraged in order to avoid children’s memory overload and permanent difficulties in reading (Dehaene, 2007). These general statements derive from cognitive theories and maintain their strength even if the identification of the posterior region of the left midfusiform gyrus as the ‘‘visual word form area’’ (Cohen et al., 2002) is still disputed (e.g., Price and Devlin, 2003).

For what concerns memory, it is widely accepted that it is not a unitary system but comprises independent storage and processing components (e.g., Tulving and Craik, 2005). Following Bartlett (1932), memory can be distinguished between reconstructive processes (episodic and prospective memories) and reproductive knowledge (procedural and semantic memories). While every-day activities rely upon reconstructive memories (i.e., decisions and actions derive from the actual interpretation of past events), education should focus on reproductive memory (i.e., transmission of accrued knowledge and skills). For memory of events, accuracy is low (the past is continuously modified according to actual intentions and acquired knowledge, with most details lost and episodes continuously transformed); in contrast, for memory of facts and habits, accuracy has to be high (to learn ideas and abilities, either the original information or the target procedure must be acquired and retained as more precisely as possible). It follows that students should not ignore the details and surface properties of texts (e.g., labels and definitions), ‘‘meaningless’’ words (e.g., historical dates

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or proper names) and redundant information in handbook chapters (e.g., summaries, tables and figures). They have to comprehend and interpret facts and ideas, but their aim is to maintain them in memory, either integrating them within the pre-existing knowledge or learning them by heart. As the Italian poet Dante Alighieri wrote, ''Open thy mind to that which I reveal / And fix it there within; for 'tis not knowledge, / The having heard without retaining it'' (Paradise, V, 40–42, translation by Henry W. Longfellow).

The functioning of human memory has been extensively explored (e.g., Schacter, 1996), leading to cognitive theories on how the mind forgets and remembers in both incidental and intentional learning (e.g., Schacter, 2001), that can inform education in a noteworthy way. In contrast, in spite of the recent remarkable progress, increased knowledge of brain functions can offer a scarce contribution to education. For example, it has been reported that amnesia can result from lesions involving either the medial temporal regions or the diencephalic structures. These areas constitute two different neural circuits (Wickens, 2005): one comprises the hippocampus and the anterior thalamus (the Papez circuit) and the other one includes the amygdala and the dorsomedial thalamus (the Yakovlev circuit). Several studies have documented the differential role of the hippocampus and amygdala complex (e.g., Phelps, 2004) and the thalamic nuclei (e.g., Van der Werf et al., 2003). These studies, however, do not provide any useful information to shape pedagogic programmes.

In contrast with knowledge of the cerebral organisation underlying the cognitive functions, psychological theories can inspire educational goals and strategies, thus avoiding either futile activities or harmful consequences. However, it is worth noting that meticulous educational programmes, specifying exercises and materials, and including procedures with progressive steps and increasing difficulties, cannot be derived by such theories. In science, theories are descriptive and explicative; they provide a general framework within which one can operate taking into consideration personal experience, strategic goals, cultural background and contextual constraints. In no case, scientific theories can be assumed as prescriptive and applied activity can be viewed as the automatic consequence of a given theoretical statement. No theory can compel the actual teaching in the classrooms or establish the correct way to study a poem or to learn the alphabetic code. If consistent with accepted cognitive theories and supported by evidence demonstrating their effectiveness, any methodological approaches are warranted and legitimate.

This does not mean that psychological studies have no direct impacts on educational theory and practice. Empirical data can offer information on how to plan, organise and conduct teaching procedures, suggesting concrete actions and adjustments. For example, Baddeley and Longman (1978) have provided evidence about the superiority of distributed practice on learning over massed practice. This is relevant when planning teaching activities which should privilege parallel courses rather than intensive seminars. Further, Morris et al. (1977) showed that memory performance reflects the overlap between study and test phase processing, thus supporting the importance of transfer appropriate processing. It follows that students' performance results more accurate when they know in advance the modality of testing and can study accordingly. However, in order to obtain a more stable learning, independent of the way to overcome examinations, teachers could decide not to anticipate how testing will be carried out. Both options (to inform students in advance or to let them know tardily) are consistent with current memory theories. The choice between them depends on the educational model (which specifies the didactic goals, the motivational approaches and the assessment tools) each teacher assumes. More recently, Roediger and Karpicke (2006) have demonstrated that a memory test is a powerful means for improving learning, not just for assessing it. Then, to ameliorate retention students should undergo repeated testing procedures before final examination. According to the authors, ''frequent testing leads students to space their study efforts, permits them and their instructors to assess their knowledge on an ongoing basis, and—most important for present purposes—serves as a powerful mnemonic aid for future retention'' (p. 254).

In conclusion, theories and models derived from studies in cognitive neuroscience are relevant for education, and may contribute to improve practice and to increase effectiveness in teaching experience, but they should be theories on mind rather than theories on brain.

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