Fostering Literacy through Understanding

What do studies of the human brain have to say to educators, parents and children interested in fostering the acquisition of fluent reading? We outline a plan to have scientists and educators work together to examine what is currently known about the brain mechanisms involved in reading instruction and to provide an environment that will foster research into the many things we do not currently know. This plan has emerged over the last two years, as the Center for Educational Research and Innovation (CERI) of the Organization for Economic Cooperation and Development (OECD) has conducted Phase I of its effort to foster understanding of brain mechanisms related to education.[1]

In this article we report some current ideas concerning the brain mechanisms of reading and then discuss plans to: (i) achieve consensus about what can currently be applied to foster the acquisition of literacy and (ii) encourage research to answer additional instructional issues.

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INSIGHTS INTO BRAIN AND LITERACY

Imaging Studies. Most of what we know about the brain and literacy comes from studies of adults using the methods of imaging the human brain. Fluent reading seems to rely upon a network of brain areas from visual centers in the back of the brain to areas of attentional control in the frontal lobes. Two brain areas in the posterior region of the left hemisphere have demonstrated robust differences between good and poor readers in reading visual words.[2] One of these regions is active in listening to speech, and is located near brain areas involved in processing sound. This area is specifically engaged by tasks that require thinking about the sounds of words (phonology), as in deciding whether two letter strings rhyme. This region may be critical during early reading experience when children learn to systematically associate the sight and sounds of words. A second region, called the "visual word form area" is part of the visual system.[3] Skilled adult readers activate this region quite rapidly after seeing a word. This area is associated with automatically chunking letters together into recognizable visual 'word forms'.

It should be no surprise that these brain areas are closely related to functions already identified in cognitive science and also to teaching methods well-explored in education. Cognitive science studies have stressed orthographic (visual) and phonological (sound) routes to word meaning, as well as the role of attention in these processes. Although visual and phonological processes appear to involve different brain systems, most models of adult reading demonstrate that the visual and phonological systems interact extensively during fluent reading.[4] Similarly, educators have explored different methods that focus children's attention on letters and sounds (phonics and decoding) or associating the sound and sight of whole words while focusing on meaning (whole language and look-say) in the earliest stages of literacy acquisition. Phonological decoding, automatic word recognition, and the role of attention in literacy acquisition form research areas that allow educators and scientists to share information and might open possibilities for these groups to join forces in optimizing literacy development.

Cognitive studies of adults demonstrate that word recognition happens automatically, so little or no attention is required to analyze word forms and their phonological content. Studies with children, have demonstrated how brain activity changes during the years children are learning to read. During the early years of reading, word recognition requires effortful attention to develop properly. During reading tasks,

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Brain Mechanisms

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young children and those having difficulty reading show much greater activity in a frontal network of brain areas associated with effortful control, perhaps as means of compensating for insufficient development of the more automatic posterior visual word form and phonological systems.[5]

Phonology. Brain regions associated with phonology also show important differences between children who show facility vs. those who show impairment in reading. When reading impaired children perform a phonologically demanding task, such as rhyming judgments, they don't show the typical pattern of increased activity in posterior brain areas related to word sounds.[6] For poor readers, operation of the phonological system seems to rely upon the ability to focus attention on the individual constituents of spoken words called phonemes. These results have implications for the interventions discussed later in this paper.

Visual word form. The visual word form area also seems to be play an important but different role in literacy development. When adults see a word, this region is selectively active within two tenths of a second. However, this rapid response of the visual word form system develops slowly over years of reading experience. Studies show that at age 10 rapid activation of the visual word form system requires highly familiar words that children have already learned.[7] However, in skilled adults the visual word form area shows a strong early response to letter strings, never before seen, and is sensitive only to whether the strings are in accord with the rules of the written language (orthography).[8] These differences between children and adults suggest possible approaches to intervention to improve reading fluency.

Genes. Another approach to the biological influence on literacy involves genetic studies. Studies of normally reading identical and fraternal twins suggest modest genetic contribution (accounting for about 40% of the total variance) for both phonological skills, (i.e. deciding whether 'row' and 'through' rhyme) and orthographic skills (i.e. deciding whether a 'bare' or a 'bear' sits in the woods.) A portion of chromosome 6 may be of special significance for reading[9] and chromosomes 1 and 15 may also be involved. Efforts are being made currently to determine the exact genes involved.

Interventions. While genes are important in the development of brain networks involved in reading, intensive instructional interventions have been shown to change patterns of brain activity in these networks. Children with reading impairments typically show reduced activation of phonological regions during reading tasks, but this can change with intensive reading remediation.[10] One intervention method that has been examined in an imaging study is called Word Building.[11] Word building is one specific effort designed to draw a child's attention to letter-sound combinations at all positions within written words. Children and tutors enjoy using word building, and it does produce considerable improvement in children learning to read English within only 20 sessions that can be covered in a few days of computer aided instruction or over a few weeks in a classroom. Children show strong improvements in word sounding skills, in comprehension of passages and in phonological awareness. Moreover, there is evidence that this kind of learning changes the brain network related to reading just the way one might predict from the idea that the child is developing the strong phonological analysis ability of a skilled reader.[12]

Another training method that has been shown to produce changes in brain activity changes is called Fast ForWord„ and seeks to teach children to listen to rapidly changing auditory information that is critical for properly hearing the phonemes within spoken words.[13] Phonemic skills are developed by contrasting artificial stimuli that draw attention to this information by amplifying and stretching out these components in time until they become obvious to children who at first have difficulty hearing some phonemes. Training in this way eventually allows the child to become more aware of phonemes in the speech stream. This kind of training was shown to improve reading impaired children's ability to sound out visual words and increase activation of the posterior areas related to phonology.[14]

EN BREF

Le Center for Educational Research and Innovation (CERI) de l'Organisation de coopération et de développement économiques (OCDE) a complété la première étape de son initiative visant à susciter une meilleure compréhension des mécanismes cérébraux reliés à l'apprentissage. Le présent article décrit certaines des idées courantes sur les mécanismes touchant la lecture ainsi que les efforts qui sont déployés pour arriver à un consensus sur ce que l'on peut accomplir dès maintenant pour favoriser l'alphabétisme et encourager des recherches additionnelles sur diverses questions d'éducation. Outre l'établissement d'un consensus et la création de nouvelles connaissances, l'initiative vise à diffuser à grande échelle l'information sur les mécanismes cérébraux à l'œuvre au cours de l'étape initiale d'alphabétisation et sur les techniques d'intervention qui les favorisent.

FOSTERING EXCHANGE BETWEEN LABORATORY SCIENCE AND EDUCATIONAL PRACTICE

Despite the progress that has taken place, there remain many things about reading we do not know and many issues still in dispute concerning the things that we think we do know.[15] However, we are determined not to allow our own doubts and uncertainties to prevent presenting our findings to those educators and lay persons concerned with literacy, in hopes that these findings could be of benefit in efforts to design and use better educational materials. We also hope the findings may be useful to policy makers in the allocation of scarce resources in the important fight again illiteracy.

Education laboratory. An impediment to educational applications of brain research is the remoteness of the classroom from the laboratories in which most research is performed on brain mechanisms underlying skills. We propose two steps to reduce these barriers. By bringing together educators, policy makers, cognitive psychologists and neuroscientists in an intensive network of meetings and electronic communication, we hope to initiate a process in which findings can be discussed and a consensus among communities achieved on what we know and what we need to know. We have already held several major meetings on general issues of brain studies related to early child education, schooling, and lifelong learning. Out of this process came the decision to concentrate on the acquisition of literacy and numeracy and lifelong learning. We are organizing the network on literacy, and we hope over the coming years to involve all of the major researchers, educators and consumer groups, here and around the world, in this enterprise. Obviously the American and Canadian educational communities are of central importance in this effort.

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We also hope to bring the classroom and the laboratory closer together by implementing web based simulations and interventions that will provide children and teachers the opportunity to try out new ideas and will also be the laboratory where researchers can implement their ideas and observe the reaction of students and teachers, including the rate of change of performance during the acquisition of literacy. The convenience and availability of real educational data could help attract new researchers to this area.

Extentions. Many of the core ideas about brain mechanisms of reading have involved processing individual words, most often English words. We plan to use the extensive data on reading of English words as a starting place and from there expand our efforts to other languages that involve different principles of relating written symbols to meaning. We also plan to move from isolated words and phrases toward the integration of text, pictures, graphs and formulae required in the comprehension of technical and scientific documents.

In all of these steps we hope to keep it clear that we are not selling a finished educational product. Rather we are trying to implement a process in which many ideas plausible to the research community can be tested in a learning environment.

DISSEMINATION

An additional barrier to fruitful exchange between laboratory investigations of brain mechanisms and educational research into reading acquisition is that results within brain research have not been particularly accessible to those outside the discipline. Theories about pedagogy in early reading and explorations of brain mechanisms critical for early reading are typically carried out by very different groups that share little knowledge of each other's experiences, methods, assumption, and goals. In addition to consensus building and innovation of new knowledge, our plan for the literacy network involves efforts to make the overlap between brain mechanisms of early literacy and intervention techniques widely accessible.

One critical aspect of this plan involves annual OECD reports, specifically targeted toward Ministries of Education, but widely published throughout the world. These reports, and supplemental materials on the web, will contain review articles contributed by teams of researchers specializing in a particular area, along with commentary pieces written by professional science writers, designed to increase the accessibility of the scientific publications.

During the next two years we plan to develop web based intervention that can be used by researchers and children for the acquisition of initial literacy of individual English words. This could potentially bring laboratory tested intervention procedures directly to many children throughout the world. Success at this venture might lead, by the end of the decade, to a broader range of curricular materials available to researchers and teachers in many languages.

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