Development and Evolutionary Foundation of Human Mind

New perspectives on cognitive development in humans from the prenatal period

Masako Myowa-Yamakoshi - Graduate School of Education

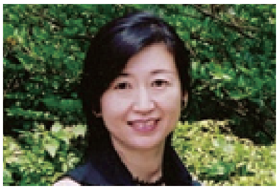
The human mind, which is not physically visible like human morphological characteristics, is a product of evolution. How have we evolved our unique minds? What has caused the differences that exist between humans and non-human primates? To address these questions, Myowa-Yamakoshi and research teams have taken an evolutionary approach, 'Comparative Cognitive Developmental Science': Comparing the development of social cognition in humans and non-human primates from their prenatal periods. Such an approach enables us to reveal the biology behind the characteristics of the human mind, both shared with non-human primates and uniquely human.

One of the findings has been the evolutionary root of human imitation. Humans have created and use a vast assortment of tools, and have also developed an extensive array of ways to communicate with each other. Imitation plays a key role in supporting human cultural traditions by facilitating the transmission of knowledge and skills from one generation to another. Myowa-Yamakoshi and colleagues have revealed that the imitative capacity is common to humans and chimpanzees in their early stages of life. However, chimpanzees do not develop their imitative abilities in the same manner as humans: Chimpanzee imitation is less accurate than human imitation. These findings suggest that the ability to imitate a broad range of whole-body actions seems to be an ability that evolved after the human lineage separated from that of chimpanzees. Such a remarkable species difference of visual-motor information processing may be reflected in the different social-cognitive abilities of the two species. The recent findings supporting this hypothesis are published online in Nature Communications in 2012.

www.educ.kyoto-u.ac.jp/myowa/en/index.html

A Japan-based Global Study of Racial Representations

Crossing disciplinary and national boundaries



Professor Yasuko Takezawa - Institute for Research in Humanities

Professor Yasuko Takezawa has led numerous collaborative research projects on race and ethnicity over her ten years at the Institute for Research in Humanities. The institute was the first to implement the now nation-wide grant program for such global collaborations. Takezawa currently leads a five-year research project – A Japan-based Global Study of Racial Representations.

Takezawa offers fresh insights into the field of race and ethnic studies by examining the 'invisible races' found in East Asia, such as the *burakumin* and Korean nationals in Japan, with a focus on their non-visual representations. She also analyzes scientific and counter representations. In doing so, she attempts to verify the ways in which these different forms of representation interact with each other to construct a socially recognized racial identity.

This project is truly multi-/interdisciplinary, bringing together an unprecedented team of scholars in a wide range of disciplines ranging from cultural anthropology to history of science, to genetics and physical anthropology. The fruits of such interdisciplinary collaborations are available in: *Racial Representations in Asia* (Kyoto University Press and Trans Pacific Press, 2011), which will soon be followed by additional volumes.

Apart from her collaborative research projects, Takezawa also pursues her various interests in the evolution of race as a concept, Asian Americans and their identities, and the development of multiculturalism in Japan.

takezawa.zinbun.kyoto-u.ac.jp/english/
race.zinbun.kyoto-u.ac.jp/?lang=en

First Stars Heavy but Not Monstrous

Researchers recreate universe's first star

Associate Professor Kazuyuki Omukai - Graduate School of Science

It is widely believed that the first stars were formed when the age of the universe was a few hundred million years old. At birth, the first stars were just tiny embryos - protostars - with masses of about one percent of the sun. The protostar is then thought to grow by accumulating the surrounding hot gas, but how much gas it can acquire has been largely unknown. Our new computer simulated study has revealed the entire process of the fist stars' growth over a hundred thousand years until they become truly active stars undergoing nuclear fusion.

Astrophysicists had previously thought that the first stars could grow huge, to as much as a few hundred times the sun in mass. It was found however, that the star regulates its own growth by emitting intensive radiation, according to the new study. The simulation showed highly dynamical features of this process. When the star grew to as large as 20 times that of the sun, it shined very bright, almost equivalent to a cluster of a hundred thousand sun-like stars. Ultra-violet light from the luminous star then quickly heated up the gas in the vicinity to above ten thousand degrees in temperature. The hot bubble launched a high speed gas flow outward, which eventually evacuated the surrounding 'parent' gas cloud from which the star was born. There remained a star with a mass, 43 times that of the sun. Such ordinary massive stars, ordinary in the sense that there are indeed such stars with similar masses in the present-day universe, finally resolve the long-standing problem of explaining the observed elemental abundances of very old stars in our Galaxy.

www-tap.scphys.kyoto-u.ac.jp/~hosokawa/firststarstop_e.html

Relay Race with Single Hydrogen Atoms

New ways of manipulating matter

Associate Professor Hiroshi Okuyama - Graduate School of Science

A relay reaction of hydrogen atoms at the single-molecule level has been observed in real space. This way of manipulating matter could open up new ways to exchange information between novel molecular devices in future electronics. An athletic relay race is a competition where each member of a team sprints a short distance with the baton before passing it onwards to the next team member. This collective way of transporting something rapidly is not a human-only activity and invention – a similar relay mechanism exists at the atomic scale, facilitating the transport of hydrogen atoms and protons in hydrogen bonded networks such as liquid water, biological systems and functional compounds. However, direct visual observation of this important transfer process in these situations is extremely difficult because of the high complexity of their environments.

Hiroshi Okuyama and his colleagues discovered that the relay reaction also occurs in molecular chains assembled on a metal surface. This new setup allowed the researchers to gain insight into the relay reactions at the single-atom level and view the process using a scanning tunneling microscope (STM). By sending a pulse of electrons through a water molecule at one end of the chain, hydrogen atoms propagate one by one along the chain like dominoes in motion. The result is that a hydrogen atom has been transferred from one end to the other via the relay mechanism. The demonstrated control of the atom transfer along these molecular chains not only sheds new insight on a fundamental problem. It could also open up new ways to exchange information between novel molecular devices in future electronics by passing around hydrogen atoms.

kuchem.kyoto-u.ac.jp/hyoumen/e/

Production of High Quality Human Embryonic Stem Cell Lines at Kyoto University

Genetic changes mapped in a diverse sample of ES Cells by international collaboration as a major step toward medical applications

Associate Professor Hirofumi Suemori - Institute for Frontier Medical Sciences
Professor Norio Nakatsuji - Director, Institute for Integrated Cell-Material Sciences

Human embryonic stem (hES) cell lines can proliferate indefinitely and differentiate into all kinds of tissues in the body. Therefore, they are considered to have great potential in medical research and applications such as cell transplantation therapy and drug discovery. Since we began deriving hES cell lines in 2003 at the Institute for Frontier Medical Sciences, we have established five hES cell lines, named KhES-1, KhES-2, KhES-3, KhES-4 and KhES-5. They have been studied extensively and characterized in detail, and so far distributed for use in over 50 research projects. We have now started a project to produce higher quality hES cell lines which can be used in clinical applications.

However, genetic changes can occur during prolonged proliferation in culture, and they cause potential risks in clinical applications. Thus, an international collaboration by the International Stem Cell Initiative (ISCI) including our group at Kyoto University began in 2008 to identify genetic changes that occur during the culture of many ethnically diverse hES cell lines. The effort, led by Prof. Peter Andrews of the University of Sheffield, analyzed 125 human ES cell lines including our five hES cell lines and 11 human induced pluripotent stem (iPS) cell lines collected from 38 laboratories across 19 countries. The study published online in *Nature Biotechnology* on Nov 27, 2011 (vol. 29, 1132-1144) revealed that most cell lines remained karyotypically normal, but change in karyotype during prolonged culture, especially in chromosomes 1, 12, 17 and 20. Copy number analysis using SNP arrays also showed that amplification of a small genomic region on chromosome 20 was found in over 20% of cell lines. These findings can be used for the accurate and cost-effective quality control of cell lines, which are needed in the application of stem cell technologies to regenerative medicine.

www.icems.kyoto-u.ac.jp/e/pr/2011/11/28-nr1.html
www.frontier.kyoto-u.ac.jp/es01/topE.htm

Mouse Genome Protection

Understanding the role of the miwi protein

Professor Shinichiro Chuma - Institute for Frontier Medical Sciences

The germline is the cell lineage that transmits genetic information to the next generation. Genetic and epigenetic changes in the germline affect embryonic development and subsequent offspring, so the genomic stability of germ cells is a critical requirement for maintaining both the individual and the species. Damage to Genomic DNA generally occurs as a consequence of physical or chemical attacks, such as from exposure to ionizing radiation, genotoxic reagents and oxidative stress. Another threat to the genome is the encoding mechanism of the genome itself, namely in the form of mobile transposable elements, which move or duplicate themselves and transpose into new genome positions. We recently discovered, in an international collaboration led by Dr. Ramesh S. Pillai at EMBL, France, the role that a particular protein plays in protecting the genome: specifically, the means by which the Miwi protein silences transposon RNAs in male mice. Among other findings, we demonstrated conclusively that disrupting the mice's capacity to produce the functional Miwi protein with RNA slicer activity leads to an inability to create viable sperm. We provide evidence for Miwi slicer activity directly cleaving transposon messenger RNAs, offering an explanation for the continued maintenance of repeat-derived Piwi proteins interacting with small RNAs (piRNAs) long after transposon silencing is established in germline stem cells. This work builds on earlier studies of our own and by other groups, investigating genomic protection, nearly completing the picture of the Miwi-based transposon silencing mechanism, and proposes that Piwi proteins act in a two-pronged mammalian transposon silencing strategy: one promotes transcriptional repression in the embryo, the other reinforces silencing at the post-transcriptional level after birth, both of which are critical for normal male fertility.

www.kyoto-u.ac.jp/en/news_data/h/h1/news6/2011/111128_1.htm

Visuoauditory Mappings Between High Luminance and High Pitch are Shared by Chimpanzees (*Pan troglodytes*) and Humans

Professor Ikuma Adachi - Primate Research Institute
Professor Tetsuro Matsuzawa - Primate Research Institute

Professor Adachi and his research collaborators have found that humans have innate preferences for certain cross-sensory combinations. For example, they consistently associate higher-pitched sounds with lighter colors, smaller sizes, and spikier shapes. Most notably, toddlers are found to have already formed such pitch-luminance cross-modal correspondences at thier young age. It has been argued that the tendency to systematically match visual and auditory dimensions was a driving factor in the evolution of language.

However, none has yet addressed the crucial question of whether or not non-human animals experience cross-modal correspondences as well. Here, the research team offers the first direct comparison between humans and chimpanzees on their pitch-luminance mapping by testing whether chimpanzees (Pan troglodytes) also associate higher pitch with higher luminance. Thirty-three humans and six chimpanzees were required to sort black and white squares according to their color while hearing irrelevant background sounds that were either high-pitched or low-pitched. Both species performed better when the background sound was congruent (high-pitched for while, low-pitched for black) than when it was incongruent (low-pitched for white, high-pitched for black). Chimpanzees made more mistakes when the background sound was incongruent than when it was congruent. In humans, the effect was evident through increased latencies in the incongruent trials, which was in line with previous research. These results suggest that an inherent tendency to pair high pitch with high luminance hence evolved before the human lineage split from that of chimpanzees. Rather than being a culturally learned or linguistic phenomenon, this mapping constitutes a basic feature of the primate sensory system.

www.pri.kyoto-u.ac.jp/ai/

Using Innovative Imaging Technologies to Preserve the World's Cultural Heritage

Science and technology for art

Professor Ari Ide - Graduate School of Engineering

Located in Kyoto, a city of culture, art and technology, at the Ide Laboratory of the Graduate School of Engineering is central in developing state-of-the-art imaging technologies to digitally record and archive cultural properties in Kyoto and around the globe. Their new high precision scanner system for cultural assets digitizes large artworks such as those on sliding doors (*fusuma*), wall paintings, as well as documents such as antique architectural plans for important historical buildings. The scanner has an extremely high dimensional and color reproduction accuracy. The digitization process has been carefully developed to minimize its intrusive effects by developing appropriate light sources and minimizing the physical bulk of the scanner itself (the lightest machine is less than 30kg). We have also been successful in adding analytical imaging features which enables non-destructive and non-invasive analysis of material composition and color.

In 2011, we collaborated with Ninnaji Temple, a UNESCO-designated World Heritage site and an Important Cultural Property, to digitize on-site and record in microscopic level, the contents of a building from the early Edo Period with wall paintings and sculptures. The world's most advanced analytical imaging technologies were utilized for the recording and preserving of the heritage assets. The database of pigments and colorants from this project hopefully are expected to significantly contribute to our understanding of the art and technologies of the early Edo period.

The research team is currently working in China (Beijing, Xian), the UK (London, Belfast), Korea (Seoul) and Egypt (Giza, Cairo) as well as over 10 sites in Japan, to establish a global network of collaboration to preserve, utilize and pass down to the next generation the world's cultural resources. We hope that this technology from Kyoto will act as a catalyst in encouraging global interest in and renewing discussions on cultural heritage.

www.kyotoheritage.jp/en/index.html