A Report of the

LEARNING SCIENCES AND BRAIN RESEARCH

Third Lifelong Learning Network Meeting

Hosted by
RIKEN Brain Science Institute

21-22 January 2005
Wako-shi, Saitama, Japan

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Organisation for Economic Co-operation and Development

OECD CERI

Centre for Educational Research and Innovation

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FRAMEWORK OF PURPOSE

The OECD's Centre for Educational Research and Innovation (CERI) held the third meeting of the Lifelong Learning network on 21-22 January, 2005 in Wako-shi, Saitama, Japan as part of the Learning Sciences and Brain Research Project. This meeting made significant progress toward the ultimate goal of ensuring that lifelong learning policy is informed by neurobiological knowledge. Working collaboratively, participants identified principles of neuroscience with relevance for educational policy design and constructed a foundation for building an integrated knowledge base. A neuroscience research agenda aimed at approaching lifelong learning policy questions was also explored. Furthermore, participants identified actions that will engender a flow of communication so that as future questions in the domain of lifelong learning are framed, neuroscience will be a tool that is readily available to tackle them.

Notes on purpose

It is critical to emphasize that the purpose of this meeting was not to construct educational policy, but rather to make relevant neurobiological knowledge accessible to those engaged in policy design. The educators at this meeting served to identify relevant neurobiological knowledge. Such knowledge must act in synergy with culture to develop appropriate policy and practice.

It is also important to clarify the term lifelong learning. Lifelong learning includes, but is not limited to, the learning that occurs in school. Learning from the lifelong perspective spans vertically from before the start of school into old age, and horizontally across extracurricular cultural, athletic, and civic activities. One of the opening speakers defined lifelong learning as follows: "All learning activity undertaken throughout life, with the aim of improving knowledge, skills and competences within a personal, civic, social and/or employment-related perspective." The participants at this meeting considered learning and education through this broad perspective. Therefore, a wide range of policy issues were considered pertinent, including maternal healthcare, early childhood homecare, daycare, preschool, primary school, secondary school, university, job training, the continued education of senior citizens, moral and values development, societal enculturation, and physical education.

Structure

This Lifelong Learning network meeting was structured to engender active dialogue among educators and neuroscientists. Little expository teaching took place. Instead, sessions were centered around discussion. This method enabled the type of constructive conversation necessary for cross-disciplinary work. It also served to promote collaboration and constructive critique among colleagues both within and across fields.

In order to concentrate discussion on pertinent issues, each session was organized around the following series of focus tasks:

1. Identify key policy issues in:
   - Lifelong learning, plasticity and periodicity
   - Early childhood education in the lifelong learning perspective
   - Aging and learning in the lifelong perspective
2. Identify the existing knowledge base.
3. Identify key knowledge gaps and where neuroscience can fill in.

Prior to the first collaborative meeting, educators and neuroscientists engaged in parallel pre-symposium brainstorming sessions guided by the three aforementioned focus tasks. The neuroscientists began with brief presentations of their knowledge. They then drew connections among their work and developed principles with possible relevance for the field of lifelong learning. Finally, they considered future research initiatives. Meanwhile, educators worked to identify key policy issues in lifelong learning and determine how neuroscience may be useful in addressing them. They also devised methods of facilitating further collaboration.

The first day of the symposium, participants were divided into three workshops:

- Lifelong learning, plasticity and periodicity
- Early childhood education in the lifelong learning perspective
- Aging and learning in the lifelong perspective

Each strategically heterogeneous group was composed of both educators and neuroscientists. The workshops began with a brief report of the pre-symposium brainstorming sessions. The ensuing discussions aimed to draw connections among the independent work with the three focus tasks and construct a consensual solution to each of them.

The last plenary session commenced with summary reports and reflections on the workshops from the following day. Presenters shared key issues that arose in the workshops and provided insightful reflections from their particular area of expertise. These reports were followed by overall reflections concerning both the content and structure of the symposium.

WORKSHOP SUMMARIES

Lifelong learning, plasticity and periodicity

Workshop participants

Reijo Laukkanen
Marie Cheour
Frank Coffield
Cassandra Davis
Masao Ito
Jellemer Jolles
Petra Hurks
Sandrine Kelner
Tom Schuller
Marianne Schuurmans
Yoshihiro Tatsuta
Daniel Wolpert

Plastic capacities and environmental influence

The brain is an active, plastic system that is keenly adaptive to the environment. Experience elicits physical events in the brain that ultimately manifest as structural changes. The effects of experience are mediated by the brain's current structure. Therefore, there is a circular relationship between brain structure and experience such that experience causes changes in brain structure, which, in turn, influence effects of subsequent experience. The brain continually undergoes a process of experience-dependent reorganization throughout the lifespan.

Because of this continuous adaptive process, previous experience has a powerful impact on the brain's readiness to learn. In fact, much research has indicated that an enriched environment, defined broadly as an environment with abundant opportunities for learning, results in structural adaptations that potentiate the brain for learning. Participants agreed that it would be useful to develop a blueprint of an enriched environment that could be used to inform the creation of such environments within particular contexts. However, several participants noted that such a framework would inherently include assumptions about desired outcomes. While constructing theories concerning desired outcomes with any precision is a complex, socio-culturally-embedded task, there was an intuitive consensus that an enhancement of the brain's proclivity to learn is a desired outcome.

Working from this assumption, neuroscientists identified several factors that promote structural features that prime the brain for learning. These factors include exercise, a healthy diet, social interaction, emotional stability, and an absence of pollutants (including drugs and alcohol). Further research is needed to elucidate the mechanism through which these factors exert their effects and the circumstances under which they are effective. Additional factors also need to be investigated. For example, several participants were interested in exploring the role of motivation, attention, autonomy, and metacognition from a neuroscientific perspective; such research could be integrated with existing educational psychology work.

One participant reminded the group that resources are often scarce in educational settings. For this reason, it is not only important to develop a list of relevant factors, but also to prioritize. Such prioritization will inform the allocation of resources to optimize learning outcomes given limited resource input.

Future neuroscience research is needed to further illuminate the mechanisms by which learning occurs, and how relevant factors influence those mechanisms. Discussion stirred numerous issues in this area. For example, the following questions were raised: How do the neurobiological mechanisms underlying cognitive learning differ from those underlying motor learning? Is there an optimal sequence of teaching, such as basic skill development before complex integration? How do relevant factors influence learning differentially across the lifespan? In what ways should the environment be flexible to accommodate individual differences? These types of issues can be used to frame future research agendas.

Periodicity

While the brain remains plastic throughout the lifespan, it is differentially malleable to certain types of learning across development. In fact, there are critical periods during which the brain is capable of undergoing functionally-significant changes that cannot be attained outside of these temporal windows. This phenomenon pertains primarily to sensory development and is relevant to cognitive development only during the prenatal period. However, there are also sensitive periods when the brain is particularly susceptible to structural changes such that specific types of learning can occur with an unmatched degree of proficiency[1]. Neuroscientists emphasized that although the efficiency and quality of learning peak during sensitive periods, significant learning occurs throughout the lifespan.

Neuroscientists have begun to identify these sensitive periods for certain types of learning. There is abundant evidence suggesting that there are sensitive periods for language, music, and motor learning. While research has begun to estimate the timing of these periods, it important to emphasize that these results are predicated on the average brain; there are variations in the opening and closure of sensitive periods. The structural organization of the brain renders it optimally receptive to language learning at approximately 10 months, after which developmental neurobiological changes lead to a gradual closure of this sensitive period that extends into early adolescence. The structural changes that underlie musical and motor abilities occur most readily between roughly 7

[1] The term sensitive period is sometimes used loosely to refer to the most effective period for certain types of learning to occur. In this report, the term is used strictly to refer to biologically-based temporal periods of heightened plasticity.

months and 8 years of age, and 3 years and 10 years of age, respectively. Although not all types of learning have a sensitive period, it is likely that others exist. Educators were interested in exploring the possibility of sensitive periods for a wide range of cognitive and emotional abilities and dispositions, including the following: mathematical thinking, problem-solving, reasoning, creativity, sociability, emotional competency, attachment (as defined by J. Bowlby), academic interest, and attitude toward learning. Future research could aim to develop a comprehensive portfolio of temporal profiles of plasticity.

Many educators identified sensitive periods as an area of neurobiological knowledge with clear relevance for the education sector. Such knowledge could be used to inform key policy issues such as maternal education, daycare program content, temporal organization of the school curriculum, and appropriate timing of social transition periods (*i.e.* transition from home to school, from school to apprenticeship or university, from vocational training to the workplace, from the workplace to retirement, etc.) and socio-cultural transition periods (*i.e.* from childhood to adolescence, from adolescence to adulthood, etc.).

In utilizing knowledge of sensitive periods, it is important to note that the plasticity of the brain is not the only neurobiological determinant of its readiness to learn. The maturational continuum must also be considered. For example, it might seem advantageous to teach reading as young as possible, while the brain is most plastic to language learning. However, one participant discussed a study revealing that literacy achievement was higher in Finland, where reading is taught at age 7, than in both the United States and the United Kingdom, where reading is taught at age 6 and 5, respectively. It is possible that this finding is explained by the fact that reading is a skill that requires the integrated activity of the left and right brain hemispheres, and the corpus callosum connecting the two is not mature until approximately 7 years of age. It would be useful for neuroscientists to develop a comprehensive maturational timeline for brain structures involved in learning. This timeline could then be superimposed onto plasticity profiles to determine optimal teaching periods for certain types of learning.

Early childhood education in the lifelong learning perspective

Workshop participants

Søren Kjær Jensen
Bruno della Cheisa
Takao Hensch
Christina Hinton
Paul Howard-Jones
Heikki Lyytinen
Nuria Sebastian
Collette Tayler
Janet Werker

Plasticity and the developing brain

The developing brain has unique features that render it particularly susceptible to structural changes underlying many types of learning. These enhanced plastic capacities enable many types of learning to occur with superior speed and flexibility during development. Educators referred to these abilities as fluid intelligence and were intrigued by a discussion of the neurobiological underpinnings of this type of intelligence. Many educators were also interested in exploring the neurobiological basis for the intrinsic motivation to learn characteristic of young children.

Neuroscience cannot yet fully elucidate the mechanisms of learning, but it is known that learning involves cumulative structural changes in the brain. The brain continually undergoes an adaptive process whereby experience shapes structure, which influences subsequent experience-dependent reorganization. This results in a cascading effect. For example, the structure of the cortex is modified as a child learns to play the violin; gradually, the cortical neurons learn to respond more precisely to musical tones. These structural changes enable the child to learn the piano more readily, which then serves to further refine the tone-elicited cortical response, and so forth. Because of this cascading effect, early learning provides an important foundation for later learning.

Current trends in educational resource allocation do not reflect the critical role of early learning. One participant cited a study indicating that daycare investment is far less than school investment despite that children spend more time in daycare. Additionally, she described a study revealing that four or five times the resources are allocated for education at the tertiary level than the primary level. From a neurobiological perspective, these allocation trends are not cost-effective, since it takes fewer resources to reach a given learning outcome when they are invested earlier than later.

Early learning environments

Creating environments that support brain development is a complex task. First, the brain is not isolated from the rest of the body. Participants across the disciplines of neuroscience and education agreed that it is most accurate to consider physical and mental development as an integrated whole. Therefore, early educational environments must support learning in this holistic way. Approaching learning from this perspective requires a cost-benefit analysis that evaluates potential elements of an environment to determine their overall impact on learning.

Additionally, learning from a lifelong perspective does not begin in school. Neuroscience research suggests that learning can begin as early as the prenatal period. Therefore, learning environments in early childhood are not all institutionalized. Consequently, many educators identified recovery of learners who encountered deprived early childhood environments as a key policy issue.

Another complexity involved in structuring early childhood learning environments relates to desired outcomes. Several educators cautioned that there is an inherent complication in the concept of school readiness: Should children be prepared for school or school prepared for children? Framing children's capabilities within adult capabilities imposes socio-cultural constraints on learning. Perhaps children should be given more agency in structuring the time and space of their environment. One participant encouraged educators to learn from children as human beings, not human becomings.

Despite these complications, educators were optimistic that neuroscience could inform the creation of early childhood learning environments. Many related policy issues were identified, including the following: What are the age-specific quality of life concerns to be considered when designing early childhood learning environments? How should the environment be structured to ensure compatibility with various sensitive periods? What types of environments support healthy social growth and minimize risk of future delinquency? What elements of early childhood learning environments contribute to morals and values development? What is critical about interaction in early childhood learning, and what criteria should be used when hiring early childhood professionals (*i.e.* teachers, daycare staff)? How can professionals be trained to structure enriched early childhood learning environments? As neuroscience research begins to address these types of questions, new information can be evaluated from the perspective that learning is an integrated, lifelong process guided by the learner.

Individual differences

Individual learning differences arise as a result of a continual and cumulative genetic and epigenetic interaction. The environment influences the expression of genes relevant to learning throughout the lifespan. This gene expression can result in structural changes in the brain. These modifications then affect subsequent experience-elicited gene expression. In this way, each individual's brain accumulates structural idiosyncrasies that mediate learning processes.

Educators identified accommodating individual learning differences as a key policy issue. Included in this issue is the exploration of gender-associated and domain-specific differences in learning style. Another aspect of learning differences is the education of learners with disabilities. One participant noted that predicting disabilities from infant brains would be useful, because it would enable earlier treatment when the brain is most plastic.

Achievement is not strictly a function of ability. Other drivers of achievement include motivation, which refers to a will to learn, metacognition, which involves understanding how to learn, and resilience, the stamina for lifelong learning. An understanding of how these factors develop would be useful for all learners, and could be of critical importance when ability is low. Neuroscience research could be used to inform a trans-disciplinary understanding of the development of motivation, metacognition, and resilience.

Aging and learning in the lifelong learning perspective

Workshop participants

Denis Ralph
Emily Groves
Hideaki Koizumi
Michael Meaney
Keiko Momii
Art Kramer
Emile Servan-Schreiber
Rudolph Tippelt
Harry Uylings

The aging brain and society

The aging society renders elderly education an increasingly important aspect of lifelong learning. The brain's plasticity decreases as a function of age, and this decrease is frequently accompanied by a decline in fluid intelligence, working memory, spatial ability, memory recall, and perceptual speed. Age-related psychosocial degeneration, emotional declines, and health disorders (including dementia) are often experienced as well.

Despite age-related cognitive declines, the elderly possess invaluable knowledge and wisdom. Certain types of abilities can remain stable, or increase across age. Crystallized (experience-oriented) intelligence and wisdom are generally enhanced across the lifespan. Many participants emphasized the importance of enabling individuals to continue learning and functioning independently well into old age. The development of a curriculum for the third age was proposed. In addition, it was suggested that seniors remain in the workforce longer, and that the workplace and community be restructured to make better use of elderly experience and expertise. Participants were interested in exploring the constraints and possibilities of transferring knowledge (both from one individual to another and from one generation to the next).

Individual differences and intervention

Many neuroscientists emphasized that there are individual differences in age-related loss of brain functions, and these differences are partially mediated by environmental influences. Neuroscience research has indicated that intellectual stimulation and novelty help maintain cognitive abilities. Effective sources of such cognitive challenge include formal education, leisure activities, and professional pursuits. Neuroscience research has also revealed that physical exercise, a healthy diet, and the maintenance and expansion of social networks can act to maintain cognitive function. The most effective programs involve the integration of several of these components.

Participants agreed that it is imperative to advocate policies that support lifelong learning and cognitive plasticity. This involves creating frameworks and providing resources that enable seniors to engage in cognitively, physically, and socially stimulating activities. It also involves developing new products and policies to alleviate age-associated health problems that can interfere with learning. For example, several participants noted that visual and auditory declines result in deterioration of brain function due to isolation from the environment. Others remarked that malnutrition and interrupted sleep patterns can stunt cognitive functioning. Many participants stressed that it is more cost-effective to invest in programs and policies that prevent cognitive decline than to treat later age-affiliated health disorders.

A few participants illustrated examples of effective elderly programs. One such program involved intergenerational learning in which adolescences were paired with seniors. Another utilized internet training to create cognitive challenge and connect the elderly to expanded social networks. Dedicating more resources to these types of programs will enable seniors to more readily impart knowledge and expertise.

THEMES IN LIFELONG LEARNING

The third meeting of the Lifelong Learning network was successful in achieving each of its focus tasks:

1. Identify key policy issues in:
    - Lifelong learning, plasticity and periodicity
    - Early childhood education in the lifelong learning perspective
    - Aging and learning in the lifelong perspective
2. Identify the existing knowledge base.
3. Identify key knowledge gaps and where neuroscience can fill in.

The table below reviews themes that arose from the work across the three lifelong learning workshops (see Table 1). The three original focus tasks are addressed for each theme. The second column of the table addresses the second task by briefly summarizing key principles from the existing knowledge base. The third column addresses the third task by citing relevant knowledge gaps in the form of potential research questions. Finally, the fourth column addresses the first task by listing several relevant policy issues. This table is not exhaustive, but merely highlights some key principles, research questions, and policy issues.

Table 1. Themes across lifelong learning workshops.

Themes in Lifelong Learning	Existing Knowledge Base (Focus Task 2)	Potential Research Questions (Focus Task 3)	Relevant Policy Issues (Focus Task 1)
▪ The brain is plastic and influenced by the environment throughout the lifespan	▪ A cascading effect occurs; consequently, early learning provides an important foundation for later learning ▪ Environmental factors can potentiate the brain for learning and prevent age-related declines in cognitive functioning ▪ Relevant factors include cognitive challenge, exercise, a healthy diet, and social interaction	▪ What are the neurobiological mechanisms underlying various types of learning? ▪ How do environmental factors exert effects on learning? ▪ What additional factors are relevant to learning? ▪ Which factors are the most crucial?	▪ Resource allocation ▪ Teaching methods ▪ Structure of learning environments ▪ Training of educational professionals ▪ Design of elderly programs ▪ Recovery from deprived early childhood environments
▪ There are temporal periods during which the brain is primed for certain types of learning	▪ These periods are a function of sensitive periods of heightened plasticity and brain maturation ▪ Sensitive periods exist for language, music, and motor learning	▪ Are there sensitive periods for other abilities and dispositions? If so, what are they? ▪ What is the maturational timeline for brain structures involved in learning?	▪ Temporal organization of the school curriculum ▪ Timing of social and socio-cultural transition periods ▪ Daycare curricula content
▪ There are individual learning differences across the lifespan	▪ Learning differences are the result of continual and cumulative genetic and epigenetic interaction ▪ Motivation and metacognitive awareness have powerful impacts on learning ▪ The brain is differentially functional across the lifespan.	▪ What are the neurobiological underpinnings of age-affiliated intelligences? ▪ What are the constraints and possibilities of transferring knowledge? ▪ What is the neurobiological basis of motivation? ▪ How are metacognitive abilities developed?	▪ Individualized education ▪ Development and maintenance of motivation ▪ Development of metacognition ▪ Age-appropriate teaching methods

NEUROSCIENCE AND EDUCATION: THE TWO CAN TANGO

The third meeting of the Lifelong Learning network made evident the likely endurance of this emerging trans-disciplinary fusion of neuroscience and education. Participants from both disciplines brought energy, openness, and a strong willingness to engage in constructive dialogue. The meeting ended with a solid foundation of nascent work, and a strategic plan for continuing progress.

Current trans-disciplinary work

An integrated model of learning

One of the opening speakers described lifelong learning from the perspective of Jean Lave and Etienne Wengers' participatory model of learning. This model describes learning as a socio-culturally-embedded process of moving from legitimate peripheral participation in a culture of practice to central participation in building that field. The principle that learning is inherently socio-culturally situated is widely accepted in the modern educational community.

Participants began to link this educational conception of learning as a social endeavor with the neuroscientific conception of learning as molecular events in the brain. Traditional constructivist theories of learning assert that meaning is not passively transmitted to the learner, but actively constructed by the learner. The participatory theory of learning adds that it is constructed within the constraints of a particular socio-cultural environment. Working from this framework of educational theory, learning is an active, socio-culturally-mediated process. From a neuroscientific perspective, learning occurs as a cascade of molecular events resulting in structural modification with significance for subsequent learning. Therefore, learning could be described as a series of socio-culturally-mediated adaptations of brain structure with functional consequence.

One participant introduced an artifact that could be used as a theoretical framework to explain a similar integrated conception of learning (see Figure 1). Individuals continually engage in an exchange with their environment, which contains a sea of symbols, or socio-culturally-mediated bytes of meaning. Inhabitants of the environment continually modify the meaning of these symbols via behavior. An iterative process occurs whereby meaning-laden symbols impact brain structure, influencing behavior, which reshapes the meaning of symbols. In this way, individuals' brains influence one another indirectly through their environment. This type of social neuroscientific perspective could provide an important link between the disciplines of education and neuroscience.

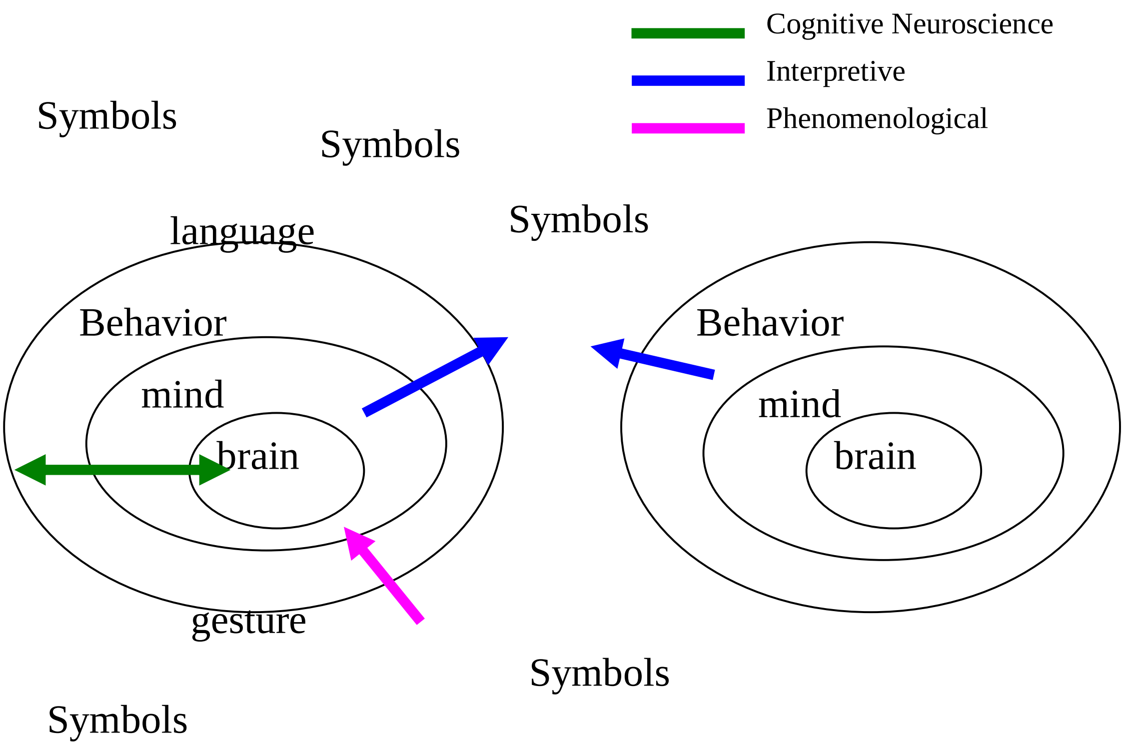

Figure 1. An interdisciplinary framework of learning (adapted from Uta Frith and John Mortons' (1995) *Three Levels* framework by Howard-Jones (2005)).

Current research

The Center for Research on Brain Science and Society of the *Research Institute of Science and Technology for Society* (RISTEX) has undertaken research projects that transcend the borders between the fields of neuroscience and education. The first, *Brain-Science and Education*, was launched in 2001. This project involves cross-sectional and longitudinal studies aimed at addressing a wide variety of questions at the nexus of neurobiology and education, such as language acquisition, motivation, effects of technology on the brain, genetic and epigenetic interaction, and neuroethics. This research makes use of non-invasive brain function imaging. *The Center for Research on Brain Science and Society* of the RISTEX has also initiated *Japan's Children's Study*, a large scale cohort study concerned with elucidating the developmental mechanisms underlying sociability, and identifying the factors contributing to nurturing early childhood environments. These research projects emphasize integration as opposed to reductionism, and involve close collaboration among neuroscientists and educators. They provide powerful evidence that meaningful research can be executed successfully in this trans-disciplinary field.

Continuing progress

Issues in trans-disciplinary research

Participants agreed that it is essential to use evidence-based studies. However, there was concern about transferring knowledge from controlled laboratory settings to the complex world of education. A few participants suggested that neuroscientists modify research tasks so that they are more representative of complex educational settings. In addition, it is imperative that there is a reciprocal integration of research and practice. Research-driven policies must be implemented through the seeding of educational trials in which the effectiveness of these policies are systematically examined. This feedback system is the only way to ensure the validity of research-based policies.

Participants cited a need to develop cross-disciplinary methodologies. It was recommended that a plural methodological approach be adapted whereby research questions are approached using a variety of qualitative and quantitative analytics, spanning from animal studies in the laboratory to ethnographic studies in educational arenas. It was also suggested that neuroscientists and educators partner in research projects. In order to integrate the results of such studies, it is necessary to align methodological procedures and tools of measurement across the disciplines of neuroscience and education. Such alignment may enable more comprehensive research. For example, aligning expensive brain research with cost-effective psychological measures would enable researchers to obtain data from a larger sample size. Once trans-disciplinary practices have been established, researchers must be trained in these methodologies.

Another critical research issue is neuroethics. It was noted that when controlled research studies are deemed unethical, evidence-based research results can be obtained from the systematic study of naturally-existing environments. Many participants recognized the importance of establishing frameworks for addressing ethical issues, which lead to the proposal of an ethics committee. This committee could include members from various disciplines to provide a vital diversity of perspectives. Cross-disciplinary collaboration is needed to nurture the development of shared institutionalized channels to debate and resolve neuroethical issues.

Building this trans-disciplinary field

Progress is not only dependent upon the scientific results, but also on the commitment to build avenues of communication. Strengthening connections among neuroscientists and educators, and aligning their activity and focused intervention were identified as primary goals. It was suggested that colleagues from neuroscience and education jointly review the international literature in both fields; accuracy in interdisciplinary work can only be achieved when work is read in the original. The creation of a common lexicon was identified as a critical step in fostering communication. Such a lexicon could provide functional definitions for key terms in the domain of lifelong learning, such as a collaborative definition of learning. A few participants also suggested inviting other relevant experts (*i.e.* psychologists, anthropologists, sociologists, cognitive psychologists, educational psychologists, etc.) into the dialogue to help build multiple pathways between the disciplines of neuroscience and education.

Another fundamental aspect of building this field is educating its members. It is necessary to develop a pool of human resources capable of managing the emerging knowledge. This involves creating a new career path. Toward this end, participants encouraged the establishment of interdisciplinary laboratories, societies, journals, conferences, and electronic discussion forums. Additionally, it is important to implement programs designed to train educational practitioners (*i.e.* teachers, daycare staff, coaches, elder care staff, etc.). One participant suggested that such programs' curriculum could follow a trans-disciplinary sequence: molecular to cellular to brain systems to individual body systems to social systems. It would be prudent for these programs to include components aimed at generating motivation and building positive attitudes to ensure that knowledge is infused into practice.

It is critical that information is communicated strategically and cautiously to non-experts. It would be practical to consider social, political, and economic forces and disseminate relevant knowledge. In addition, it is crucial that information is communicated precisely and with clear caveats and qualifications. Oversimplifying knowledge could lead to dangerous misinterpretations and distortions. One participant proposed the development of trans-disciplinary models, visuals, and graphics to augment communication. Neuroscientists and educators must develop mechanisms for communicating the field's shared knowledge in a clear and unified manner.

OVERALL REFLECTION

The third meeting of the Lifelong Learning network was a powerful demonstration of authentic trans-disciplinary work. The accomplishment of the three focus tasks required cross-disciplinary collaboration among participants. For example, educators were essential in identifying relevant knowledge, while neuroscientists were needed to communicate knowledge accurately and assess feasibility of addressing particular policy questions via neuroscience research. The interdisciplinary nature of the meeting was the nucleus of its success. This level of synthesis across the learning and brain sciences is paramount to the spawning of this field. As expressed so eloquently by Frank Coffield, "It takes two to tango."

LITERATURE CITED

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APPENDIX I: AGENDA

Lifelong Learning

Seminar co-organized by

RIKEN Brain Science Institute

21-22 January 2005

Wako-shi, Saitama, Japan

20 January 2005: Pre-Symposium brainstorming

10:30~17:30	Neuroscientists' brainstorming (chaired by Takao Hensch)
13:30-17:30	Educationalists' brainstorming (chaired by Tom Schuller)

21-22 January 2005: Symposium

Day 1

9:30~10:00	Opening session (chaired by Bruno della Chiesa)
10:00~11:30	Goals and context of the workshops (chaired by Bruno della Chiesa)
11:30~11:45	Coffee break
11:45~13:00	Parallel working groups: Lifelong learning, plasticity and periodicity (chaired by Reijo Laukkanen) Early childhood education in the lifelong learning perspective (chaired by Søren Kjær Jensen) Aging and learning in the lifelong learning perspective (chaired by Denis Ralph)
13:00~14:30	Lunch break
14:30~18:00	Parallel working groups continued
18:30~	Reception

Day 2

10:00~12:45	The way forward: Towards implementing a learning science research agenda (chaired by Takao Hensch) Reports from working groups. ▪ Reijo Laukkanen: Lifelong learning, plasticity and periodicity ▪ Søren Kjær Jensen: Early childhood education in the learning perspective ▪ Denis Ralph: Aging and learning in the lifelong learning perspective Reflections on the meeting. ▪ Jellemer Jolles: Reflection on lifelong learning, plasticity and periodicity ▪ Collette Tayler: Reflection on early childhood education in the lifelong learning perspective ▪ Arthur Kramer: Reflection on aging and learning in the lifelong learning perspective ▪ Rudolf Tippelt: Overall reflection
12:45~13:00	Closing session (chaired by Takao Hensch) ▪ Masao Ito, RIKEN Brain Science Institute ▪ Bruno della Chiesa, OECD-CERI