Basic neuroscience research has important implications for child development

To the editor:
In a recent Commentary in *Nature Neuroscience,* John T. Bruer[1] advances his view that developmental neuroscience is of little or no relevance to child development and education. Bruer would have been nearly correct two or three decades ago, but since then, points of contact between these disciplines have increased rapidly, to the point where developmental psychologists are becoming experts in developmental neuroscience and vice versa. Old borders between disciplines are rapidly disappearing, in large part driven by new methods of investigation such as functional magnetic resonance imaging (fMRI). Examples of neuroscience data with practical implications are on the increase.

Bruer doubts the existence of "critical periods" or "windows of opportunity." He implies that the ability to learn is independent of age or developmental stage. However, there are now well-studied examples of age limits for certain types of learning. Accent-free second language learning[2] is not possible after mid-adolescence. Apparently, this results at least in part from the gradual loss of the ability to discriminate sounds that do not occur in the native language[3]—an example of the developmental 'use-it-or-lose-it' process. The optimal time window for learning differs for different languages[4], and such information can be used in rational educational planning. Another example of a critical period effect relates to absolute pitch, a skill important for musicians, which is unlikely to develop if music training is started after children are 10 years old[5]. Therefore, if excellence in music is a desired goal, music training is best started early in childhood. Bruer ridicules early intervention. Yet, many recent studies show that early education programs, begun before children are 2 years old, carry long-lasting benefits in selected populations, including disadvantaged and prematurely born infants[6,7].

In my work on synaptogenesis in the human cerebral cortex, I have stated repeatedly that there is no evidence of a direct relationship between synaptic density or number in the cerebral cortex and intelligence[8]. Nevertheless, the presence of an anatomical substrate that is rich in synaptic contacts may be important for early learning. According to the Changeux hypothesis, early synaptic contacts (the points of contact between growing axons and dendrites) are largely random. Some synapses become incorporated into functional systems and are stabilized; those that are unused or redundant disappear[9]. Language functions, for example, are at first represented bilaterally in the cerebral cortex. During development, language representation typically becomes more modular and shifts predominantly to the left frontal and temporal cortex[10]. Modular representation is apt to increase the efficiency of information processing, at the expense of decreasing plasticity. Physiological and anatomical data show exuberant synaptogenesis early in brain development, followed by synaptic pruning. There is a rather good correlation between age of synaptic pruning and decline in plasticity[8]. Bruer is critical of structure–function correlations such as this, referring to them as the "pediatrician's error." In fact, much of what we know about the functional organization of the human cerebral cortex is based on structure–function correlations, starting with the work of 19th century anatomists such as Broca and Wernicke.

The interface between developmental neuroscience and child development is an exciting area of investigation, driven by new technologies such as functional imaging. Collaboration between neuroscientists, developmental psychologists and educators will best advance this field.

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