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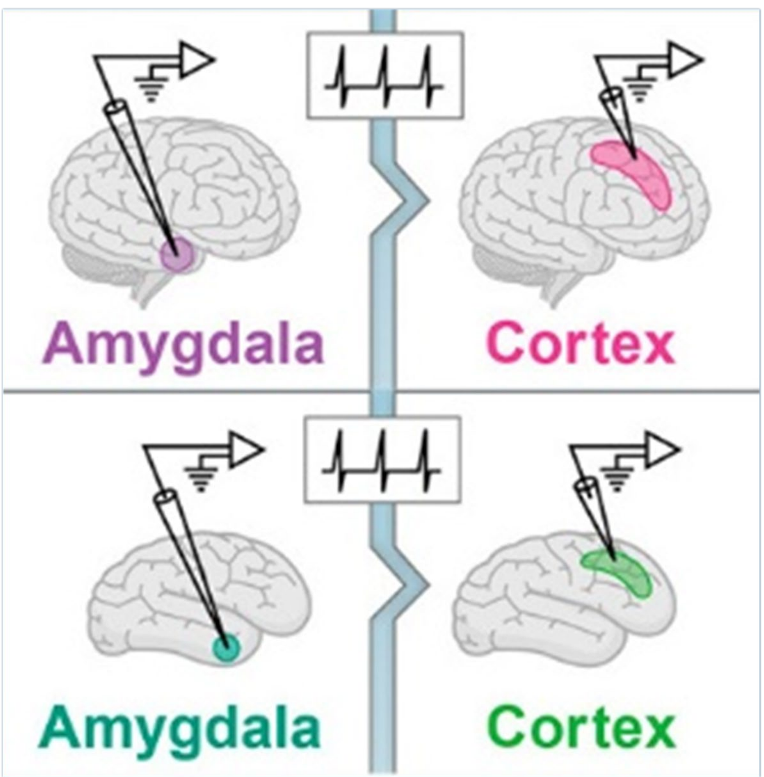
All Too Human

The price we pay for our advanced brains may be a greater tendency to disorders



The tradeoff in human brains (top) and monkey brains (bottom). The more evolutionarily advanced, the more efficient and the less robust each area proved to be

Prof. Rony Paz of the Weizmann Institute of Science suggests that our brains are like modern washing machines – evolved to have the latest sophisticated programming, but more vulnerable to breakdown and prone to develop costly disorders. He and a group of researchers recently conducted experiments [comparing the efficiency of the neural code in non-human and human primates](), and found that as the neural code gets more efficient, the robustness that prevents errors is reduced. Their findings, which recently appeared in *Cell*, may help to explain why disorders as ADHD, anxiety, depression, PTSD and even autism are common in humans.

Paz, in the Institute's Neurobiology Department, says that anatomical differences between humans and other primates have been described – particularly our large pre-frontal cortex and its extended number of neurons. But differences in the neural code – the "software," in contrast with the "hardware" (the physical structure) – have not been explored.

Raviv Pryluk, a research student in Paz's group, devised a way to test and compare the efficiency of the neural code in several regions of the brain. "We defined efficient communication as that which uses the least amount of energy to transmit the maximal information – to pass on as complicated message as possible with the fewest 'words'," says Pryluk.

The researchers recorded the electric activity of single neurons both in humans and in macaque monkeys in two regions: the pre-frontal cortex, where higher functions like decision making and rational thinking occur, and the amygdala, a more evolutionarily ancient region that is responsible for the "fight or flight" basic survival functions, as well as emotions. Paz and his group worked in collaboration with Prof. Itzhak Fried of Sourasky Medical Center in Tel Aviv and UCLA Medical School in Los Angeles. Patients with pharmacologically intractable epilepsy come to Fried to have electrodes implanted for diagnostic purposes, and these provide a rare opportunity to record the electric activity of single neurons in the human brain. Also participating in this research were Dr. Hagar Gelbard-Sagiv of Tel Aviv University and Dr. Yoav Kfir, at that time a research student in Paz's group.

The findings of this research provided support for the "washing machine" theory of brain evolution: The neural code in the "more evolved" pre-frontal cortex is more efficient than the amygdala, both in humans and monkeys. And the neural code of both areas in the human brain was more efficient than its monkey counterpart. But the higher the efficiency of a particular neural code, the less it was robust to errors. Paz likens the amygdala to the washing machine drum: "It's not highly sophisticated, but it is less likely to fail – which is important to animals' survival," he says, adding: "The lower resistance of the human amygdala to errors may play a role in exaggerated survival-like responses in inappropriate contexts, such as those we see in PTSD and other anxiety disorders."

Pryluk: "Evolution works with trade-offs. There may be a zero-sum game between efficiency and robustness; and our complex, multidimensional brains have gained one at the price of the other." Fried: "Comparing single-cell recordings from human and monkey brains is a large step forward toward answering the question of what makes the human brain unique." Paz adds: "Why, on the one hand, do humans have such superior learning, cognitive and adaptive abilities and, on the other, this tendency to anxiety, depression and other mental diseases? We have shown that these may be two sides of the same coin."

Prof. Rony Paz's research is supported by the Adelis Foundation; the Irving and Dorothy Rom Family Discovery Endowment Fund; the Irving B. Harris Fund for New Directions in Brain Research; the Bernard and Norton Wolf Family Foundation; the Leff Family; the Oster Family Foundation; Mr. and Mrs. Gary Clayman; Rosanne Cohen; the estate of Toby Bieber; and the European Research Council.

I. Suisetz, https://commons.wikimedia.org/w/index.php?curid=2448732

Plants Blink: Proceeding with Caution in Sunlight

Like eye's adjustment to sudden changes in light, plants have sensitive mechanisms to protect their leaves from rapid changes in radiation

Plants have control mechanisms that resemble those in human senses. According to a new Weizmann Institute of Science study, plants adjust photosynthesis to rapid light changes using a sophisticated sensing system, much in the way that the human eye responds to variations in light intensity. This sensory-like regulation operates at low light intensities, when the photosynthesis machinery is most efficient but also most vulnerable to sudden light increases.

A widely accepted view has been that since the more sunlight a plant absorbs, the more energy it has for growth, photosynthesis would tend to increase proportionally to sunlight intensity. Only upon reaching a level at which excessive radiation causes damaging "sunburn" would the plant turn on repair mechanisms and turn photosynthesis down. Prof. Avihai Danon of the Plant and Environmental Sciences Department and his colleagues evaluated plant fluorescence (light reemitted by nonproductive photosynthesis, used as a nonintrusive proxy to measure photosynthesis levels) at low light exposure, and they were surprised to see a back-and-forth pattern.

Danon initiated a collaboration with Prof. Uri Alon of the Molecular Cell Biology Department, whose lab studies biological networks and circuits, among them, those in the human body. The team – Avichai Tendler (from Alon's lab) and Drs. Bat Chen Wolf and Vivekanand Tiwari (from Danon's lab) – exposed *Arabidopsis thaliana*, model plants from the mustard family, to a series of step-by-step, 10-minute-long increases in light intensity in the low to moderate range, roughly equivalent to outdoor morning light – that is, below the level that causes stress to the plants.

As reported in *iScience*, the scientists saw that the fluorescence, instead of rising steadily when the light grew stronger, soared for a short while at each step, then dropped back to the initial level. Each time, its peak was smaller than at the previous step. This was because, as the researchers found, when the light grew stronger, fewer photons arrived at the plant's photosynthetic reaction center than would have been expected from the increase in light intensity. Each time the researchers had to double the light's intensity to produce the same fluorescence peak as at the previous step – a pattern typical of sensory mechanisms in bacteria, animals and humans.

These findings supply evidence that under low-light conditions, the control mechanisms of photosynthesis resemble those operating in such sensory systems as, for example, human vision. When the pupils adjust to the brightness of light, these adjustments not only protect the retina but ensure we remain sensitive to our surroundings despite changing light conditions. When the pupils are narrow, we distinguish only high contrasts in lighting. In low-light conditions, for example at dusk, the pupils widen, letting in more light, thus enabling us to identify objects that differ only slightly in their reflected light. In the same manner, the photosynthesis antennae – the light-harvesting complexes of proteins and chlorophyll molecules in the plant – shrink in bright light and enlarge under low-light conditions. Like pupils, when the antennae grow larger, they harvest the light more efficiently and grow more sensitive to small changes in light intensity – but they also become more vulnerable to change, especially sudden change.

“Plants handle photosynthesis in a cautious manner that sacrifices efficiency in the short term for the sake of long-term stability,” Danon says. “In a way, the photosynthesis machinery ‘senses’ the environment, making rapid adjustments to the amount of ‘harvested’ light before the situation runs out of hand, rather than escalating its activity in an uncontrolled manner until sustaining damage.”

The newly discovered controls kick in fast, buying time for the slower mechanisms that adjust photosynthesis to developing conditions. This exquisite coping strategy is one of the ways in which plants make the most of sunlight under rapidly changing outdoor conditions, for example, when clouds come and go, or when the wind alters the angle of leaves to the sun.

Prof. Avihai Danon is the incumbent of the Henry and Bertha Benson Professorial Chair.

Prof. Uri Alon’s research is supported by the Kahn Family Research Center for Systems Biology of the Human Cell; the Sagol Institute for Longevity Research; the Braginsky Center for the Interface between Science and the Humanities; the Zuckerman STEM Leadership Program; the Rising Tide Foundation; the European Research Council; and the Leff Family. Prof. Alon is the incumbent of the Abisch-Frenkel Professorial Chair.

Israeli and Czech Scientists Join Forces in Advancing Drug Discovery

To expand the ties between the Israeli and Czech scientific communities, their countries are developing new forms of collaboration between talented young scientists. One such project is the “Joint Prague-Weizmann Winter School on Drug Discovery.” This intensive week of professional lectures is attended by more than 120 scientists and students from around the world. The project provides a unique opportunity for young Israeli and Czech researchers to meet and discuss the latest trends and challenges in drug development, as well as to meet with world leaders in academia and experts from such multinational pharmaceutical giants as MSD, Roche and Astra Zeneca.

This year’s winter school, organized by the Institute of Organic Chemistry and Biochemistry (IOCB) of the Czech Academy of Sciences, the University of Chemistry and Technology in Prague, and the Weizmann Institute of Science, was held for the first time in Israel at the Weizmann Institute, on December 3-7.

Prof. Martin Fusek, Deputy Director of the IOCB Prague, who is one of the co-organizers of the event, said: "After organizing four consecutive and successful sessions of Summer School on Drug Development in Prague, the IOCB Prague and the UCT Prague were approached by Prof. Irit Sagi, Dean of the Feinberg Graduate School of the Weizmann Institute, with an interesting offer to organize an annual winter school jointly – every other year in Prague and then in Rehovot. Right now, it’s our first Joint School stemming from this new tradition, and I would like to thank my colleagues from the Weizmann Institute of Science, especially Dr. Nir London and Dr. Haim Barr, for the excellent organization and a very friendly atmosphere. I am very pleased to be able to deepen cooperation with this top research organization."

Among the attendees of the event were Czech Ambassador to Israel H. E. Martin Stropnický; Prof. Karel Melzoch, Rector of the University of Chemistry and Technology in Prague; Dr. Zdeněk Hostomský, Director of the IOCB Prague; and Doc. Jan Konvalinka, co-organizer and vice-rector of the University of Charles University.

“There was tremendous interest in attending from all over Israel, and the interaction between the Israeli and Czech scientists will surely lead to fruitful collaborations. I look forward to expanding the scope of this school in the coming years,” says co-organizer Dr. Nir London of the Weizmann Institute.

The initiative and the conference were supported by the Feinberg Graduate School and by three of its Research Schools: the Solo Dwek and Maurizio Dwek Research School of Chemical Science; the Ekard Research School of Biological Science; and the Lorry I. Lokey Research School of Biochemical Science.