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Epharmology: a Plea for a New Science and a New Education Paradigm

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Technological development is characterised by a series of related phenomena – digitalisation, informatisation, robotisation, and globalisation – resulting in continuous and essential adaptations of human brain and behaviour. These adaptations have awoken the interest of numerous disciplines, but their systematic study, actually, is missing. In the present paper, along with the list of several adaptation fields and examples, the establishing of a new science is suggested – epharmology (from the Greek epharmozein = to adapt) which might be able to comprehensively approach the gathering and analysis of data from various observations and sources and, based on discerning between wishful and unwishful adaptations, which could exert influence upon legislation and education reform.

Key words: *digitalisation, education, epharmology, science.*

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Introduction¹

When it comes to technology, the human society of our time has been facing at least four interrelated phenomena: digitalisation (or digitisation: increased recording/storing of information using the binary code; increased use of computer technology and/or electronic image; convergence of the real and virtual worlds due to ICT; automated and networked virtual operation system inconceivable to human mind in/for its extension, velocity, and number of combinations); informatisation (increased relying upon computers; increased production and exposal to information); automation (also called robotisation and AI; resulting from digitalisation; increased transforming of man-governed processes into „self-governed” processes); and globalisation (resulting from digitalisation and informatisation; increased planetary interconnectivity; global networking of people and things).² The attitude of scientific community, as much as of general public, with respect to those phenomena is extremely ambiguous, spanning from uncritical embracement (e. g., Nicholas Negroponte, the co-founder of the MIT Media Lab) to panic rejection (e. g., Mark Boyle, Irish activist and writer, columnist of *The Guardian*).³ Nevertheless, one thing is certain: those phenomena cause significant changes in the brain, mind, and behaviour of humans.

1. Adaptations: Assessing the Problem and Its Range

An average adult spends about 3 hours per day online (some teens 9 hours with digital media).⁴ We are contemporarily exposed to three series of visual and auditory information while watching TV news („multi-tasking”); we travel by planes and by television to the distances greater than we are able to master cognitively and chronobiologically; we cannot identify ourselves with the contents of fresco paintings, like the peasants in Istria in the 15th century, or with

¹ This paper is supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2017S1A6A3A01078538), and represents a result of the project „Bioethical aspects of urban(ised) artificial intelligence” (PI: S. Byun; 2019-2020), partly realised at the Humanities Research Institute at Chung-Ang University, Seoul, Korea.

² A useful, even if quite disquieting vision of the impact of those phenomena upon politics, economy, and the everyday life, can be seen in: Eric SCHMIDT and Jared COHEN, *The New Digital Age: Reshaping the Future of People, Nations and Business*, New York, Knopf, 2013.

³ To see the radical shift of this attitude within the official Lateran stands, see: Pier Cesare RIVOLTELLA, Internet i odgoj: analiza pedagoških modela i smjernice za razmišljanje [Internet and education: the analysis of pedagogical models and directives for consideration], *Kateheza*, 24 (2002) 3, 265-280.

⁴ Cf. also: Cris ROWAN, Unplug – don’t drug: A critical look at the influence of technology on child behavior with an alternative way of responding other than evaluation and drugging, *Ethical Human Psychology and Psychiatry*, 12 (2010) 1, 60-68.

a theatre play, like the poor Londoners in the 16th century, or with a book, like our parents in the 20th century:⁵ will holograms be able to satisfy us, once we will become bored by the film?⁶ Harold Klawans claims that we have exaggerated already by subtitling films, since our brain allegedly is not able to follow the image and to read contemporaneously the translation of conversation.⁷ Sheena Iyengar and collaborators found out proofs that human brain, when exposed to excessive information, brings lower-quality decisions.⁸ It also has already been stressed that a screen-centered 2D learning cannot replace child's 3D learning using touch.⁹

Some of our general adaptations to these phenomena include quantitative rather than (critical) qualitative selection of information and specialisation (equally in science, education, and practice), and changes in human mental functioning and behaviour due to formal features (hugeness, diversity, changing velocity). Digitalisation also speeds up the processes (information transmission, order execution, etc.) and increases the exploitation (expenditure) of our resources, which is contrary to the concept of „sustainable development.”¹⁰ According to one review, the net generation („homo zappiens“) is characterised by four components: the increase of speed of our reactions („dictatorship of urgency“), multi-tasking skill, learning by searching for information (superficial browsing), and attention-span widening („floating attention“).¹¹

Among numerous specific adaptations of humans, we also can list certain harmful anomalies like Computer Vision Syndrome (CVS; sight deterioration due to excessive screen watching);¹² „electromagnetic hypersensitivity” (EHS;

⁵ Cf. Amir MUZUR and Iva RINČIĆ, Ljudski mozak na putu od subjekta prema objektu biotehnoških procesa [The human brain on its way from a subject to an object of biotechnological processes], in: Velimir VALJAN (ur.), *Integrativna bioetika pred izazovima biotehnologije* [Integrative Bioethics in Front of the Challenges of Biotechnology], Sarajevo, Bioetičko društvo u BiH, 2012, 149-159.

⁶ On the experiments related to the interactivity of the film, see: Tihoni BRČIĆ, Interaktivni film: odgovor na pasivnost medija [Interactive movie: A response to passivity of the medium], *In medias res*, 8 (2019) 15, 2471-2483.

⁷ Harold KLAWANS, Špiljska žena: *priče iz evolucijske neurologije* [Defending the cavewoman and other tales of evolutionary neurology], transl. Meri Tadinac, Zagreb, Jesenski i Turk, 2008, 87-107.

⁸ Cf. Sharon BEGLEY, The science of making decisions (27.02.2011), <https://www.newsweek.com/science-making-decisions-68627> (18.11.2019).

⁹ Cf. Catherine STEINER-ADAIR, *The Big Disconnect: Childhood and Family Relationships in the Digital Age*, New York, Harper Collins Publishers.

¹⁰ Cf. Predrag SLIJEPČEVIĆ, *Svetac i grešnik: kako zloupotrebjavamo nauku i budućnost čovječanstva* [A Saint and a Sinner: How We Abuse Science and the Future of Humanity], Novi Sad, Akademska knjiga, 2018.

¹¹ Cf. Vesna BILIĆ, The net-generation methods of learning, online activities and upbringing outcomes, *Croatian Journal of Education*, 18 (2016) 1, 259-277.

¹² Cf. James E. SHEEDY, Vision problems at video display terminals: A survey of optometrists, *Journal of the American Optometric Association*, 63 (1992) 10, 687-692.

the alleged set of disturbances due to electromagnetic waves);¹³ mobile-phone usage consequences (sleep, depression, hyperactivity, etc.);¹⁴ Internet Addiction Disorder (IAD);¹⁵ „Sponge Bob Effect“ (deterioration in executive functions after watching cartoons);¹⁶ decrease of empathy and increase of aggressivity;¹⁷ or some phenomena the effect of which is still to be studied, like the changes in personal identity of the Internet users,¹⁸ the increased thumb representation area in the cortex as a result of typing, or the rise of „action per minute“ (APM; total number of actions performed in one minute) in video-gamers;¹⁹ etc. Multi-tasking can make information bypass the hippocampus and go to the striatum resulting in procedural instead of explicit memory.²⁰ A „cognitive offloading“ has been observed, that is, the use of technology even when not necessary (e. g., searching for well-known information in the Internet).²¹ Reading a pdf on digital platform has been proved to result in focusing more on details, while reading a printout of the same pdf text in being able to find/form a more abstract framework.²² We mentioned here only a few examples of cerebral

¹³ Cf. Jutarnji.hr, Nova epidemija širi se SAD-om: deseci Amerikanaca pobjegli u osamu u strahu od bežičnih mreža, (18.09.2011), <http://www.jutarnji.hr/template/article/article-print.jsp?id=974871> (18.11.2019).

¹⁴ Cf. Sara THOMÉE, Annika HÄRENSTAM and Mats HAGBERG, Mobile phone use and stress, sleep disturbances, and symptoms of depression among young adults – a prospective cohort study, *BMC Public Health*, 11 (2011) 66; Hozefa A. DIVAN, Leeka KHEIFETS, Carsten OBEL and Jørn OLSEN, Prenatal and postnatal exposure to cell phone use and behavioural problems in children, *Epidemiology*, 19 (2008) 4, 523-529; Tamir S. ALDAD, Geliang GAN, Xiao-Bing GAO and Hugh S. TAYLOR, Fetal radiofrequency radiation exposure from 800-1900 MHz-rated cellular telephones affects neurodevelopment and behavior in mice, *Scientific Reports*, 2 (2012) 312, doi:10.1038/srep00312.

¹⁵ Fuchun LIN, Yan ZHOU, Wasong DU, Lindi QIN, Zhimin ZHAO, Jianrong XU and Hao LEI, Abnormal white matter integrity in adolescents with Internet Addiction Disorder: a tract-based spatial statistics study, *PLoS One*, 7 (2012) 1, e30253.

¹⁶ Angeline S. LILLARD and Jennifer PETERSON, The immediate impact of different types of television on young children's executive function, *Pediatrics*, 128 (2011) 772-774.

¹⁷ Craig A. ANDERSON, Akiko SHIBUYA, Nobuko IHORI, Edward L. SWING, Brad J. BUSHMAN, Akira SAKAMOTO, Hannah R. ROTHSTEIN and Muniba SALEEM, Violent video game effects on aggression, empathy, and prosocial behavior in eastern and western countries: a meta-analytic review, *Psychological Bulletin*, 136 (2010) 2, 151-173.

¹⁸ Cf. Susan GREENFIELD, *ID: The Quest for Meaning in the 21st Century*, London, Sceptre, 2009.

¹⁹ Cf. Gifford CHEUNG and Jeff Huang, Starcraft from the Stands: Understanding the Game Spectator, in: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, CHI 2011, Vancouver, BC, Canada, May 7-12, 2011*, New York, Association for Computing Machinery, 2011, 1221-1224.

²⁰ Karin FOERDE, BARBARA J. KNOWLTON, RUSSELL A. POLDRACK, Modulation of competing memory systems by distraction, *Proceedings of the National Academy of Sciences of the USA*, 103 (2006) 31, 11778-11783.

²¹ Benjamin C. STORM, Sean M. STONE, Aaron S. BENJAMIN, Using the Internet to access information inflates future use of the Internet to access other information, *Memory*, 25 (2017) 6, 717-723.

²² Pablo DELGADO, Cristina VARGAS, Rakefet ACKERMAN and Ladislao SALMERÓN, Don't throw away your printed books: A meta-analysis on the effects of reading media on reading comprehension, *Educational Research Review*, 25 (2018) 23-38.

and/or behavioural adaptations: it would be hardly possible to list all of them, especially if we would like to include the vast range of behavioural changes related to body posture, cybercriminal experiences,²³ or modern economy of platforms and cryptocurrencies.²⁴

2. Adaptations: Proposing a Way to Proceed

Obviously, adaptations to digitalisation, automation, informatisation, and globalisation are worthy of being studied. But how should we do it? Of the existing disciplines, many would be needed: theoretical, experimental, and clinical neurosciences (neuroanatomy, neurophysiology, psychology, neurology, psychiatry, etc.), to discern the „normal” from the „adapting;” mechanics, robotics, computer science, etc., to determine what causes the adaptations; sociology/anthropology, to explain what it means for the individual and society; ecology, to study what it means for environment; philosophy, to decide what we want; bioethics, to articulate what is to be suggested; law, to discern the legal from illegal; history, to find out what we have encountered already, etc. If none of the existing disciplines can address the adaptations alone, maybe we need a new discipline to overcome current pitfalls: let us tentatively call it epharmology (from the Greek *epharozein* = to adapt).²⁵ What should this new discipline study and how should it help improve modern human society and individual life quality? First of all, the new discipline should study changes in human brain, mind, and behaviour due to informatisation and digitalisation (the influence of the Internet, typing,²⁶ mobile-poning, using Windows-like softwares, etc.), and then measure and evaluate the new range of capacities resulting from those changes (attention span,²⁷ action per minute, hyperactiv-

²³ Cf. Misha GLENNY, *Dark Market: kako su hakeri postali nova mafija* [DarkMarket: How Hackers Became the New Mafia], transl. by Andrea Milanko, Zagreb, Ljevak, 2014.

²⁴ More on that in: Željko IVANOVIĆ, *Besplatno: uvod u političku ekonomiju digitalnog doba* [Free of charge: an introduction to political economy of the digital age], Jastrebarsko, Jesenski i Turk, 2018.

²⁵ For the first mention of „epharmology,” see: Amir MUZUR, Interdisciplinarity as a state of mind: how can individuals and societies reach it? *European Review*, 26 (2018) 2, 76-84, Suppl. One might think of „adaptology” as a better word, but linguistic rules do not prefer coining words out of roots from different languages, and besides, „adaptology” was already used by the Indian scholar Agrawal in a pejorative sense (suggesting modern Indian psychology is nothing more than imitating Western trends). Cf. K. G. AGRAWAL, Review: psychology or adaptology?, *Social Scientist*, 3 (1975) 10, 69-73.

²⁶ Cf. Rainer HARF and Jörn AUF DEM KAMPE, Zarobljeni u virtualnom svijetu [Trapped in a virtual world], *Geo – Hrvatska*, 5 (2011) 72-79.

²⁷ In one study from 2012, 75 % of the surveyed British teachers had noted a significant decrease in attention duration of their pupils. Cf. Susan GREENFIELD, *Promjene uma: kako digitalne tehnologije utječu na naš mozak* [Mind Change: How Digital Technologies Are Leaving Their Mark on Our Brains], transl. by Vedran PAVLIĆ, Zagreb, Školska knjiga, 208, 27.

ity, etc.). Based on those studies, it should foresee further changes in the brain and, if negative, prevent them, while, if positive, suggest how to adapt to them (for instance, the use of Internet social networks has proved to be positively correlated with the activity in civil society associations,²⁸ while some video-games may be able to improve visual data elaboration and psycho-motor skills). Optimal biological profile of humans should be estimated, suggesting standards to improve the quality of life – how much to sleep or to watch screens per day;²⁹ should the movies be provided with titles or synchronised; what is the best way of „using“ books or music; should we accept or even prefer digital-age journalism,³⁰ etc. Finally, a strategy of a radical reform of the educational system should be suggested – both in content and in method – being able to follow the changes in brain, mind, and behaviour in a maximally flexible and anticipating way.³¹ Methodologically, epharmology would rely upon gathering (archive, library, online databases) and elaborating (systematic reviews, meta-analyses, etc.) information from all relevant disciplines and research groups. The basic approach would be interdisciplinary critical evaluation, resulting in suggesting research directions and ethical and legal stands (founded on the Precautionary Principle). Directives provided by epharmology would also be useful in determining state regulation (e. g. filtering) and self-regulation (e. g.

²⁸ Krešimir KROLO and Ivan PUZEK, Upotreba internetskih društvenih mreža i participacijske dimenzije društvenoga kapitala mladih na primjeru Facebooka [The use of Internet social networks and the participatory dimensions of the youth social capital on the example of Facebook], *Društvena istraživanja*, 23 (2014) 3, 383-405.

²⁹ Previous recommendations used to limit time of mobile device use to 2 hours: today, adult supervision of use is more stressed. Cf. Roman GLOBOKAR, Impact of digital media on emotional, social and moral development of children, *Nova prisutnost*, 16 (2018) 3, 545-560.

³⁰ Cf. Sherry RICCHIARDI, Can quality journalism survive digital age?, *Liburna*, 1 (2012) 1, 6-13.

³¹ The diagnosis of the obsolescence of the prevailing teaching methods has long been reached: the surrounding the younger generations learn and grow up in, has profoundly changed during the last twenty years, while most of the schools still offer didactic scenarios originating from more than two centuries ago. Cf. Milan MATIJEVIĆ and Tomislav TOPOLOVČAN, Izazovi i trendovi u multimedijalnoj didaktici [Challenges and trends in multimedia didactics], *Radovi Zavoda za znanstvenoistraživački i umjetnički rad HAZU u Bjelovaru*, 11 (2017) 87-99; Vatroslav ZOVKO, ICT-enabled education – need for paradigm shift, *Croatian Journal of Education*, 18 (2016) 2, 145-155. In the UK, for instance, one of the major shifts in education curricula occurred in 2014 with the promotion of programming and networking (Computing) instead of application use (ICT). Cf. Yota DIMITRIADI, Who you're gonna call? The development of university digital leaders: a case study, *Medijske studije*, 10 (2019) 19, 102-118. The inappropriateness of informatics education in Croatia is demonstrated by the fact that the number of years the students attended informatics classes are not correlated with their level of knowledge. Lada MALEŠ, Monika MLADENović and Saša MLADENović, Znaju li studenti prve godine što je internet [First year students: Do they know what Internet is?], *Školski vjesnik*, 65 (2016) 105-117. Marc Prensky, again, lists several advices on how to adjust teaching by posing graphics before the text, transforming content to be taught into games, allowing random access to various contents, etc. Marc PRENSKY, Digital natives, digital immigrants, *On the Horizon*, 9 (2001) 5, 1-6.

„terms of service;“ or applications like *Freedom* or *SelfControl*)³² of the Internet-based media (mainly search and social media platforms). It is highly probable that, like in the case of smoking and illicit drugs, a certain degree of control over the use of digital media will have to be imposed by legal force. (Some scholars even go so far to compare digitally provoked changes in humans with what climate change causes to the Planet.³³) Even where digitalisation of public services and everyday life seems to serve its purpose perfectly, like in Estonia, resulting in transparent administration and growing economy, the problems of its individual use and social consequences may still be provoking anxious vision of the future.³⁴

Conclusion

Some authors, worried for the dehumanisation in the digital age, suggest the „four dimensions of human nature“ – cognition, social interaction, emotion, and ethics – be preserved and fostered by applying decision-making theory (wilfully blocking the „negative use“ of technology), increasing self-awareness and self-knowledge, teaching academic honesty, and responding to problems with technology addiction through impulse control training programmes (e. g., Harm Reduction Therapy, HRT).³⁵ Efficient or not, we can be sure that, without a significantly new approach, we shall only be passive observers of our own changing world. More important and dangerous, we shall not be able to transmit knowledge and control its efficiency. New disciplines do create a certain degree of confusion and overlapping (as bioethics, for instance, did once), but always stir up fresh ideas.

³² For an insight on how Twitter applies those rules, see: Marko MILOSAVLJEVIĆ and Sally BROUGHTON MICOVA, Banning, blocking and boosting: Twitter's solo-regulation of expression, *Medijske studije*, 7 (2016) 13, 43-58.

³³ GREENFIELD, *Promjene uma*, xv.

³⁴ Cf. Andrew KEEN, *Kako popraviti budućnost* [How to Fix the Future], transl. by Ivana KRENCER, Zagreb, Ljevak, 2018, 56-60.

³⁵ Junko YAMAMOTO and Simeon ANANOU, Humanity in the digital age: Cognitive, social, emotional, and ethical implications, *Contemporary Educational Technology*, 6 (2015) 1, 1-18.

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Efarmologija: pledoaje za novu znanost i novu paradigmu obrazovanja

Sažetak

Tehnološki razvitak karakterizira niz povezanih fenomena – digitalizacija, informatizacija, robotizacija i globalizacija – koji rezultiraju stalnim i bitnim prilagodbama ljudskog mozga i ponašanja. Ove prilagodbe bude interes brojnih disciplina, ali njihovo sustavno proučavanje, zapravo, izostaje. U ovome članku se, uz navođenje mnogih područja i primjera prilagodbi, sugerira ustrojavanje nove znanosti – efarmologije (od grč. *epharμοζειν* = prilagođavati se) koja bi na sveobuhvatan način pristupila prikupljanju i obradi podataka iz raznih opservacija i studija te temeljem razlučivanja poželjnih od nepoželjnih adaptacija mogla utjecati na zakonodavstvo i reformu obrazovanja.

Ključne riječi: digitalizacija, efarmologija, obrazovanje, znanost.

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