3RD MEETING OF THE LIFELONG LEARNING NETWORK

RIKEN, Wako, Japan

20 January 2005 - 22 January 2005

PROPOSITION PAPERS

CONTENTS

CHRISTINA HINTON

christinadiane315@yahoo.com

In the development of a transdisciplinary approach to educational policy design, it is important to be clear about the purpose of utilizing neurobiological knowledge. It cannot be used to generate a universal, prescriptive pedagogical approach but to inform the construction of pedagogy within each context. Neurobiologically-based educational policy cannot simply be inserted into schools in a unidirectional manner; the educational implications of any research must engage in a synergistic interaction with each educational community such that policy that is appropriate for each school culture is developed. Therefore, a prudent goal is to make potentially informative neurobiological knowledge widely accessible to those engaging in educational policy design. Those designing educational pedagogy would then be responsible to use this information to construct policy that is appropriate for a given school culture and then systematically examine the effectiveness of such policy once implemented.

Applying this framework of purpose to the domain of lifelong learning, it is necessary to identify neurobiological knowledge concerning lifelong learning with relevance for educational policy design. This identification process requires a working knowledge of what is known or could be discovered about lifelong learning in the field of neurobiology as well as an understanding of key educational policy issues. The overlap between these two can be used to shape the objectives of a transdisciplinary approach to the study of lifelong learning.

One such area of overlap involves how the brain evolves across the lifespan as a result of learning experiences, and how this could impact the conception of the lifelong learning process. Neurobiological research has revealed that the brain is not a stable, isolated entity but rather an active, dynamic system that is keenly responsive to experience (Squire and Kandel, 1999). Elements of the brain involved in learning continually undergo experience-dependent structural reorganization with functional significance for how future information is processed (Cruikshank and Weinberger, 1996; Elbert et al., 1995; Frégnac et al., 1988, 1992; Pantev et al., 1998; Recanzone et al. 1993; Schulz et al., 2003; Squire and Kandel, 1999; Sterr et al., 1998). This continuous brain reorganization results in a unique architecture of each individual's brain at a given time (Squire and Kandel, 1999). This conception of an active, responsive brain supports the idea that the ability to learn is a malleable rather than fixed capacity, which informs a long-standing debate in education between an incremental (malleable) and entity (fixed) theory of intelligence (Dweck, 2002; Dweck and Leggett, 1988; Dweck and Sorich, 1999; Henderson and Dweck, 1990; Stipek and Gralinski, 1996; Stone, 1998). Furthermore, because the structure of the brain underlies its function, the fact that each individual's brain has a unique structure suggests that knowledge is not passively etched into the brain but rather uniquely constructively represented based up on its current architecture. This supports a constructivist view of learning whereby the learner actively constructs knowledge rather than passively acquiring it (Piaget, 1954; Smagorinsky, 2001; Vygotsky, 1978).

A deeper understanding of temporal constraints on the brain's evolution across the lifespan could also have important implications for the design of educational policy.

Neurobiological research suggests that there may be patterns of periodicity during the brain's development (Curtiss, 1977, 1988; Ebert et al., 1995; Herrman and Arnold, 1991; Hubel and Wiesel, 1968; Johnson and Newport, 1990; Newport 1990, 1991; Sanes et al., 2000). In fact, there may be sensitive periods in development for specific types of learning during which the brain is capable of undergoing functionally-significant changes to a degree that cannot be attained after the closure of these periods (Curtiss, 1977, 1988; Ebert et al., 1995; Herrman and Arnold, 1991; Hubel and Wiesel, 1965; Johnson and Newport, 1990; Newport 1990, 1991; Sanes et al., 2000). Recent research suggests that such periods may exist for the development of language (Curtiss, 1988; Johnson and Newport 1990; Newport, 1990, 1991) and musical (Ebert et al., 1995; Pantev et al., 1998) abilities. A thorough understanding of these and any other sensitive periods could inform the timeframe of teaching certain subject matter.

An awareness of the factors influencing the brain's evolution can provide further insight into the construction of optimal learning conditions. For example, Progressive educators argue that optimal intellectual abilities can be developed only under conditions in which the health of the "whole child" is maintained (Dewey, 1938; Dworkin, 1959; Zilversmit, 1993). Recent neurobiological research has confirmed that physical, emotional and social health all have significant effects on the brain's state and receptivity to learning (Anderson et al., 2000; Geyer et al., 1993; Heritch et al., 1990; Kempermann, 1997; Krugers et al., 1997; Lu and Chow, 1999; McEwen, 1999; Neeper et al., 1996; Russo-Neustadt et al., 2000; Samorajski et al., 1985; Schrijver and Wurbel, 2001; Tong et al., 2001; van Praag et al., 1999; Winterfield et al., 1998). This knowledge indicates that educators have an indisputable responsibility to construct learning environments that nurture the health of the "whole child." Further neurobiological research concerning the factors that influence the lifelong evolution of the brain can be used to inform the construction of an educational environment that more optimally supports learning.

The field of neurobiology can support an understanding of the process of learning, the developmental constraints on learning of particular subject matter, and the factors affecting optimal learning conditions. Making use of this information to create pedagogy that is appropriate within particular context will foster the creation of educational policy that more optimally supports student learning.

Literature Cited

Anderson, B. J., D. N. Rapp, D. H. Baek, D. P. McCloskey, P. S. Coburn-Litvak, and J. K. Robinson. (2000). Exercise influences spatial learning in the radial arm maze. Physiol. Behav., 70 (5): 425-429

Cruikshank, S. J and N. M. Weinberger. (1996). Receptive-field plasticity in the adult auditory cortex induced by Hebbian covariance. Journal of Neuroscience, 15: 861-875.

Curtiss, S. (1988). Abnormal language acquisition and the modularity of language. In Newmeyer, F. (Ed.), Linguistics: The Cambridge survey ii. Linguistic theory: Extensions and implications. Cambridge, MA: Cambridge University Press.

Dewey, J. (1938). Experience and education. New York, NY: Macmillan.
Dweck, C. S. (2002). Development of ability conceptions. In A. Wigfield & J. S. Eccles (Eds.), Development of Achievement Motivation. Chapter 3. New York: Academic Press.
Dweck, C. and E. Leggett. (1988). A Social-cognitive approach to motivation and personality. Psychological Review, 95, 256-273.
Dweck, C. S. and L. Sorich,. (1999). Mastery oriented thinking. In C.R. Snyder (Ed.), Coping. New York: Oxford University Press.
Dworkin, M. (1959) Dewey on Education. NY: Teachers College Press.
Elbert, T., C. Pantev, C. Wienbruch, B. Rockstroh and E. Taub. (1995). Increased cortical representation of the fingers of the left hand in string players. Science, 270(5234): 305-307.
Frégnac, Y., D. Shulz, S. Thorpe, and E. Bienenstock. (1988). A cellular analogue of visual cortical plasticity. Nature, 333: 367-370.
Frégnac, Y., D. Shulz, S. Thorpe, and E. Bienenstock. (1992). Cellular analogues of visual cortical epigenesis. I. Plasticity of orientation selectivity. Journal of Neuroscience, 12: 1280-1300.
Geyer, M. A., Wilkinson, L. S., T. Jumby, and T. W. Robbins. (1993). Isolation rearing of rats produces a deficit in prepulse inhibition of acoustic starle similar to that in schizophrenia. Biol. Psychiatry, 34: 477-481.
Henderson, V., & Dweck, C. S. (1990). Achievement and motivation in adolescence. A new model and data. In S. Feldman & G. Elliot (Eds.), At the threshold: The developing adolescence. Cambridge, MA: Harvard University Press.
Heritch, A. J., K. Henderson, and T. C. Westfall. (1990). Effects of social isolation on brain catecholamines and forced swimming in rats: Prevention by antidepressant treatment. J. Psychiatr. Res, 24: 251-258.
Herrmann, K. and A. P. Arnold. (1991). The development of afferent projections to the robust archistriatal nucleus in male zebra finches: A quantitative electron microscopic study. J. Neurosic., 11: 2063-2074.
Hubel, D. H. and T. N. Wiesel. (1968). Receptive fields and functional architecture of monkey striate cortex. J. Physiol, 195(1): 215–43.
Kempermann, G., H. G. Kuhn, F. H. Gage. (1997). More hippocampal neurons in adult mice living in an enriched environment. Nature. 386: 493-495.
Krugers, H. J., B. R. Douma, G. Andringa, B. Bohus, J. Korf, and P. G. Luiten. (1997). Exposure to chronic psychosocial stress and corticosterone in the rat: effects on spatial discrimination learning and hippocampal protein kinase Cgamma immunoreactivity. Hippocampus. 7: 427-436.
Lu, B. and A. Chow. (1999). Neurotrophins and hippocampal synaptic transmission and plasticity. J. Neurosci. Res., 58: 76-87.
McEwen, BS. (1999). Stress and hippocampal plasticity. Annu. Rev. Neurosci. 22: 105-122. Berardi, N., T. Pizzorusso, G. M. Ratto, and L. Maffei. 2003. Molecular basis of plasticity in the visual cortex. Trends in Neuroscience, 26(7): 369-378.
Neeper, S. A., F. Gornez-Pinilla, J. Choi, and C. Cotman. (1996). Physical activity increases mRNA for brain-derived neurotrophic factor and nerve growth factor in rat brain. Brain Res., 726: 49-56.
Newport, E. (1990). Maturational constraints on language learning. Cognit. Sci., 14: 11-28.

Newport, E. (1991). Contrasting concepts of the critical period for language. In S. Carey and R. Gelman (Eds.), The epigenisis of mind: Essays on biology and cognition. Hillsdale, NJ: Lawrence Erlbaum Associates.

Pantev, C., R. Oostenveld, A. Engelien, B. Ross, L. B. Roberts, and M. Hoke. (1998). Increased auditory cortical representation in musicians. Nature, 23;392(6678): 811-814.

Piaget, J. (1954). The construction of reality of the child. (M. Cook, Trans.). New York: Basic Books.

Recanzone, G. H., C. E. Schreiner, and M. M. Nerzenich. (1993). Plasticity in the frequency representation of primary auditory cortex following discrimination training in adult owl monkeys. The Journal of Neuroscience, 13(1): 87-103.

Russo-Neustadt, A. A., R. C. Beard, Y. M. Huang, and C. W. Cotman. (2000). Physical activity and antidepressant treatment potentiate the expression of specific brain-derived neurotrophic factor transcripts in the rat hippocampus. Neuroscience, 101: 305-312

Samorajski, T., C. Delaney, L. Durham, J. M. Ordy, J. A. Johnson, and W. P. Dunlap. (1985). Effect of exercise on longevity, body weight, locomotor performance, and passive adoidance memory of C57BL/6J mice. Neurobiol. Aging, 6: 17-24.

Schrijver, N. C. A. and H. Wurbel. (2001). Early social deprivation disrupts attentional, but not affective shirts in rats. Behav. Neurosci., 115: 437-442.

Schulz, M., B. Ross, and C. Pantev. (2003). Evidence for training-induced crossmodal reorganization of cortical functions in trumpet players. NeuroReport, 14(20): 157-161.

Smagorinsky, P. (2001). If meaning is constructed, what is it made from? The Elementary School Journal, 102, 200-214.

Squire, L. and E. Kandel. (1999). Memory: From Mind to Molecules. New York, NY: Henry Holt and Co.

Sterr, A., M. M. Muller, T. Elbert, B. Rockstroh, C. Pantev, and E. Taub. (1998). Perceptual correlates of changes in cortical representation of fingers in blind multifinger Brailler readers. J. Neurosci., 18(11): 4417-4423.

Stipek, D. J. and J. H. Gralinski. (1996). Children's belief about intelligence and school performance. Journal of Educational Psychology, 88, 397-407.

Stone, J. (1998). Theories of intelligence and the meaning of achievement goals. Doctoral Dissertation. New York University, New York.

Tong, L., H. Shen, V. M. Perreau, R. Balazs, and C. W. Cotman. (2001). Effects of exercise on gene-expression profile in the rat hippocampus. Neurobiology of Disease, 8: 1046-1056.

van Praag H., B. Christine, T. Sejnowski, and F. Gage. (1999). Running enhances neurogenesis, learning, and long-term potentiation in mice. Proc. Natl. Acad. Sci. U. S. A. 96: 13427-13431.

Vygotsky, L. (1978). Mind and society. Cambridge, MA: Harvard University Press.

Winterfield, K. T., G. Teuchert-Noodt, R. R. Dawirs. (1998). Social environment alters both ontogeny of dopamine innervation of the medial prefrontal cortex and maturation of working memory in gerbils (Meriones unguiculatus). J. Neurosci. Res., 52(2): 201-209.

Zilversmit, A. (1993). Changing Schools: Progressive education theory and practice, 1930-1960. Chapter 1, (pp. 1-18).Chicago: University of Chicago Press.

PAUL HOWARD-JONES

Bristol University, UK

Scientific issues on the way to interdisciplinary research in lifelong learning

Several scientific issues appear pivotal for studies aimed at applying neuroscientific approaches in education. Would answering these neuroscientific questions help generate "provisional principles" for interdisciplinary investigations that inform education more effectively?

For example:
Q: Links between blood flow in the brain and effortful learning are not clearly understood (e.g. we do not know the details of what physiologically accounts for increases in volume in some instances - Draganski et al, 2004). Would a better understanding of the mechanisms and correlates of learning-induced plasticity, over the life course, and its apparent physiological precursors such as blood flow, be of fundamental importance in using neuroimaging, and other techniques, to make claims about the effectiveness of a teaching and learning strategy?

Q: To what extent *should* we expect successful educational remediation to be linked with increased activity in particular areas of the brain?

Q: What is the role of physiological measures/imaging in helping to evaluate learning? How should we employ such physiological investigations to enhance appropriate educational/cognitive/behavioural assessments?

General Issues regarding research strategy

In terms of educational impact, Gardner's theory of multiple intelligences has entered the educational bloodstream with great success.

Q: Gardner's theory (Gardner, 1983) is thought by many educators to be a successful example of neuroscience informing education. Is this a positive example of an uncontroversial and unthreatening idea (in educational terms) becoming easily accepted and "owned" by education? Or should neuroscience be focused more upon counter-intuitive insights, as suggested by Blakemore and Frith (2000)?

Koizumi (2004) proposes a "need to create a new methodology and new organizations, including a common language that makes it possible to transcend the borders between disciplines….a strong incentive is necessary for bringing the precession of disciplines into convergence" Research aims that are professionally appropriate might be a strong incentive. In education, research is usually expected to have prompt observable impact in terms of practice. In neuroscience, research is usually expected to provide fundamental knowledge about the brain. Different categories of interdisciplinary neuroscience/education projects may vary in the extent to which they serve these very different aims. For example

1. Neuroscientific laboratory-based projects extending neuroscientific knowledge in ways that provide insights to educators.

2. Educational classroom-based projects that involve field-testing of approaches inspired by insights from neuroscience.

Q: Can exemplar projects, or models of projects, be envisaged that involve educators and neuroscientists and that combine both types of approach?

Cognitive aspects of computer-based learning, including collaborative learning, appear more amenable to investigation by neuroimaging than other types of lifelong learning.
Q: Should future interdisciplinary research be targeted here?

Issues regarding specific research questions

Q: EEG feedback has been shown to provide significant improvements for music performance and in other cognitive tasks (Egner and Gruzelier, 2001, 2003). Despite its apparent success, these interventions are not built around any particular cognitive model and the processes by which improvement were achieved are not well understood. Since this was a successful intervention, should more be done to understand neurofeedback works and whether it can be more widely applied?

Q: Should educators focus more upon learners' understanding of their own and others' minds, including their brains, & assume this construction of mind/brain is a fundamental tool of learning?

Issues of policy

Q: How should the practical implications of life long plasticity/periodicity be determined?

Issues of theoretical perspective

The basic notion that brain science can be worth considering within an educational context has been challenged by educators (e.g. Davis, 2004). Such challenges often refer to the dangers of ignoring the wider social environment.

Q: Does this rejection, in some instances, of the relevance of brain science emphasise the need for a clearly articulated model of how our knowledge of the brain, and the epistemologies related to its determination, interrelate with other, more social, perspectives on learning?

The resonance between the emphasis of cognitive neuroscience upon brain function, and education's increasing interest in transferable "soft" skills may help redefine what education is for. Koizumi (2004) has proposed a radical re-definition of education in terms of the brain:

"Education is a process of optimal adaptation such that learning is guided to ensure proper brain development and functionality"

Q: Is there evidence that shows we should concern ourselves more with how learning across the life course contributes to maintaining mental health?

Q: Are cognitive programs, such as those for the control of Alzheimer's or affective disorders, a suitable target for interdisciplinary education/neuroscience research?

References

Blakemore, S.J. and Frith, U. (2000) Report on the implications of recent developments in neuroscience for research on teaching and learning - a consultation paper commissioned by the Teaching and Learning Research Programme, ESRC.

Davis, A. (2004) The credentials of brain-based learning, Journal of Philosophy of Education, 38(1), 21-35.

Draganski, B., Gaser, C., Busch, V., Schuierer, G., Bogdahn, U., May, A.(2004)Nature, 427, 311-312.

Egner, T. and Gruzelier, J.H. (2003) Investigating the use of EEG biofeedback in the enhancement of music performance, Abstracts of the British Psychological Society 30th Annual Scientific Meeting, JOP 17(2) p104.

Egner, T. and Gruzelier, J.H. (2001) Neuroreport, 12, 4155-4160.

Gardner, H. (1983) Frames of Mind: The theory of multiple intelligences. London: Fontana Press.

Koizumi, H. (2004) The concept of "developing the brain": a new natural science for learning and education, Brain and Development 26, 434-441.

JELLEMER JOLLES and H. B. M. UYLINGS
(Position paper 1)

Brain & Learning in developmental perspective in relation to brain plasticity, cognition and education[1]

J. Jolles[1] and H. B. M. Uylings[1]Institute Brain & Behavior, division of Neuropsychology, University Maastricht, Box 616, 6200 MD Maastricht, The Netherlands, j.jolles@np.unimaas.nl. [2] Netherlands Inst. Brain Res., KNAW, Amsterdam; Dept Anat. VU university medical center, Amsterdam, The Netherlands

Introduction on the 'Brain & Learning' viewpoint.

A conference on 'Brain & Learning' and the implications of a new learning science as proposed by OECD-CERI has been organized in the Netherlands in February 2004. J.J was chairman and H.U was member of the organizing committee, which was installed by the Dutch Science Foundation (NWO). A report has been made which gives the direction in which the field should develop in the next five years. The committee states that an active interaction should develop between researchers from brain science, cognitive science and educational science in collaboration with educational professionals. A special place should be taken by evidence-based interventions in an educational setting. According to the committee, it is essential to take the whole life span into consideration, according to the motto 'A Life Long Learning for All', as has also been proposed by OECD-CERI.

In the Netherlands, NWO has started the development of a strategy document describing the research in the period of 6 years to come. 'Brain & Learning in relation to development and education' has high chances to be selected as a major field/topic in this strategy. In the next paragraph, statements are given which are derived from the 'Brain & Learning endeavour in the Netherlands, as contribution to a strategic discussion in the Japan meeting of the LifeLongLearning Network of January 20-22, 2005. This is part 1, which is dedicated to brain changes and cognitive factors. Part 2 has to do with emotional/motivational factors.

Statement 1. The dialogue between disciplines needs to be stimulated. It is imperative that priority is given to clarification of the position of the various disciplines, research fields and applied fields. There are strong indications that lack of progress in the development of 'a new learning science' may be due to misunderstandings between representatives of the various disciplines. There is especially a need for clarification of words, concepts and approaches related to 'learning', 'education', 'memory', 'concentration', 'attention', 'motivation', 'emotion' and the like. In research and educational settings, very different aspects of 'learning' may be involved.

Statement 2. It is essential that clear models and theories are created with hypotheses, which can be evaluated, and an approach, which is 'evidence-based'. Revolutions in both brain research and cognitive research have been based upon clear models and approaches for evaluation of new interventions. Similar approaches should be developed and used in educational settings. Experimental learning interventions should be used.

[1] The paper is based upon the report 'Learning the brain to know' bij Jolles, de Groot, van Benthem, Dekkers, de Glopper, Uijlings and Wolff-Albers. Dutch Science Foundation/NWO 2005.

Statement 3. Insight into neural principles (brain structure, function, neurochemical processes) is needed in order to understand how to approach the plasticity of the brain in an optimal fashion. The effectiveness of interventions which are directed at behavioral change or improved performance can be monitored not only at the cognitive and behavioral level but also on the neural level (eg by functional imaging, outgrowth of neurons, sensitization of receptors etc).

Statement 4. Special emphasis should be given to the evaluation of the influence of environmental influences on learning in the various phases from young to old. Individual differences in environmental stimulation are of great importance in explaining different learning trajectories and cognitive potential. The plasticity or adaptational capacity of the brain is influenced by these environmental factors, in interaction with biological factors. Relevant are psychosocial factors, education, empathy of parents and teachers, but also diseases, drug-use, hormonal factors and other biological factors.

Statement 5. Cognitive factors related to 'executive functioning' should be investigated in relation to learning in more depth and applied in educational settings. The executive functions should be considered the central cognitive function in a learning environment and educational setting as they allow us to learn new behavior in relation to a changing environment. Relevant executive functions are planning, behavioral organization, working memory, attention, concentration, impulse-monitoring, behavioral evaluation and self-monitoring.

Statement 6. Evaluation of different learning trajectories in girls/boys, women/men and the influence of age on optimal educational strategies is of major importance; what is the influence of knowledge, use of strategies and efficiency of information processing. There is much relevant information, which has been obtained in 30 years of research in cognitive psychology. This knowledge should be linked to developing knowledge on the biological basis of brain development and possible differential use of the brain. As an example, young subjects use information-driven capacities whereas adults and older people compensate for reduced information processing efficiency by better anticipation and other –more explicit- processing strategies.

Statement 7. More attention should be given to existing individual differences in cognitive functioning and to the nature of effective learning strategies which underly these differences. Current knowledge about brain and cognitive mechanisms has the potency to contribute to an optimal instruction technology, which is tailored to the target population. It should be different for the various age groups, for subjects with a learning problem, dyslexia, attentional problems, for mentally gifted subjects, for adults and for older people.

Statement 8. The quality of the learning environment is of utmost importance for the result of the learning process. The quality of the teacher, his/her didactic model but also 'empathy', the nature of the support system (parents, peers, social environment, dogma's as to 'learning is for nerds') and related factors are at least as important as the biology of the brain. Both brain, cognitive and psycho-social/environmental factors are important for learning. More research emphasis should be directed at transdisciplinary approaches.

JELLEMER JOLLES and H. B. M. UYLINGS
(Position paper 2)

Brain & Learning in developmental perspective in relation to emotion/motivation and education[2]

J.Jolles[1] and H.B.M. Uylings[2]

Prof. Dr Jelle Jolles, [1]Institute Brain & Behavior, division of Neuropsychology, University Maastricht, Box 616, 6200 MD Maastricht, The Netherlands, j.jolles@np.unimaas.nl.
[2] Netherlands Inst. Brain Res., KNAW, Amsterdam; Dept Anat. VU university medical center, Amsterdam, The Netherlands

Introduction on the 'Brain & Learning' viewpoint.

A conference on 'Brain & Learning' and the implications of a new learning science as proposed by OECD-CERI has been organized in the Netherlands in February 2004. J.J was chairman and H.U was member of the organizing committee, which was installed by the Dutch Science Foundation (NWO). A report has been made which gives the direction in which the field should develop in the next five years. The committee has the opinion that an important place should be taken by research into emotional and motivational mechanisms underlying learning and by evidence-based interventions in an educational setting. According to the committee, it is essential to take the whole life-span into consideration, according to the motto 'A Life Long Learning for All', as has also been proposed by OECD-CERI.

With respect to the Netherlands, NWO has started the development of a strategy document describing the research in the period of 6 years to come. 'Cognition in relation to development, education and emotional/motivational factors' has high chances to be selected as a major field/topic in this strategy. In the next paragraph, some topics are described as a contribution to a strategic discussion in the Japan meeting of the LifeLongLearning Network of January 20-22, 2005. This is position paper part 2, which has to do with emotional-motivational factors. It has also been used as position paper for the November 2004 meeting on Emotion, motivation and learning in Copenhagen, also organized under auspices of OECD-CERI. Position paper 1 was dedicated to brain changes and cognitive factors

Topic 1. Cognitive versus social learning in adolescence and the role of emotions and motivations. The adolescence is the period in which the brain is optimally suited for cognitive learning. However, the adolescent boy or girl is much more interested in social interactions with peers. Negative attitudes and perceptions can develop in that period with respect to the importance of learning '(learning is for nerds', arithmetic is totally unimportant'). This has major implications for the learning trajectory, which the student follows. Brain research, on the other hand, shows that individual differences in brain maturation could determine the way the subject copes with environmental stimulation. Psychosocial circumstances thus could modulate further maturation of the brain and thereby 'tune' further learning in positive but also negative direction. It is of major importance to study the role of emotions and motivations in this target group, especially

[2] The paper is based upon the report 'Learning the brain to know' bij Jolles, de Groot, van Benthem, Dekkers, de Glopper, Uijlings and Wolff-Albers. Dutch Science Foundation/NOW 2005.

in relation to optimizing learning motivation. Learning could be stimulated in settings, which favor the social interactions which adolescents are interested in.

Topic 2. Motivational processes and learning attitudes. Animal and human brain research on the basic mechanisms underlying learning have shown that particular emotional stimuli but also motivational factors are essential for optimal learning. Memory consolidation is dependant upon a minimum level of emotional or motivational stimulation. Likewise, recent cognitive psychological research is compatible with this notion. This research suggests that better incentives could be developed for the stimulation of motivation and learning attitude. It is suggested that particularly 'negative emotions' should be changed. The learning context should be changed in such a manner that learning and knowledge acquisition induces a positive emotion in the learner. Dedicated 'applied' research should be performed in this direction.

Topic 3. Negative emotions and stress can disrupt optimal learning. The emotional development of the child and adolescent is of crucial importance for the development of an optimal information processing ability. Knowledge acquisition is dependent upon an optimal 'rewarding' atmosphere in which the knowledge is presented. Stress and associations with 'negative' character are known to disrupt learning. This is known from animal experiments and learning in humans. The OECD report on Brain & Learning is compatible with this notion as 'self-control' and 'self-compassion' are of importance, in which emotional factors play a major role. Emotional and motivational factors are especially relevant in subjects with a learning disability or brain dysfunction and in aging subjects beyond the age of 30 years. Motivational/emotional factors are especially important in these groups because learning does not proceed as 'automatic' in these subjects as in young or young adult subjects. It appeared to be of utmost importance to develop and evaluate learning interventions in these groups and apply them in practice. Both cognitive factors and psychological factors are relevant in this respect. Cognitive factors are related to the nature of knowledge acquisition, and psychological factors are related to the 'attitude' towards change (e.g. 'This is too difficult, why would I try?').

Topic 4. The developing brain needs an 'external' motivator up till adulthood. Recent neuroscientific research shows that functional brain maturation proceeds up into the third decade of life. Adolescents are thus not fully 'ready' to take their role in society although many adolescents think they are. From a brain research point of view, this finding suggests that didactic/educational concepts which state that the educator should retreat and that education should change into 'facilitating' the autonomous learning process in children/adolescents should be considered with caution. It can be questioned whether children and adolescents are already able to find their own way in the diversity of knowledge domains. The role of a good teacher but also that of the parents as external 'motivator' should be reconsidered in a positive way. Research suggests that the educator should not only be the passive facilitator and 'tutor' who can give directions when asked, but should have a more pro-active attitude and motivate the student to engage in fields or domains in which he/she would never have started on his/her own. On the other hand, Motivation of the (older) teacher is essential too. More evidence-based research should be performed where self-initiated learning and leaning based upon external motivators are directly compared.

Topic 5. Motivational problems in students could be due to inappropriately organized education. Brain areas which are involved in planning, problem solving,

social learning, self-monitoring and social monitoring as well as self-initiation and impulse-management develop until well in adulthood. They are related to the frontal areas in the brain. Environmental factors, learning experience, culture and other psychosocial factors could therefore be of major importance for optimal learning. It is therefore probable that motivational problems are especially due to insufficiently organized education, which does not take into consideration inherent motivations and interests of the student and 'culture'. Important issues to evaluate in new 'evidence based' educational research are 1) the role of information processing styles (language thinkers versus perception thinkers), 2) the role of diurnal rhythms, 3) the role of emotions and stress ('angry children can not learn'), 4) the possible use of 'gaming' and social interactions via the computer, 5) hormonal changes in the adolescence but also the difference between boys and girls in motivation, 6) the effects of movement on learning and individual learning styles.

Topic 6. Motivational processes, learning attitudes and curiosity. A possibly very relevant role is that of 'curiosity' which according to quite some brain research is innate. Quite some indications exist that curiosity is not stimulated by the present school systems. The curiosity appears to be related to brain-based attention to 'novelty'. New research should be performed in the educational setting which is directed at finding strategies to stimulate curiosity. It is important in this respect to change the educational system from 'knowledge-centred' into 'learner-centred'. It is relevant in this respect that the brain circuits underlying emotions are different from those underlying the primary motivations, but that they overlap in anterior brain areas. Use of insights from brain research and cognitive research should be relevant in this respect.

Topic 7. The role of emotional distress. Quite some children develop a negative attitude towards learning. They have negative experience with respect to some aspect of cognitive learning (e.g. problems with reading or arithmetic), some aspects of motor learning (being 'clumsy', bad performance in sports, or some aspect of social learning (not being able to make friends). These negative experiences can have a major influence on behavior, emotions and attitudes. Quite some children can develop a phobia towards cognitive or motor learning or social interactions. The prevalence of anxiety and depression in children is relatively high. This can have a major influence on their further development, choice of school type and thus determine their whole life. This is the more important because of the fact that individual differences appear to exist in brain and cognitive development. Children who are 'late' in development of a particular function could reach an asymptote later and even reach a higher asymptote than children who have a faster development. More research should be performed into these aspects of individual development and into strategies to preclude the development of emotional problems, anxiety and depression.

SANDRINE KELNER

Brain Research and Lifelong Learning
Proposition Note: a Teacher's Perspective

1) Key issues in lifelong learning

Dyslexia, dyscalculia, ADHD…

Those troubles are generally known and most of the time acknowledged by teachers but not really thoroughly. It is not always part of teachers' training and they start teaching knowing more or less that they might come across the problem without really knowing what it is all about.

- Teachers must use different ways of teaching/evaluating those children: how? when? where? to what extent have the tasks to be different?
- What has to be part of teachers' training (in terms of knowledge), what has to be done by therapists, how can the work be shared so as to be as efficient as possible? Would having specialists within schools be advisable?
- How can we lead administrators and politicians to set out real policies for these children as far as exams are concerned?
- Teachers have started working with speech therapists but it is not always satisfying, considering they don't always have answers to the wide range of issues that can come up. There's a strong need for training more accurately more specialists in the fields of neuroscience and education.

Sensitive periods

The concept probably is a key one in the field of lifelong learning. Although teachers have always observed and sensed it in a way (they can say a pupil is not mature enough for such and such a task) they don't have any concrete idea of what really is involved.
Do we have enough information on this issue to draw some sort of 'list' which could guide program makers, teacher trainers as well as teachers and parents towards a more appropriate progression in learning at school, out of school, and after school?

Emotional competency

Knowing about the existence of an 'emotional brain' can and has to have a major impact on teaching and learning. Here again, educators have a rough idea about the importance of emotions and the psychological state of mind of the children (or adult learners), but too often, they tend to avoid taking it into account.

- One reason is that they don't have enough scientific information about this emotional brain.
- Another reason is that if they've been trained to teach a particular subject, they haven't been trained to deal with emotions in the classroom. What often happens is that a teacher who has noticed something 'unusual' (that is which is not in the 'norm') sends the child to see either a social worker, a therapist or an educator.

- So the questions are: what should teachers learn about the emotional brain and the limbic system, how could scientists spread the information in the field of education, how can we get to a new way of teaching and make room within the programs for emotional regulation?

2) Miscellaneous questions

- For some children, 'learning' just seems to be impossible.

They can be taught something "easy to remember" (countries and their capitals, colours, or the days of the week in another language) and yet, though they have spent a few hours learning, playing, repeating one topic, they can't even remember half of it the next week. Is it important to carry on teaching them such topics in order to train their brain, keep it at work, and get them to 'think'? In other words, do teachers have to stick to manual tasks/handcrafts with these children/teenagers or is it important to stimulate their thinking skills?

- What do we know about the transfer of knowledge?

Lots of pupils acquire a certain amount of knowledge (in or out of school) which is piled up somewhere in their brain but when it comes to using this knowledge to fulfil a task, they're unable to link up what they know and what they have to do.
For example, although they can make full sentences in their own language, they are unable to make structured sentences in the foreign language they learn. They don't think of using conjugation, pronouns etc…they just use one word next to the other without trying to transfer what they 'naturally' do in their own language.
Could mental imagery be an answer to the problem?

- The problem of stimulating 'environments'

We know that a child grown up in an impoverished environment might still get to a higher level of education. However, if we look at national evaluations, it comes out that the results are much lower in 'ghetto schools' than others.
Pupils coming from immigration are confronted to real problems to adapt a new school system, not only because they have lost their usual landmarks, but also because they often live in ghettos where the stimuli are either very poor or inappropriate to the new culture they have to fit in.

- Towards a new science of learning

Would it be relevant to put less weight on 'writing'? In most educational systems 'writing' is much more important than 'speaking' and 'being'. If it is not always the case in class, exams are almost always based on 'writing' and going up the scale of degrees is synonym of being more and more 'academic'.

SØREN KJÆR JENSEN

Learning Lab Denmark (LLD)

-Questions from an educator

Practitioners get it all wrong, yes?
Having worked intensively with early child education in Denmark for the past three years, it sometimes has seemed to me as if 'brain science – education, a bridge too far' was an appropriate position: there is widespread misunderstanding of concepts from psychology and other fields. So what with brain science, are the dangers of misconception and wrong application not even graver?

For example there is a deep longing for theories like the Multiple Intelligencies and Multiple Learning Styles to fill certain needs in Kindergarten and school. These needs have to do with a.o. legitimising pedagogy, with supporting ideals of a varied and holistic pedagogy, and a wish for arguments that may shield the field and its children from international benchmarking and curriculum driven influences. It creates a fashion in education that is at least in danger of claiming untrue facts about e.g. how the brain works and learns. In using a traditional trickle-down view of how true research gradually moves into society there is obviously a problem.
But what if the problem does not lie first with the educators but with research and the universities?

I believe that it may seem as if this longing for evidence based methods is actually somehow a result of the research community and the universities failing in delivering practical methods and guidelines that are sufficiently sound, applicable, and appropriate for the daily life in kindergarten and other preschool institutions, as well as in schools and higher education.

So I shall argue that there is indeed a true need for the research community to address the needs of this community. And I believe that it is possible, as our researchers at LLD aim to do so every day.

From my place in the world the demand is particularly strong on exploring new terrain in brain science in relation to first embodiment, physical activity, and second the field of emotions and feelings. Jarl Bengtsson suggested in Copenhagen in September 2004 that we change the 'bridge' metaphor a bit: for example the bridge between Sweden and Denmark consist of bridge, tunnel and artificial island.
What, then, are the disciplines needed, and what are their tasks if we are to have a meaningful relationship between brain science and the learning community?

Embodiment, please
Embodiment has come into vogue in a number of disciplines. In Tokyo I should like to learn more about the role of the body in relation to learning in children, adults and seniors.
What can brain science tell us about the importance of embodied learning in different age groups?

Do environments that either inspire or prevent physical activity and exploration make a marked difference in human learning, particularly for children, but also for others? –How may this be investigated?
Can other disciplines than those within brain science itself move brain scientists to look into combinations of lab work and ecological quasi experiments, particularly on the importance of embodied cognition and learning? If not, why then?

HIDEAKI KOIZUMI
(Proposition Paper 1)

Building bridges between brain-science and education

Hideaki Koizumi, Ph.D.
Director, Brain-Science & Education Programs, Japan Children's Study, and the Center for Research on Brain-Science and Society (all under RISTEX, JST)
Fellow (Corporate Chief Scientist, Corporate Director), Hitachi, Ltd.
** RISTEX: Research Institute of Science and Technology for Society*
** JST: Japan Science and Technology Agency*

In 1996, the Japan Science and Technology Co. (JST) sponsored the Trans-disciplinary Symposium on Environmental Analysis and Measurement, held over four days in Sapporo. The symposium brought home the importance of considering the brain in environmental science and the interrelationship between the two. While knowledge of the epigenetic processes of the brain, or learning in other words, is a key to understanding the nature of the brain and human society, many environmental problems are due to the excessive production of artefacts as projections of the human brain. This consideration led to the concept of "brain-science & education". A further 4-day international symposium Trans-disciplinary Symposium on Developing the Brain: Science of Learning and Education was held in Oiso, right at the end of the 21st Century, under the auspices of the same sponsor.

The most important by-product of this symposium was the launching of a Brain-Science & Education program by JST in 2001. From that year until 2003, we commenced nine projects covering various aspects of the new trans-disciplinary field that we call brain-science & education. Of the nine, eight were cross-sectional studies. In 2004, we enlarged the organization and changed the structure to consist of two programs under the names Brain-Science & Education Type I and Brain-Science & Education Type II. The Type I program is for cross-sectional studies and the Type II program is for longitudinal studies. We added three new projects within the Type I program and started the Type II program with six projects. Almost all of the projects are strongly dependent on non-invasive brain function imaging.

Each project theme was selected through a competitive bidding system: the program coordinator sets a general field, and teams propose specific lines of research. Selected teams then receive grants. In each application process, we have had to choose from among a number of worthwhile projects, all having keen, capable, and experienced leaders.

We have a strong commitment to the concept of trans-disciplinarity; that is, we encourage research that transcends borders between completely different fields to arrive at new syntheses. Almost all of the projects involve close collaboration between brain scientists and educators. However, we wished to expand the scope of collaboration by creating bridges between scientists and scholars on the one hand and practitioners (teachers and clinicians) on the other. For this reason, we have also started a large-scale cohort study called the Japan Children's Study (JCS) as a separate top-down program. The objectives of this study are to elucidate the developmental mechanisms behind "sociability" and apply developmental and behavioral cognitive neuroscience to identify factors that make a nurturing

environment suitable or unsuitable for babies and children. A two-year pilot study commenced this year and will be followed by the study proper. The development of 10,000 babies and children is to be followed over 10 years (full and formal acceptance has been obtained for a five-year cohort study; this is to be followed by evaluation). All of the programs are coordinated by the Center for Research on Brain-Science and Society within the Research Institute of Science and Technology for Society (RISTEX).

We nominated the six themes listed below for projects to operate within the Brain-Science & Education Type II program.

1. Twin studies to clarify points of contact between genetic and epigenetic processes.
2. Studies of emotion intended to uncover mechanisms responsible for the will to learn.
3. Mechanisms of second-language acquisition.
4. Techniques for the early diagnosis of learning disabilities (including autism).
5. Preventing and intervening in dementia.
6. Gene-chip methodology to find out how environmental stimuli drive mRNA expression.

Where this is useful or required, the longitudinal cohort studies are to include further prospective or retrospective (generally prospective) follow-up studies based on completely non-invasive higher-order brain-function imaging or other techniques for observing brain functions.

We are also fostering collaboration between the project teams while ensuring that the originators get the credit for new ideas. The large-scale cohort study, the Japan Children's Study, is to be linked with follow-up studies.

Human cohort studies based on the concept of brain-science & education are likely to have three major sets of implications.

1. Human cohort studies based on brain science are expected to produce scientific evidence that will contribute to policy-making, especially on education and related issues that pose serious problems for modern human society. For example, we might uncover implications for policy on childcare, school education, or aging.

2. We will be able to assess the potential effects of new technologies on babies, children, and adolescents. For example, while humans had no experience of electronic information technology until very recent times, we have little idea whether or not such technology affects the human brain and mind. If it does have effects, we need to find out what they are.

3. Human cohort studies will allow us to test hypotheses drawn from animal and genetic case studies to see if they actually apply to people. For example, genetic mapping recently led to the hypothesis that the lack of only a few of the 3,000,000,000 base-pairs of DNA causes a particular kind of difficulty with language. The results of animal studies can neither conclusively prove nor disprove the validity of the hypothesis. Also, while a number of recent animal studies have indicated links between behavior and the expression of particular genes, we have no idea whether these findings have implications for human

development.

Through these projects, we intend to apply trans-disciplinary methods in the pursuit of greater human security and well-being.

HIDEAKI KOIZUMI et al.
(Proposition Paper 2)

Functional Reorganization in Damaged Elderly Brains (III)

H. Koizumi, Y. Yamamoto, M. Kiguchi and H. Kawaguchi
Advanced Research Laboratory, Hitachi, Ltd., Hatoyama, Saitama, Japan

H. Kato
Department of Neurology,
International University of Health and Welfare, Tochigi, Japan

E. Watanabe
Department of Surgical Neurology,
Jichi Medical School, Tochigi, Japan

I. Introduction

Since 2002, we have been studying the functional reorganization of damaged brains in elderly people as a project within the Life-Long-Learning Network under the Learning Sciences and Brain Research Program of OECD/CERI. The objective of this study is to elucidate the recovery mechanisms of the brain after injuries including those referred to as strokes, i.e., significant cerebral infarctions or haemorrhages. The results could give us important information on neuronal plasticity and the functional organization of the brain. This could reveal new details about the mechanisms that drive learning in neuronal systems. Also, the knowledge could lead us to practical new methodologies for higher-order brain-function rehabilitation, including countermeasures for paralysis and aphasia.

II. Working hypothesis

We prepared the following working hypothesis at the start of this project: “injuries to the brain are followed by a second critical period, i.e., a period where neuronal systems exhibit a high degree of plasticity”. If we are able to identify second critical periods of this kind even in the brains of elderly people, it will be instructive to find the similarities to and differences from the first critical periods, i.e., those which appear in the developmental stage. If there are similarities, they will be of particular interest as bases for bridges between the fields of aging and development, which are currently perceived as being very far from each other. In the future, this might also lead to a new emphasis on learning in the field of regenerative medicine. This will be extremely important as the issue of an aging society confronts various countries and is likely to face many more in the future.

III. Research organization

In this study, a number of institutions have been collaborating in a trans-disciplinary manner. The central part of the organization consists of three teams. The brain-science-application study team at the Hitachi Advanced Research Laboratory (HARL) is developing and supporting new non-invasive higher-order brain function imaging methodologies, such as near-infrared optical topography and fMRI. The neurology team of the International University of Health & Welfare and the surgical neurology team of Jichi Medical School are conducting longitudinal and cross-sectional clinical studies of paralysis and aphasia, respectively. Satellite teams from Tohoku University, Showa University, Tokyo Women’s Medical University, Nippon

Women's University and the National Institute for Physiological Sciences are loosely collaborating on these projects, and in some cases were at the core of the initial work.

IV. Results

1. Paralysis

One of the authors led teams, under initially at Tohoku University and then at the International University of Health & Welfare, that confirmed the working hypothesis; i.e., they demonstrated the existence of a second critical period of remarkable brain plasticity. Subjects were patients who had suffered acute strokes (cerebral infarctions or hemorrhages leading to severe brain damage). Longitudinal studies based on noninvasive higher-order brain-function imaging techniques such as fMRI and NIRS (optical topography) revealed processes of reorganization in functional areas within 2 months of the injuries. Three types of processes were observed.

2. Language

Groups under another of the authors, initially at the Tokyo Metropolitan Police Hospital and then at Jichi Medical School, discovered the migration of active areas during language task after infarctions which affected these areas, which are usually on the left hemisphere of the brain. The initial finding was reconfirmed by the identification of several similar cases. This fact will change conventional thinking with regard to the language areas of the brain. One longitudinal study by optical topography of a 68-year-old patient showed migration of the active area during language task from the left to the right hemisphere of the brain six months after the stroke. Furthermore, the active area during language task was shown to have returned to the left hemisphere (region peripheral to the injured language area) twelve months after the stroke.

Areas contra-lateral to the language areas are often related to music and might be involved in prosody. The findings suggest that language processing actually involves a broad network, bridging the left and right cerebral hemispheres. This challenges the conventional view, where the focus is on specialized functional loci of language processing. Furthermore, the mechanism underlying the reorganization of functional areas seen in these cases is likely to differ from the kind of reorganization described in the previous section.

3. Improvements in imaging methodology

The team at the HARL has been improving the imaging methodologies. Various improvements have been achieved, including greater safety and the elimination of motion artifacts. Among other things, this has allowed clinical teams to start work on a meaningful comparison of second critical periods triggered by injuries and the first critical periods seen in infancy.

V. Conclusions

To date, our project has revealed that brain injury to at least some regions of the brain is followed by a critical period in which plasticity is restored; this is probably comparable with the plasticity seen in younger brains. As next steps, functional imaging and molecular biology will be applied to compare and reveal details of plasticity in the brains of fetuses and infants, and in injured elderly people. This

should lead to a comprehensive concept of plasticity. We are particularly interested in the possibility that plasticity following a brain injury is due to gene expression. Furthermore, this research might also be related to stem cell studies conducted in the future.

The project has also shown that functional areas of the brain can migrate to compensate for injuries. In this area, we intend to perform observations that are more finely grained, in terms of both space and time. One objective is to see whether reorganization of this type is also associated with critical periods.

Regardless of the findings, the work will lead to improved methods of rehabilitation. In general, our hope is that the work will lead to greater human security and well-being.

Acknowledgement
We thank the other collaborative institutions and the many researchers whose names were precluded by considerations of space from inclusion at the top of this paper.

ART KRAMER

Take Home Messages for Educators Related to Aging and Learning

University of Illinois
December 29, 2004

What we know now (with varying degrees of certainty):

- Old dogs (and people) can learn new tricks.

  Although older adults may take longer and not reach the same level of mastery as younger learners current research does suggest that older adults can learn new perceptual-motor and cognitive skills.

  - Efficient learning may require that instructions and learning strategies be adapted for the capabilities and limitations associated with aging.

- There are multiple routes to cognitive vitality for older adults.

  - An ever increasing body of research suggests that older adults cognitive vitality can be aided by:
    - maintaining physical fitness
    - maintaining and expanding social networks
    - being involved in intellectually engaging activities – both through informal and formal training and learning
    - diets high in anti-oxidants, omega-3 fatty acids, etc

- The research on maintenance of cognitive vitality in human old age is supported by animal research which suggests that interventions like those listed above can result in:

  - increased angiogenesis
  - increased synaptogenesis
  - increased neurogenesis
  - increased production of neurotrophins and neurotransmitters

- There is a small but growing body of human neuroimaging research which tentatively suggests changes in brain structure and function with physical and cognitive training for older adults. Some of this research suggests the development of novel brain circuits to support performance improvements while other research suggests that it may be possible, in a sense, to turn back the clock , with regard to brain structure and function

- Interventions like physical training, cognitive training, and expanded social interactions appear to delay the onset of age-associated neuropathologies such as Alzheimer's dementia

Interesting topics for the next decade:

- What is the marginal utility of multiple “interventions” for the maintenance of cognitive vitality (and delay of age-associated neuropathologies) in old age?
    - Do you get more bang for your buck when you combine subsets of diet, exercise, cognitive training, and social programs?
    - How are the benefits of these interventions (both separately and in combination) realized in brain changes?

- When (and how much) should these interventions start for maximal benefit with regard to cognitive maintenance and delay of age-associated neuropathologies?
    - Do benefits of these interventions also depend on disease-related constraints (e.g. can people with MCI still benefit from these interventions)?

- How do we change public policies to engender individual and group behavior such that the interventions that we know are effective in the maintenance of cognitive vitality will actually be pursued and maintained by individuals?

- Can interventions be effectively custom-tailored based on genotype (i.e. consider the emerging field of molecular genetics for the understanding of disease and human cognition) to enhance the positive benefits with regard to cognitive vitality?

- How best do we integrate our increasing knowledge of pharmacology with non-pharmacological interventions for cognitive growth and maintenance for the mind and brain?

HEIKKI LYYTINEN

My proposal is based on data of potential interest to both educationalists and brain scientists

The key issues of learning that I propose for discussion are:

1. the language development that precedes and prepares for reading acquisition in children with and without familial risk for dyslexia
2. identification of precursors and predictors of failure to acquire reading skill using brain-related and behavioural methods at an early age
3. what can be done to prevent the failure of reading acquisition

Our intensive follow-up of 200 children has documented in detail what goes wrong in the development preceding a child's failure to acquire reading skill normally.

Of the methods of early identification, the development of letter knowledge is the most easy to assess and a surprisingly accurate predictor of reading problems. All children who failed to read during the first two grades (20/200) showed delayed development of letter knowledge, 1-3 years before school.

Although several routes of language development leading to such failure were observed, one training method helps most if not all and independent on IQ, - at least in regular orthographies. (It must be noted, however, that IQ is not any clear correlate of the ability to acquire reading skill - reading is based on its own relatively specific domain of cognitive architecture which shows substantial inter-individual variations in certain, mainly language related areas). Direct intensive training of the core skills of reading * grapheme-phoneme associations helps if the child can be motivated to continue training for sufficient time. A promising method is an implementation of the training into computer game contexts of interest to 5 to 8 year olds. The efficiency of one implementation has been intensively experimentally assessed and the results are available.

Presentation illustrating our data from a nine year follow-up of reading related cognitive development from birth is available. I am also prepared to report results of the training game.

MICHAEL MEANEY

The quality of early life defines development both in terms of human capacity and health. These outcomes are interdependent. Health is determined by education and cognitive-emotional function over the lifespan. Oddly, institutionally, these two crucial domains are often considered independent. Thus, governments are usually comprised of ministries of health (often including social services) and education. Only in a few rare cases do these ministries interact in defining initiatives that influence child development.

This perspective is completely at odds with developmental biology. The development of the brain, as with all organs and tissues, is influenced by rudimentary environmental influences that include parental care, nutrition, housing, social interactions with peers and extended family, community services, etc. Stressful environments, where fundamental requirements for development are insufficient, including emotional needs, alter function throughout the body. Research in Pediatric Endocrinology reveals that children born in to and reared under impoverished conditions respond with a series of adaptations that bias the individual towards obesity (through hyperlipidemia and hyperglycemia), diabetes and heart disease. These very same conditions also compromise neural development and lead to alterations in attention and learning. Such children are often easily distracted, show poor behavioural and emotional impulse control and a proclivity for early drug use and sexual interactions (often associated with early pregnancy). Our approach to education rarely accounts for such individual needs. Rather, our egalitarian bent leads to a “one size fits all” approach. Failings within educational settings are considered as the baliwick of educators, as opposed to health professionals.

The question then is what could be gained with an integrative approach that views health and education as interdependent issues that require a concerted and unified focus from governments. Health scientists and macroeconomists have clearly outlined the remarkable health benefits associated with increased education. This is particularly true for women’s health, but that is largely a question of the specific outcome under study. Countries that invest in education experience remarkable benefits in the health of individuals, as well as in the health of children born into those societies. But the reverse is also very likely true. Investments in the health of women and infants would likely improve performance on educational outcomes: Certainly everything we know from health research suggests this is the case (i.e., consider the cognitive development of premature and small for gestational age babies).

There was a time in Canadian schools, when each institution had an on-site nurse and psychologist. I wonder whatever happened to that tradition. With the proliferation of Western lifestyles, there is an ever-increasing rate of childhood diabetes and anxiety disorders. In many instances the serious health problems of even younger children are now detected simply because scientists are bothering to study the issue. It is a rather daunting picture. How can we expect children whose health is seriously impaired to function in an educational setting? Unlike our colleagues in developing countries, why do we ignore the obvious benefits of institutionally linking health and education? In North America, intervention studies that directly target relevant environmental conditions examine effects on either educational or health outcomes,

but rarely both. We in the health sciences in OECD countries are left in the peculiar position of advocating for childhood education on the basis of studies from the developing world as if such concerns were no longer relevant to our children.

My argument is for an expanded discussion between health practitioners and educators that works in both directions. Perhaps such discussion might involve potential initiatives that could be commonly supported by ministries of health and education.

DENIS RALPH

Professor Denis W. Ralph
Faculty of Education, Humanities, Theology and Law
Flinders University, Adelaide, Australia

Proposition Note: Brain Research and Lifelong Learning: Impact capacity shaping strategies for enhancing the quality of teaching and learning across education and training systems

In order to meet the challenges facing society we need to make profound changes in the nature and effectiveness of learning across all stages of the lifespan of our citizens. There is a need for the shaping of policies, priorities and programmes which will have a dramatic impact on our capacity to rethink a wide range of elements. A list of these elements could include pedagogy, knowledge of the learning sciences, curriculum theory and construction, learner engagement, well-being and achievement and a focus on Learning to Learn, schooling and learning institution redesign, enhancement of the knowledge and skills of our teachers , adult learning principles and arrangements, to mention a few!! In fact it can be so overwhelming to the educational practitioner that we should not be surprised to find that many of them ignore the change agenda and continue down what they see as a more uncomplicated well-trodden path which sadly results in poor outcomes for the 21st century learner.

Those leaders in learning who recognize a need to change many aspects of the way we instill change across education systems are exploring new policy frontiers and seeking political commitment and resource allocations to fuel sustainable, system-wide developments. One such area is in the quest to better understand individual human learning and the workings of the brain and mind. Many educators are grappling with the complexities of brain research and the neurosciences. In seeking simplistic descriptions of complex processes some have fallen prey to the perpetrators of “neurobabble” and those populists with an amazing capacity to produce big neuroscience primers, but which sadly lack proper scientific credibility. Unfortunately, there are many examples of early adopters of new and largely unproven ideas who have implemented changes not helpful to quality learning. However, there are many who are taking a measured and sensible approach which draws on the verified outcomes of brain research and cognitive science findings. An outstanding example of the latter group is in the Department of Education and Children’s Services (DECS) in South Australia where their “Learning to Learn” project is proving to be an innovative and productive approach to instilling research findings into educational practice. Details are available at: www.learningtolearn.sa.edu.au

The “Learning to Learn” project in South Australia has a commitment to draw from recent research in the neurosciences and this education system has a strong lifelong learning perspective impacting on all aspects of its work. The staff in the participating schools collaborate and share their learning through a Project Colleagues Network and through participation in Learning Circles. Evaluation studies of the project have shown impressive improvements in teacher morale and performance and most importantly student engagement, well-being and achievement.

Projects such as “Learning to Learn” and others which draw upon the latest in quality research to shape transformational change can only succeed if there is political and organisational commitment backed with the necessary resources and public endorsement. It is in this aspect that many good notions falter due to a lack of philosophical competence and the inadequate political nous of the project champions. Fortunately, in South Australia this was not the case and projects such as “Learning to Learn” and others have caught the positive attention of the political leaders. So much so that the Premier has funded a six month program involving the highly respected Baroness Professor Susan Greenfield as part of the “Thinkers in Residence” programme to promulgate new knowledge in the neurosciences across the South Australian community and to explore strategies to link the neurosciences and educational development . Town Hall meetings to hear from and interact with Susan Greenfield have been a big hit with the community. In turn, the politicians have been receiving very positive community feedback, something all politicians hunger for daily! Therefore, more funds are being directed to projects linking the neurosciences and educational change including a new post graduate programme in this field being specifically designed for teachers. The Premier has given enthusiastic support for the recently formed SANI (South Australian Neurosciences Institute) linking all those scientists in the State’s Universities and other institutions associated with the neurosciences, largely due to the enthusiasm generated by the programme involving Susan Greenfield. Details can be found at www.thinkers.sa.gov.au

This “proposition note” contends that a commitment to the importance of lifelong and lifewide learning is essential for the personal fulfillment of our citizens, the social development of our communities and the economic prosperity of the state. Further it contends that the nature of learning developments needs to keep pace with emerging scientific findings such as from “Brain Research”. However, both contentions will only be that and not successfully implemented, if not backed with the necessary political will and appropriate allocation of resources. The “note” puts forward a brief overview of some projects in South Australia which seem to take account of these factors and augur well for further growth in this field.

COLLETTE TAYLER and JOHN BENNETT

An early childhood perspective on the life-long learning debate

Collette Tayler, Queensland University of Technology and John Bennett, Education Directorate, OECD

A What are the key issues in life-long learning (LLL) and early childhood education and care (ECEC)?

1 *A LLL focus that commences with institutional education (schools) denies the vital importance of the early childhood phase of development and learning.* LLL studies normally assume that formal education institutions have the role of key provider of human capital. Trajectories of school performance, whether positive or negative, tend to remain stable over time. Yet life-cycle learning commences in early childhood, a critical foundation period for individual development & learning. Because the early childhood years are outside the realm of formal education institutions there is an need for a different orientation to the study of LLL.

- Attention to the early childhood phase of learning cannot be achieved effectively through a downward extension of an institution (school) based research orientation. Different, locally sensitive and less institutionally oriented approaches are needed.
- Because the brain is not fully developed at birth and neural pathways are developed in the birth to age 3 there is a need to document the impact of ECEC experiences/programs on growing cognitive, social, and emotional competency. Environmental conditions are known to effect the development of brain circuitry, making attention to the type and diversity of environments in which children grow important (Eming Young, 2002). Patterns of behaviour, competence and learning are initiated during EC.
- All children do not start school with equal competencies. Their different life and educational experiences have already resulted in variation. It is important to establish the variation within any pre-school cohort, and the background factors that may have contributed to this variation.
- Factors that contribute to different levels of competency that are assessed in preschool or early primary years will continue to affect children's progress. Family and prior educational experience remain influential. Understanding the effects of early education on life-long learning requires attention to the other (contextual and outside of program) influences that are operating simultaneously.
- Quality educational provision in the early childhood years (0-6) is found to be beneficial to children's development. Numerous research studies reveal that participation in well-run, high quality programs has measurable positive impact on intellectual performance, social achievements, self-esteem and task orientation upon entry to school.
- Targeting the development of local service and support capacity is an effective means of understanding and enhancing child outcomes in the local context. Research into trajectories of LLL behaviour need to begin with the study of infants and very young children interacting in family settings,

including family day care homes, and the study of centre-based early childhood programs.

2 *A strongly cognitive perspective on early learning risks underplaying the importance of environment, relationships and social engagement.*

- The way in which attention is given to social, emotional, cultural linguistic and cognitive development in EC programs can make a difference to children's learning outcomes. Depending on context and country history of ECEC provision, early childhood pedagogues/educators may (indirectly) prepare children for later academic learning by stressing play, creativity and mental health or they may emphasize particular academic content. There is general agreement that identifying and building on children's interests and maintaining informal approaches is of primary importance.
- Any research conducted on *early educational programs* needs to account for the effects of age, family background and previous educational experience, so that the *independent* effects of the program can be examined (see for example, Thorpe et al, 2003).
- When assessing programs for their contribution to learning, the kind of pedagogy in place is an important study factor. Play-based programs for young children are generally strongly supported in the literature, although they vary widely in application and in the assumptions made about the place of play in learning. Observing play environments can help us to understand the development of young children's intuitive thinking. The relative balance of child-initiated strategies (including play) and adult-led experiences may reveal important insights and generate varied child learning outcomes.
- Pro-active adults with sound knowledge of young children and high expectations of their capacity make a positive difference to learning. The experience and qualifications of adults engaged with young children, their motivation, their work conditions and job satisfaction, along with the regard in which they are held by parents contribute to the success of early childhood learning programs.
- Sensitivity to *diversity* in learning and development is critical in early childhood. Programs designed or modified to meet the local needs of individual communities and individual children have been found to be more successful than centrally driven learning programs which target the "theoretical child".
- Loading parents or teachers with *education products* that interpret brain development findings to suit market devices is problematic as a technique for developing or assessing young children's learning. Similarly, the development of compartmentalised, subject oriented curricula (which may be easy to publish) that separates learning into distinct domains and lessons for mastery is problematic in regard to young children's development and learning (Lally, 1998). Human relationships are primary in early childhood development. New initiatives on how young children learn need to pay attention to not only to brain research per se but also to established knowledge about early childhood development and learning.

3 *Investing time and resources in the development of young children "at risk" offer superior rates of return, although universal service approaches to early childhood development and support ensure optimum chances of later success*

for all young children (Lynch, 2004; Thorpe, et. al., 2003; Heckman, 1999, Ramey et. al, 2000; Duncan et. al, 1998). Growing research indicates that a higher rate of return is achieved from investments at this stage than investing heavily on recovering low-skilled adults. Social context and SES markedly affect the development of child capabilities. Children "at educational risk" may include children from socially disadvantaged backgrounds, children from culturally diverse backgrounds; children identified by their parents as having health or behavioural problems; and children who perform poorly on assessments of social, emotional, physical, cognitive, and/or linguistic development.

- When basic needs are met (health, nutrition, care and education) optimum conditions are in place for children's learning, particularly regarding the development of confidence, critical skills, problem solving and cooperation (Ramey et. al. 2000).
- Enriching the learning environments of young children and studying the impact of particular enrichments across different contexts may establish clear, context sensitive, directions for effective learning policy and practice.

B QUESTIONS THAT might be explored in relation to early childhood education and care

Question 1. Can one extrapolate from current neuroscience research to children and children's learning?
Few research groups actually do neuroscience research on young children as many ethical and practical issues are involved. Much of the research is still based on animal systems, especially on rats. Thus, when rats are given an enriched environment - freedom to be together, lots of things to play with and to stimulate them - sysnaptogenesis is increased. Can parents and educators extrapolate this finding to enriched environments for young children?

Question 2. The neurosciences provide evidence of *critical learning periods* in the first two years of life, notably for the acquisition of a first language and relational skills, (as well as for vision, hearing). **Does research provide further evidence of critical learning periods in the following years, e.g. for developing further language, cognitive and social skills.** In sum, is the attached chart (see below - distributed by a district authority for early childhood services) based on good evidence?

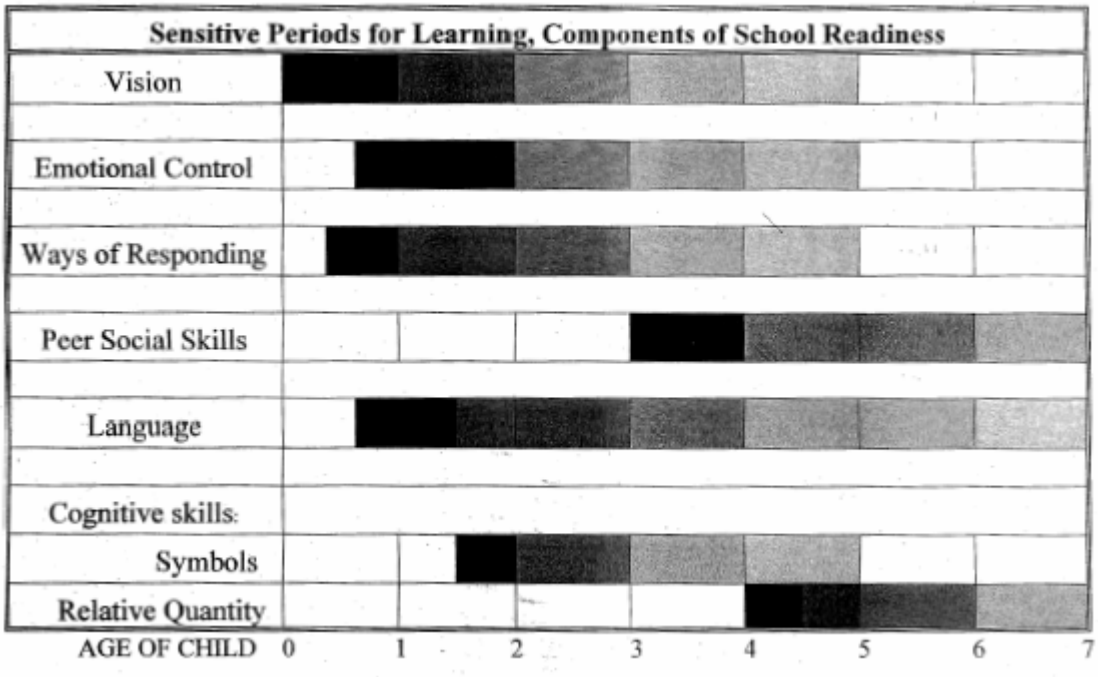
Question 3. How important are the early years?
Jay Belsky (Director, London University Institute for the Study of Children, Families and Social Issues) claims: "I have real problems with the notion that the early years are crucial. Crucial implies that if something doesn't happen or something does happen, then that foretells everything afterwards".
Yet, accumulated psychological and psychiatric research suggests that the early years are in fact crucial for the way people function later both emotionally and cognitively.

Question 4. Can brain research and the neurosciences throw light on what we should be doing in early development? For example, findings such as the development of the pre-frontal cortex in infants depending on loving and pleasurable relationships with significant carers; the release of high levels of cortisol in situations

of prolonged stress; the higher metabolic rate of the child's brain and its greater capacity for synaptic connectivity in early childhood - what significance have these findings?

Question 5. Much of the educational research undertaken by the Nobel prize-winning economist, James Heckman, pleads for greater investment in young children's education - as compared to other levels of education and to job retraining or welfare-to-work schemes. **Do the neurosciences have anything to say in this debate?**

Question 6. How might neuroscience research contribute to understanding young children's curiosity and the linkages to learning habits and dispositions that sustain LLL? Children's curiosity and their questions they ask provide a key to learning about children's understandings and learning processes. Basic understandings are constructed by children through self-directed problem solving. The process of doing, and talking to clarify thinking, are enacted in different kinds of informal early learning environments. How can parents and educators improve early learning environments to support the development of LLL?



REFERENCES

Duncan, G.J., Brooks-Gunn, J., Yeung, W.J. & Smith, J.R. (1998). How much does childhood poverty affect the life chances of children? *American Sociological Review, 63*, 406-423.

Eming-Young , (2002). *Early Child Development: A Stepping-stone to Success in School and Life-long Learning.* Human Development Group. World Bank.

Heckman, J. (1999). *Policies to Foster Human Development*. Working Paper 7288, Cambridge, Mass: National Bureau of Economic Research.

Lally, R. (1998) Brain research, infant learning and child care curriculum, *Child Care Information Exchange, 5*(48), 46-48.

Lynch, R.G. (2004). *Exceptional Returns. Economic, Fiscal and Social Benefits in Early Childhood Development,* Economic Policy Institute, Washington D.C.

Ramey, C.T., Campbell, F.A., Burchinel, M., Skinner, D.L., Gardner, D.M. & Ramey, S.L. (2000). Persistent effects of early intervention on high-risk children and their mothers. *Applied Developmental Science, 4,* 2-14.

Thorpe, K., Tayler, C., Bridgstock, R., Grieshaber, S., Skoien, P., Danby, S. & Petriwskyj, A. (2004). *Preparing for School: Report of the Queensland Preparing for School Trials 2003-2004*. Queensland University of Technology, Australia.

RUDOLF TIPPELT

Prof. of Educational Science, Ludwig-Maximilian-Universität München, Germany

Key issues in lifelong learning and specific interests in this meeting

The following framework focuses on the key issues in lifelong learning and offers a number of important questions to Neurosciences from the perspective of Educational Science.

1. Aims of lifelong learning and the acquisition of competences during the life cycle:

Lifelong learning and competence development is critical for economic, social, and individual development. The following aspects can be distinguished:

- **Individual resources** , economic, and non economic benefits: self concept, life expectations, plans, and individual goals, attitudes and values, health;
- **Human Capital** and economic outcomes of education: qualification, knowledge and skills; cognitive and sensumotoric capacities;
- **Social competences** and understanding of others: empathy and role taking, social networking and friends, civic participation;
- **Cultural Capital** and „normative competences“: reflecting norms and values of societies and different social or ethnic groups, aesthetic judgements, life-styles.

Questions to Neurosciences:

It is obvious and very important that progress in brain research helps understanding the acquisition of implicit and explicit knowledge, of cognitive and sensumotor developments over the life cycle. What are the explanations and empirical findings in Neuroscience that help understanding the

- Interactions in socially heterogeneous groups (abilities to cooperate, to resolve conflicts and to relate well to others);
- Acting self-directed and autonomously (abilities to conduct life plans and personal projects);
- Using tools interactively (abilities to use language, knowledge, information and technology interactively).

2. Levels of educational and learning environment in socio-ecological perspective:

Educational Science discriminates the influences of different levels of environment, and these influences cannot be seen as “one-way-roads”, they are interactive and highly complex.

- Macro-systems: economical, political, social and cultural changes of societies;
- Exo-systems: regional developments, urbanisation, rural changes;
- Meso-systems: organisational management of educational institutions;
- Micro-systems: interaction of learners with teachers, lecturers, moderators, councelers, and other learners.

Questions to Neurosciences:

- Educational Psychology and also Neuroscience help understanding processes of learning on the micro-level of education. Is it possible to explain also the dynamic changes of organizations, the developments of regions and whole societies with the results of brain research?

- In other words: Does brain research yield specific empirical results that are relevant for discussion the "sociological problems" of lifelong learning?
- Which empirical results of brain research are particularly suitable for planning the institutional and organisational structures of lifelong learning?

3. Processes of learning (from lifelong to lifewide learning):

Lifelong learning is also lifewide learning. In order to cope with rapid social change and the challenges of the global knowledge society, we must ensure that people can return to learning throughout their lives. The "lifewide" dimension brings the complementarity of **formal, non-formal and informal learning** into sharp focus.

Question to Neurosciences:

- Informal learning in particular is not always intended learning. It happens in everyday situations e.g. at the work place, in confrontation with media or in discussions with friends. These situations are highly complex. Educational Science has empirical evidence that complex environment exhibits more capability to solve problems and creates better learning motivation. Is there empirical support from brain research for learning in a complex environment and also in real life situations (on the job training).

4. Learning settings, methods of instruction, and motivation

Learning settings and methods of instruction are influencing motivation and emotions in learning processes. Nevertheless we need a variety of methods, highly structured learning environments, like expository teaching (D. Ausubel) as much as open and very complex learning environments, like project learning, discovery method (J. Dewey, G. Kerschensteiner, J. Bruner).

Questions to Neuroscience:

- What do we know about motivation in learning?
- Should we apply specific methods for learners in specific situations?

5. Differences in learners and chrono-systems

Coherent, long term strategies in lifelong learning differ among social groups. In theory and practice some variables are important, e.g.

- Social milieus and social classes
- Age
- Generations, cohorts
- Gender
- Styles of learning

Questions to Neurosciences:

- There is no doubt that age groups differ in learning: The fluid intelligence in younger and the crystallised (experience oriented) intelligence in older persons are integrated in a concept of plasticity of information processing. But what do we know about interindividual differences other than age: differences in learning between social milieus, generations (cohorts under the influence of change in societies), gender or basic learning styles of individual learners?
- The structure of the brain is not pre-determined and may be related to lifelong learning. But can we describe and explain differences between men and women, cohorts of the 60^{th}, the 80^{th} and today or social milieus (with different educational background)?
- Are there sensitive periods for developmental pathways and transitions in educational institutions and work?

6. General approaches of research in lifelong learning

Lifelong learning research is based on a variety of quantitative and qualitative empirical research methods. The experimental method is common in Educational Psychology and in learning research. Validity, reliability and objectivity are highly accepted methodological standards of educational research: Cohort analysis, biographical analysis, "Lebenswelt" and milieu analysis, learning analysis (cognitive and constructivistic approach).

Questions to Neurosciences:

- Are we familiar with the research methods of each other?
- Are there preferences of certain research methods? When are quasi-experimental designs possible? Are there ethical constraints?

7. Networking of learning institutions

Cooperation between different institutions of adult education is necessary and effects of cooperation are often evaluated. But also vertical networking between different educational institutions makes sense for the different age groups (cooperation between Kindergarten, primary schools, secondary schools, vocational training, universities and polytechnics, adult education). Vertical networking – rarely realised – is important for lifelong learning. ***Questions to Neurosciences:***

- Do we get support for the idea of institutional networking from brain research?
- Do sensitive periods for learning in domains exist over the life cycle?
- How can we adapt learning and educational institutions to the transition processes of the learners?
- How important are "intergenerational" learning settings in this context?

JANET WERKER

There is undeniable evidence that experience early in life sets the stage for more or less successful life long learning and development. The challenge is to ascertain just what types of early experience are most optimal for facilitating optimal development, and why these rather than other types of early experiences are successful. To add to the complexity, the world is changing more rapidly than ever, so it is no longer possible to identify a particular knowledge base that will be optimal. Instead, it is important to determine just what kinds of early experience promote acquisition of specific knowledge, attitudes, and skills while at the same time allow for continued flexibility to radically change in later life if required.

As a developmental cognitive scientist who focuses on infant speech perception and its impact on later language development, my goal is to identify sensitive periods in development when exposure to one or more language environments helps establish the perceptual language categories required for learning the words, morphology, and grammatical structure of the native language. But that is not enough. It is also essential to identify the underlying learning processes that allow for this language specific tuning, and to investigate, as far as is possible, their neural correlates. This can allow for detailed investigations of whether or not the same mechanisms that allow for optimal initial tuning (perhaps during sensitive periods of development) allow for retuning later in life in response to a changing world, or for "catch-up" for those individuals who missed out on optimal early opportunities. For example, our work has shown that speech perception categories are tuned on the basis of the input in the first year of life, and our work has identified one possible learning mechanism to account for this. This now positions us to investigate how that learning mechanism can be tweaked to allow acquisition of new speech sound categories at later points in the life span. Linking speech perception categories to word learning sets the stage for later successful language acquisition, and perhaps even literacy readiness. Linking studies like mine to broader indicators of success, such as school readiness and ultimately success in school, will facilitate our understanding of LLLD.

It is challenging to translate these ideas into key messages for educators, but I suppose four broad ideas that follow from it would be:

1. On the basis of their earlier experiences, children may be more or less ready to learn – in our case – to acquire language and learn to read – at the time of school entry. Thus, a program that is ideal for one child may be too advanced or too simple for another child.
2. Opportunities for catch-up, perhaps repackaged as "new learning" could possibly be provided
3. Learning begins long before the school years.
4. Learning continues throughout life, but most likely with a very different basis.

Translating these very basic notions into specific programs is probably not the ideal goal because the scientific knowledge base changes minute by minute. Rather the ideal goal is to use networks such as this to ensure the dialogue continues and that particularly insightful educators are in positions to implement the principles derived from neuroscience.

DANIEL WOLPERT

Professor Daniel M. Wolpert
Institute of Neurology, University College London

Over recent years there has been a dramatic increase in our knowledge of how skill learning proceeds. However, currently this rather abstract knowledge does not transfer directly into questions which I expect educators would like to have answers to:

For example:

1. Skill acquisition

Traditional theories of learning posit that new memories and skills are transferred from a short-term labile state to a long-term fixed state that is more or less permanent and protected from new learning. The time course of this consolidation process after learning can be probed by having subjects learn new material and testing for retention of the original material. The process by which new learning may interfere with the consolidation of previous learning is referred to as retrograde interference. Recent evidence suggests a new emerging view that emphasizes active and inactive memory states rather than labile and consolidated states. According to this view, new memories transfer from an initial active state to an inactive state but then can be returned to the active state when needed. Importantly, when reactivated, these memories can be modified and then restored in their modified form to the inactive state. These studies have implication for both cognitive and skill learning. For example, it could suggest that there are optimal orders to lessons within a curriculum or lesson duration and intervals to maximize storage of new information without preventing interference from new learning. Over the coming years there is huge potential to elucidate how such benefits can be determined.

2. Early experience and learning potential

As children and adults we show a vast range in both our cognitive and motor skills. A universal feature of neural processing is that resources are allocated in proportion to their importance when interacting with the environment. It has been shown that experimentally increasing or decreasing the sensory input from a body part, leads to a corresponding increase or decrease in its cortical representation. Moreover, the representation of sensory processing areas, such as visual and auditory cortex, is determined, to a large extent, by the statistics of natural stimuli. Indeed the statistics of early experience determines what can be perceived in later life—for example, infants' perception of speech sounds is affected by the statistics of the language they are exposed to during the first year of life. While the statistics of sensory inputs has received a great deal of attention and careful characterization, the statistics of the output system, that is movement, has received little attention outside of a laboratory setting. Importantly, the range of tasks we perform in our daily life does not require all movements to be performed equally often. It is unknown how early motor practise influences our ability to perform motor skills later in life although based on analogy with the perceptual systems we might we expect the statistics of tasks to have a profound effect on motor performance. Studies of how early motor experience affects later ability to learn skills would have implications for both parents and educators.