EXTENDED REALITY TRAINING ANALYTICAL TRANSCENDS IN THE FUTURE DIGITAL SOCIETY

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Abstract: *The upcoming digital Society 5.0 is expected to give a more creative role to the new digitally (i-) transformed people that is naturally requiring and a suitable way for their successful training. The main idea is to implement an extended reality in the new educational process, combining: mixed, virtual and augmented realities, within a holistic integration model and advanced human-machine smart interaction. The paper outlines a transcending system-of-systems analytical foreseeing for the future digital transformation transcends, related to both technologies and humans, accentuating on the training process for successful establishment of new, diverse cognitive i-skills and i-behaviour. Further, user-feedback, extended reality experimental validation is performed. Finally, a wrap-up discussion on the future training transcends for the upcoming transformed digital society is provided.*

Keywords: *extended reality training, analytical foreseeing, experimental validation*

Introduction

Proper understanding of the future digital (i-) society progressive needs towards multiple new extensions of the classical and innovative education subjects is of vital importance for the successful knowledge and skills gathering to the next generations to come, jointly with their agile social realization and global digital resilience establishment.

From one hand these requirements are also connected to the digital transformation in itself [1], requiring genuine i-literacy within the future jobs adaptation [2]. Whilst, from another are the transformed millennial and post-millennial generations [3], both rising diverse cognitive i-skills, adaptive memory, robust attention, i-engaged consciousness, mixed creativity and rich enough imagination [illegible] people should also be featuring and an adequate i-behaviour with an appropriate curiosity and living motivation, providing advanced learning achievements, working and entertaining capabilities cultivation in harmony with the modern, highly integrated, hyper-connected, ultrafast, heterogeneous and progressive extended smart reality [5].

In general, the digital reality extending [6] could have multiple understandings, ranging from objective with virtual joining, to augmenting via smart IoTs (devices, sensors and implants) and computational resources, assuring not just an ad hoc

mixing or overlaying but complete holistic system symbiotic re-creation as is hereafter assumed.

The developing of these phenomena for interactive learning within the extended digital environment gives a dual outlook towards the future, producing: (i) excessive capabilities for the trainees' advanced i-skills creation, provoked by the communication with the evolving machine intelligence and (ii) a demand for fast rewarding adaptation towards the new smart environment interfaces.

This new extended digital reality adaptation is also providing and unique opportunities for the future of digital learning [7] and fast accessing to huge amounts of knowledge for the world around us, combining both objective and simulated realities in a totally new, transcending way.

By joining human intelligence with the artificial one in a new "extended intelligence" [8], progressing towards a symbiotic singularity for huge data analytics, the upcoming digital society marked presently as "Society 5.0" [9] will outsource the unpleasant and monotonous activities to smart machines, providing a new, extended reality for peoples' insights like: imagination, creativity, emotions, ethics and intuition [10]. Whilst this new digital world will give multiple innovative opportunities, it is also going to create and numerous obvious and hidden adversaries, divides and challenges towards both technologies and users. This closer change will be mainly provoked by the future embracing of the smart technologies and the humans, bodies' implantations, fabricating extended digital people abilities with the cloud and quantum computing new levels of analytical power.

Further in the paper this original research area will be explored from multiple perspectives, trying to design: (i) a transcending system-of-systems analytical foreseeing, together with (ii) user-feedback, extended reality experimental validation. A (iii) wrap-up discussion on the future training transcends to the upcoming transformed digital society is finally provided.

2. Analytical Foreseeing

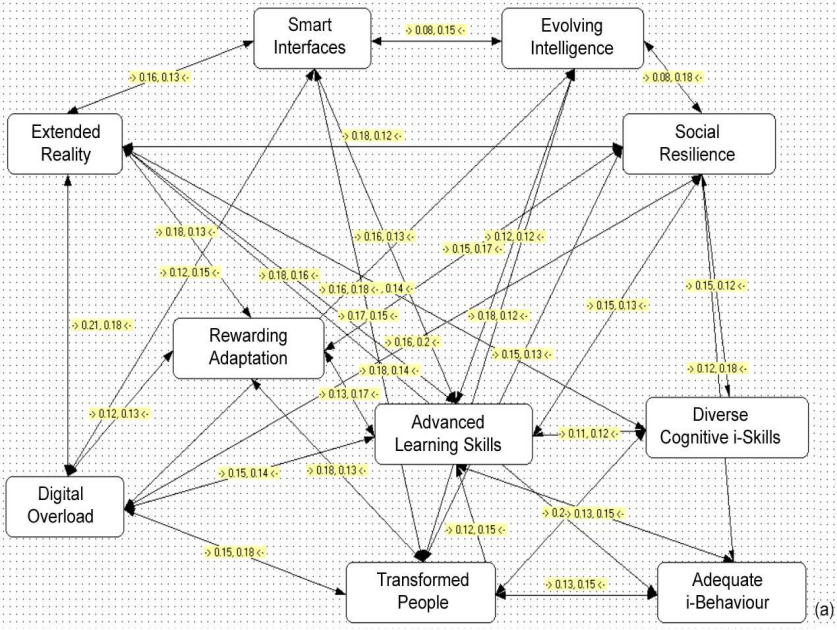
The foreseeing idea is based on the design of an oriented graph probabilistic model interpretation over the problem of "extended reality digital training transcending role", giving both a priori (current) and a posteriori (future) holistic assessment. The solution is practically encapsulating the "Entity-Relationship" paradigm [11] subsystems outlines in I-SCIP-EA environment [12].

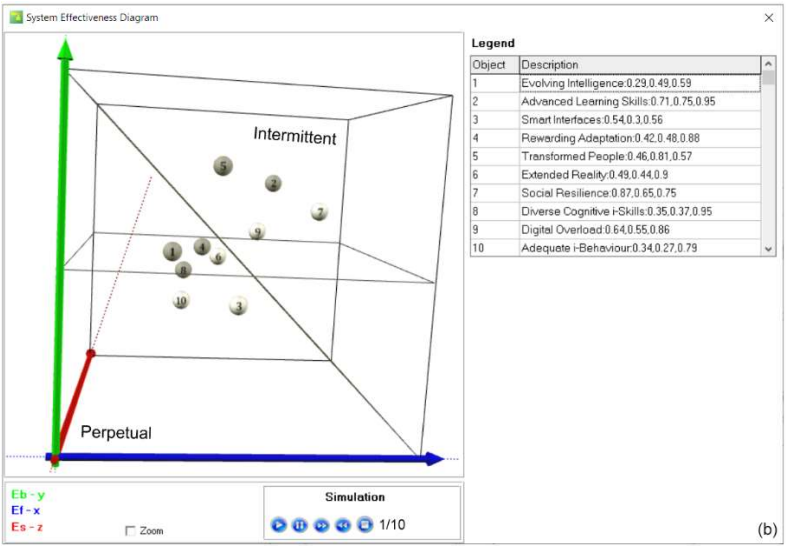
The "Entities" (marked with labeled round rectangles) are a collection of objects or agents, featured with own properties and behaviour objectives that are assumed to have a granted interaction capability with the others in the model via the multiple "Relationships" (marked with bi-directional arrows). The aggregated "Relationships" weights are obtained following a Bayesian approach in accordance with a selected scenario objective (see e.g. [1], [13]).

Both "Risk" and "Utility" variables are implemented for "Effectiveness" assessment. The results are visually generalized into a 3D "System Effectiveness Diagram" – "SE Diagrams", noting two main entities' behavior subclasses: "Perpetual" vs "Intermittent" (divided by the North-West/South-East plane), discriminating both "active" (white) and "passive" (grey) labeled spheres, in accordance with the relationships' aggregated probabilistic weights, using: E_f – forward entities relationship effectiveness, E_b – backward entities relationship effectiveness for E_s – entities generalized system effectiveness evaluation [14].

The model results are based on the working discussions organized in the framework of "Securing Digital Future 21" initiative [15]. Data from above 100 participants (both experienced and rising researchers), wide spread throughout the globe with 39 countries was used to define a system-of-systems model with 10 entities and 31 bi-directional relations (see Fig. 1a).

The produced 3D SE Diagrams (to the present – year 2019 and future expectations towards year 2029) for the extended reality digital training transcending role) are depicted in Fig. 1b and Fig. 1c.





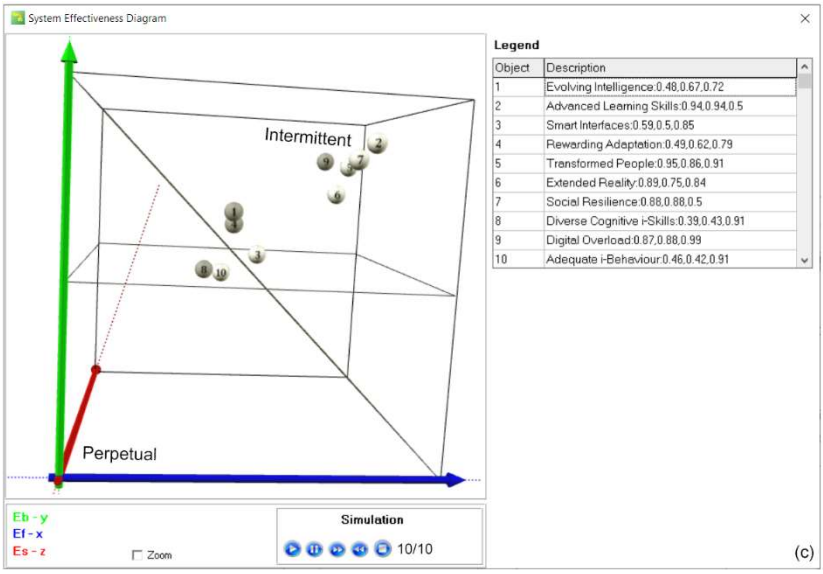


Fig. 1. Extended reality digital training transcending role modelling (a) and effectiveness assessment results, concerning technological progressive scenario towards advanced human-machine interaction for the current (2019 – (b)) and near future (2029 – (c)).

The results from Fig. 1, outline some digital training transcending role due to the model plausible future dynamic changes beliefs both for the present (2019) and near future (2029), as follows:

2019:

Perpetual: active: 3 – "Smart Interfaces", 6 – "Extended Reality", 10 – "Adequate i-Behaviour"; passive: 1 – "Evolving Intelligence", 4 – "Rewarding Adaptation", 8 – "Diverse Cognitive i-Skills".

Intermittent: active: 7 – "Social Resilience", 9 – "Digital Overload"; passive: 2 – "Advanced Learning Skills", 5 – "Transformed People".

2029:

Perpetual: passive: 8 – "Diverse Cognitive i-Skills"; active: 10 – "Adequate i-Behaviour"

Intermittent: active: 2 – "Advanced Learning Skills", 3 – "Smart Interfaces", 5 – "Transformed People", 6 – "Extended Reality", 7 – "Social Resilience"; passive: 1 – "Evolving Intelligence", 4 – "Rewarding Adaptation", 9 – "Digital Overload".

The outlined model discoveries could be further aggregated around several key findings for the digital training extended reality human and society transformational role, taking into account the entities both perpetual and intermittent dynamics within the next 10-years' time horizon:

(i). The new generation people learning transformation will become more active and smart in order to meet the growing digital overload that is approaching their natural limits;

(ii). The evolving intelligence is going to become not so stable as the AI is also progressing jointly with human-machine smart interfaces, giving humans completely new capabilities of data sourcing, analytics and hyper connectivity;

(iii). New extended realities elements and overlays are going to be created, focusing human imagination and knowledge, stimulated and assisted by machines;

(iv). The rewarding adaptation of transformed people will become unstable as the extended reality complexity progress is also growing, drawing a necessity for new advanced learning skills;

(v). The social resilience in this new digital world will be still under control, keeping dominance of humans for the final decisions and cultivating suitable i-skills and i-behaviour.

Being plausible by nature, the presented model aggregations for the near future (up to year 2029) extended reality effects related to the broader digital transformation expectations were next empirically validated, implementing both mixed & virtual experimental environments with elements of augmented ones and active user response multilayered monitoring.

3. Empirical Validation

The validation of the analytical system model future foreseeing (see Section 2) was further organized in two stages: (3.1) a mixed reality interactive simulation, during CYREX 2019 [16], incorporating some augmented reality elements and (3.2) virtual reality experimental design, implementation and observation.

3.1.1. Mixed Reality Experimentation Set-Up

Using an imaginary scenario events script, played (for about 180 minutes) from about 30 international trainees (organized in several multirole teams, during CYREX 2019) a dynamic exploration of extended reality digital training transcending role effects has been performed.

The architecture included several key attack vectors (social engineering, industrial & corporate espionage, malware, targeted & DDoS attacks) with seven main teams, organized as follows: a start-up company – *New Future*, developing a singularity smart robot control software was established by a terrorist group *Kill-the-Machines*. They were controlled by *Federation for Safe Earth* that wants to stop the singularity experiments on the New Moon colony as in the past these experiments brought the First Human-Machine War and practically almost ruined the Earth. *New Future,* funded by the *Union of Smart Countries* plans to use the smart machines as weapons. The *Global Digital Association* that was observing for the digital space human dominant control and peace both on the Earth and on the Moon enforce the criminal group *Blue Eagles* to influence the terrorist group *Kill-the-Machines*, using a money laundering scheme of AI movies creation by media innovations company – *Smart Media Group* from Cyber Land on the Earth. Finally, the smart robots from the New Moon base were re-programmed to create new kind of AI movies that had become very popular and also supported the Earth restoration after the war instead of establishing a new one with the help of the growing smart robot squads from the Moon, as was initially planned by the *Union of Smart Countries*.

The participants' teams used several device types: multimedia corporate telephones VING, phablets, desktop and mobile computers, several open cloud services (data storage and sharing, encryption, chats, social media, avatar multimedia messaging, e-mail accounting and participants DLP multi asset configurable monitoring, including selected key words and devices control) some accessed directly or in an augmented reality manner with encrypted or on purpose designed application, accessible via QR codes.

The exercise was primarily organized in a closed Facebook social network group, partially implementing also Telegram & Viber, while participants' network access to the used cloud services was accomplished via a VPN.

The trainees' i-behaviour and i-skills were observed using a multilayered monitoring and recording, implementing response times, full exercise video recording

(similar to [17]) and COTS DLP solution CoSoSys My Endpoint Protector, v. 4.7.4.7 (similar to [18]). The DLP environment was configured to control "Data-in-Motion" and "Data-in-Rest" types of data. Based on client-server architecture the environment provided client agents, installed on the users' endpoint devices and a work archive, stored on a remote accessed server. These agents were practically capable to control all the communication channels used in the exercise. The accomplished DLP solution was able to detect the content of the data and to compare it with preliminary defined keyword dictionaries, distinguishing sensitive data, whilst coping multiple I/O interface devices and allowing ad-hoc security policy definitions, according to the exercise scenario.

The implemented users' monitoring approach provided an opportunity for deeper trainees' analysis and rewarding adaptation better understanding, concerning their cognitive and behavioral responses, cultivating at the same time new advanced learning skills, using a mixed digital reality environment.

Fig. 2. Towards digital transformation better understanding with CYREX 2019 training, encompassing mixed experimental environment with active user response monitoring [16].

3.1.2. Mixed Reality Experimentation Assessment

Having empirical nature, the accomplished mixed reality in CYREX 2019 was quantitatively assessed (see Fig. 3) from the trainees (using inputs for both: *Positive* and *Indefinite* indicators' percentage measures, similar to [19]), referring five key parameters: "Environment & Scenario Adequacy", "Interface & Software Complexity", "Technological Effects", "Human Factor Effects" and "Training Satisfaction". Additional DLP monitoring data log leakeges aggregated results were provided for the different exercise attacks vectors, concerning: "Unauthorized Devices Connection", "Targeted & DDoS Attacks", "Marked Key Words & Phrases", "Malware & Fake Links", "Insiders & Espionage", "Social Engineering" and "Equipment Attacks".

The obtained epirical results are addressing successful understanding for CYREX 2019, giving only a little bit diminished mark to the "Technological Effects" asset (75% in contrast with the others, being greater then 80%) due to the rather complex mixed reality implementation. The data leaks results, are giving highest priorities (between 23 – 25 %) to "Insiders & Espionage", together with "Malware & Fake Links". Other visible attack vectors but with lower priorities (between 12 – 13 %) are based on "Targeted & DDoS Attacks" and "Social Engineering". The rest of the implemented attacks that are normally controlled by DLP systems (related to devices and key words) are with low frequency (between 7 – 10%).

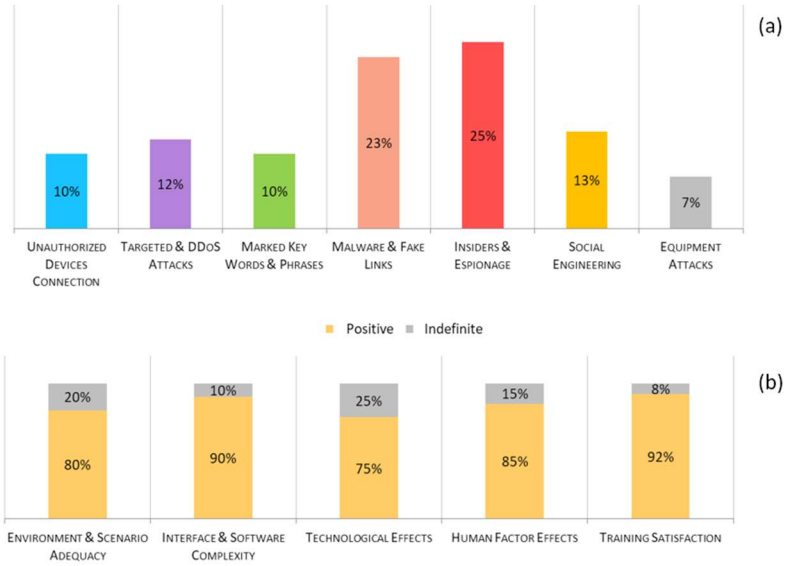


Fig. 3. CYREX 2019 attack vectors (a) and quantitative overall event assessment (b) results.

Obviously human i-behaviour and i-skills dynamics are difficult to be directly measured with questionnaire sets and technical monitoring systems. Apart of this, their further control in complex mixed training environment is also hard for achieving, though being rather close to the real world objective one. One of the key reasons for this could be the high level of noisy environment distractors (human, technological, organizational), creating an overall high cognitive overload towards the trainees. So, a virtual reality experiment with specific biometric monitoring in combination with questionnaires survey was next tested.

3.2.1. Virtual Reality Experimentation

The virtual reality experimental training has been designed, following the ideas for Intelligent Teaching Avatar – ITA [20] implementation, but explores the possibility to build a mobile solution that is providing capabilities for both Oculus Rift and Android phablet VR applications with supportive passive VR glasses and joystick, implementing also AI based decision logic. The virtual teacher ITA using Ginger character [21] and the assistant Robot Eliot [22] (see Fig. 4a & Fig. 4b) have been created on the bases of DAZ Studio 3D and Unity Asset Store models, that are further tailored in Unity, v.2017.1.0f3 Personal Edition. The intelligent part was also ad-hoc designed, following a rule-based knowledge representation with advanced fuzzy assessment and probabilistic voice recognition [20]. Additional machine learning

component similar to [23] is added, as the main idea of the VR training is to gather basic knowledge in an interactive training regime, i.e. both human and software are capable on progressive dual education. The current experiments were addressing some of the modern astronomy challenges [24] and missions to Mars past and future perspectives [25], [26] that are preliminary build-in the training environment as scenarios of interaction and machine knowledge. Both audio interactions and joysticks 3D controls have been accomplished in the used prototype, giving possibility for virtual avatar training, travel to Mars and environment user-navigated exploration (see Fig. 4c and the video recordings available at [27], [28]).

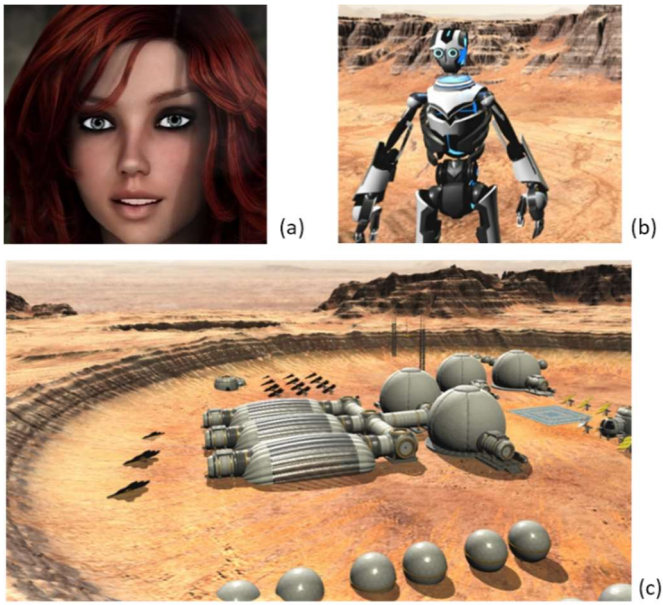


Fig. 4. Screen-shots from ITA (a) and Eliot (b) avatars together with Mars virtual exploration (c) VR experimental training.

3.2.2. VR Experimentation Assessment

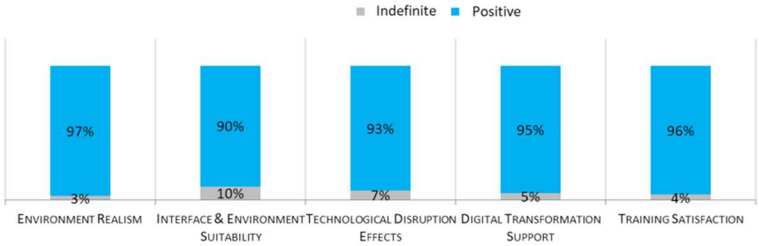
The quantitative assessment of the VR training was organized by using both questionnaires and EEG brain activity monitoring with Nation 7128W – C20 wearable, wireless polyphysiographic device over a pilot group of ten healthy participants (8 male and 2 female, average age 37.5 years). Six surface Ag/AgCl electrode leads (F3, F4, C3, C4, P3 & P4, mounted according to Jasper 10/20 system [29] with special conducting paste Ten20) were recorded for three epochs from 3.5 min each with rest of 10 min between the training sessions. The records have been taken while the trainees were comfortably sitting. Further data processing was performed in Matlab

R2011b environment, similar to the methodology in [30] with initial band-pass filtering in order to remove potential set hums and low frequency oscillations, followed by Fourier Relative Power Spectrum (RPS) calculations.

A photo of a trainee, using the VR environment with generalized EEG RPS results (for four frequency diapasons: alpha, beta, theta & gamma) during the initial and the final training session of the experiment, together with generalized questionnaires results are provided in Fig. 5.

(a)

(b)



The presented analytical assessment of the VR experimental training demonstrates two interesting findings: (i) the participants are quite fascinated from the innovative VR manner for training and give rather high marks (ranging between 90 – 97 %) in their questionnaires for the environment realism, interface, disruption, digital transformation support and overall satisfaction; (ii) these results are quantitatively strongly confirmed from the EEG RPS measurements that demonstrate a clear change (with approximately 5%) between the first and the final training series, beta and gamma activities for the frontal (F4) and central (C4) brain zones of the right hemisphere together with the parietal ones (P3) for the left hemisphere. Apart of this findings that are normally correlating with increased attention of the training subjects and imaginary engagements [29], a really intriguing dynamics is observed in the theta activities diminishing (with 5% in the left parietal zone (P3) and 10% for the right central zone (C4)) that is a visible evidence for the definitive strong engagement of the trainees during the VR experiment.

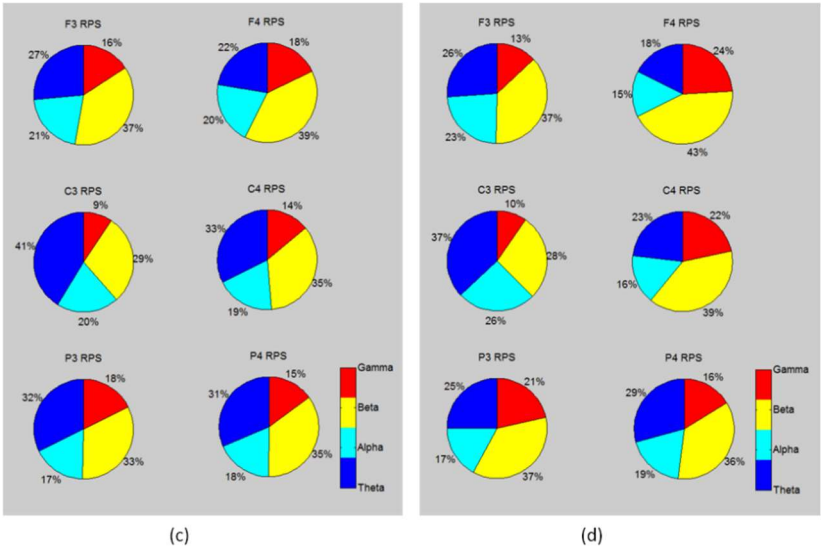


Fig. 5. VR experiment trainee position photo (a) with generalized questionnaire results (b) and EEG RPS aggregated results during the initial (c) and final (d) training sessions.

4. Discussion

The future digital society training transcends will be apparently referred to the new technological disruptions, innovations of smart gadgets, and software solutions. This is naturally addressing the Z- and Alpha- generations' interests and priorities towards a successful establishment of a suitable i-behaviour and i-skills that are going to effectively support the new social transformation and resilience in the future digital world. In this context, it is of vital importance to gather relevant knowledge for the new highly dynamic digital reality, combining both fast evolving and intelligent humans with machines, interactively learning from each other in a symbiotic singularity. A suitable support in this sense could also be taken from the extended reality training, stimulating peoples' insights like: imagination, creativity, emotions, values and intuition. The presented system-of-systems holistic model expert findings and empirical human feed-backs validations confirm the necessity to implement new technological extended intelligent solutions in the future educational process, stimulating a more fascinated, fast, effective and dually (for both human and machines) adaptive training. This new transformation is however also addressing and some digital transcends, mostly referred to the upcoming human excessive capabilities towards successful handling of the higher digital overload from both cognitive (to note: digital dementia and complex environment orientation mixing) and purely physical perspectives (like:

augmented body and mind capabilities presence due to cyber-physical implants fast advancing, multiplatform-connectivity and wide spreading). Thus the new intensive reality mixing and symbiotic extending have to be performed with care not to limit the transformed people, giving priorities to technologies but rather benefiting from the singularity objective. Additional stimulation of the new human – machine advanced smart interfaces and interactions is also needed for successful solving of the more complex and significant for the future digital society educational and training problems in the upcoming post-informational age.

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Bibliography

1. Minchev, Z. (Ed) Future Digital Society Resilience in the Informational Age, SoftTrade, 2019.
2. The Future of Jobs Report, WEF, 2018, http://bit.do/eZn2b
3. Harari, Y. Homo Deus: A Brief History of Tomorrow, HarperCollins Publishers, 2017.
4. G. Leonhard, Technology vs. Humanity: The Coming Clash between Man and Machine, Fast Future Publishing, 2016.
5. Multigenerational Online Behavior and Media Use, IGI Global, 2019.
6. Fast-Berglunda, Å., Gong, L., Li, D. Testing and Validating Extended Reality (xR) Technologies in Manufacturing, Procedia Manufacturing, Vol. 25, 2018, pp. 31-38
7. The Future of Education and Skills. Education 2030, OECD, 2018, http://bit.do/eZnZZ
8. Kreye, A. The State of Artificial Intelligence, White Paper, T-Systems, November 2018, http://bit.do/eZnZN
9. G. Wahlers (Ed), The Digital Future, International Reports, Konrad Adenauer Stiftung, No. 1, 2018, https://goo.gl/8CLcvn
10. Leonhard, G. Technology & Humanity, Key Note Talk, APCC Lisbon 2019, https://youtu.be/-GO4Ac60-x8
11. Chen, P. The Entity-Relationship Model-Toward a Unified View of Data, ACM Transactions on Database Systems, 1, 1976, pp. 9-36.
12. Minchev, Z. Digital Security Future Objectives Foresight Modelling and Analytical Assessment, Extended Abstracts from 12th Annual Meeting of BGSIAM, Sofia, December 20-22, 2017, pp. 76
13. Minchev, Z. Data Relativities in the Transcending Digital Future, In Proc. of BISEC 2018, Belgrade, Serbia, October 20, 2018, http://dx.doi.org/10.13140/RG.2.2.15409.22887
14. Minchev, Z., Boyanov, L., Georgiev, A. & Tsvetanov, A. An Analytical Outlook towards Digital Training Security Transformations, In Proc. of ICAICTSEE – 2017, UNWE, Sofia, November 3-4, 2017, September, 2018, https://dx.doi.org/10.13140/RG.2.2.20333.28645

15. Securing Digital Future 21 Web Forum, http://securedfuture21.org
16. CYREX 2019 Web Page, http://securedfuture21.org/cyrex_2019/cyrex_2019.html
17. Minchev, Z. Security Challenges to Digital Ecosystems Dynamic Transformation, In Proc. of BISEC 2017, Belgrade, Serbia, 2017, pp. 6-10,
- http://dx.doi.org/10.13140/RG.2.2.32354.84160
18. CoSoSys My Endpoint Protector Web Page, www.endpointprotector.com
19. Gaydarski, I., & Minchev, Z. Modelling, Analysis, Experimental Validation and Verification of Information Security Systems in Corporate Environment, IT4Sec Reports, No. 132, Sofia, Institute of Information and Communication Technologies, 2019, http://dx.doi.org/10.11610/it4sec.0132
20. Minchev, Z. Challenges to Future Training with Interactive Intelligent Avatars, In Proc. of QED 2014, Sofia, October 30-31, 2014, pp. 157-163
21. Ginger Character, Daz 3D Studio Female Models Shop, https://www.daz3d.com/ginger
22. Robot Elliot, Unity Asset Store,
- https://assetstore.unity.com/packages/3d/characters/robots/robot-elliot-112654
23. Minchev, Z., Boyanov, L., Georgiev, A., Tsvetanov, A. An Analytical Outlook towards Digital Training Security Transformations, In Proc. of ICAICTSEE-2017, Sofia, UNWE, November 3-4, 2017, http://dx.doi.org/10.13140/RG.2.2.20333.28645
24. Habing, H. J. The Birth of Modern Astronomy, Springer, Cham, 2018
25. Musk, E. Making Humans a Multi-Planetary Species, New Space, 2017, pp. 46-61
26. NASA Mars Exploration Program Web Page, https://mars.nasa.gov/
27. ITA Video Demo, http://bit.do/eZnZr
28. Mars Virtual Travel Video Demo, http://bit.do/eZnZc
29. Niedermeyer, E., & da Silva F.L. Electroencephalography, Lippincott Williams & Wilkins, 2005.
30. Minchev, Z. Cyber Threats Analysis In On-Line Social Networks With A Study On User Response. IT4SEC Reports, 115, http://dx.doi.org/10.11610/it4sec.0115