Human and Digital Resilience, AI and Deep Learning, GAFAM and Ecological Footprint: Towards More Inclusive and Sustainable Technologies

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Abstract

This chapter addresses human and digital resilience, the impact of AI and deep learning, and the ecological footprint of tech giants (GAFAM), while exploring more inclusive and sustainable technologies. The authors propose a transdisciplinary approach to understanding digital resilience, integrating economic, political, socio-historical, and individual dimensions. They introduce a resilience model in the form of a 'Temple-Structure,' which articulates various levels of analysis, from biological to social, highlighting the conceptual and practical challenges of this integration. The emergence of AI and deep learning is analyzed through their potential to develop alternative solutions, emphasizing the importance of their ethical and sustainable use. The authors criticize the dominance of GAFAM and their environmental impacts, illustrated by energy consumption analogies. They question the effectiveness of market self-regulation and the sufficiency of scientific knowledge alone to solve these problems, advocating for an integrated approach combining science, culture, politics, and public engagement. An example of digital sobriety in music is presented to demonstrate how collective and low-tech practices can reduce the ecological impact. The chapter concludes by emphasizing the need for a multifaceted approach to mitigate the environmental impacts of digital technologies and promote a more sustainable future.

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1. General Introduction

In an era where digital technologies are omnipresent, the concept of resilience – both human and digital – has become increasingly significant. This article adopts a transversal and transdisciplinary approach to examine resilience, leveraging insights from the humanities, social sciences, and cognitive sciences. By exploring the multifaceted nature of resilience, from economic and political dimensions to psychological and spiritual aspects, we aim to provide a comprehensive understanding of how individuals and societies can adapt and thrive in the digital age. The intersection of artificial intelligence (AI) and deep learning with resilience further underscores the importance of developing inclusive and sustainable technologies, particularly in the context of the dominant influence of tech giants and their substantial ecological footprint.

2. Human and Digital Resilience

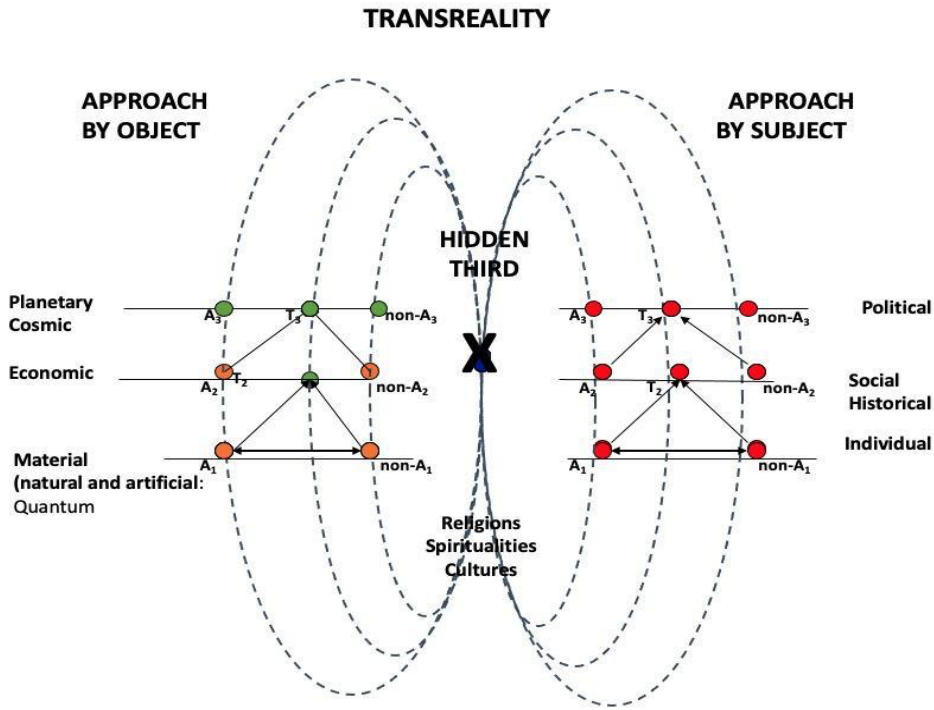
We present a transdisciplinary approach[1] to digital resilience, considering both objective (object-centered) and subjective (subject-centered) aspects. On one hand, we examine the economic, political, and socio-historical

[1] Ruano, J. C., & Pasquier, F. (2023). *Transdisciplinary*. In N. Wallenhorst & C. Wulf (Éds.), *Handbook of the Anthropocene*. Springer International Publishing, p. 491-495.

dimensions of digital resilience. On the other hand, we focus on individual, psychological, emotional, cognitive, and spiritual dimensions.

2.1. The Transdisciplinary Approach to Human and Digital Resilience

Fig. 1 *– Approach to Transreality (author Basarab Nicolescu)*

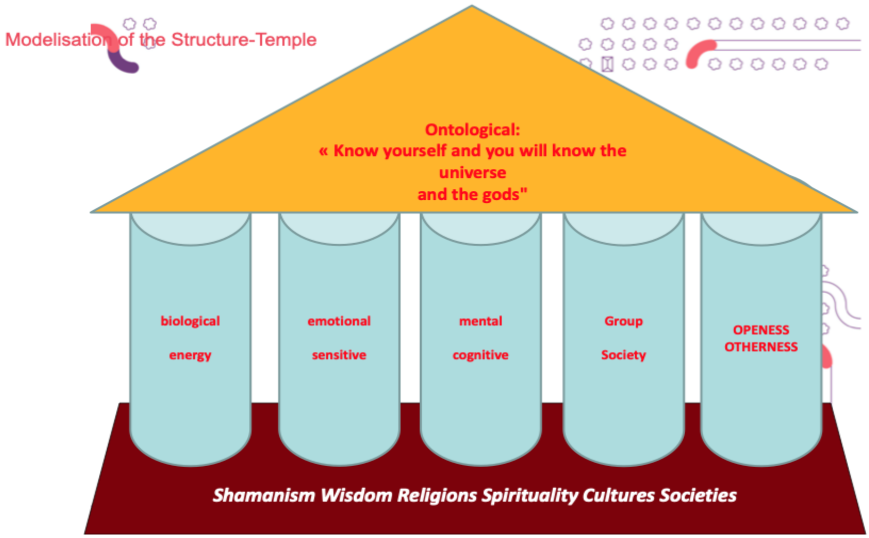


The dual approach presented in this diagram captures the complexity of human and digital resilience by considering interactions between micro (quantum/individual) and macro (cosmos/political) levels. We utilize concepts from philosophy, anthropology, neuroscience, and traditional wisdom to understand the mechanisms of human resilience in the digital age.

2.2. Theoretical Modelling of a 'Temple-Structure'

We propose a model of human and digital resilience in the form of a 'Temple-Structure,' inspired by holistic and integrative approaches. This model articulates different levels of analysis, from the ontological level (relationship to self and the universe) to the biological, energetic, emotional, mental, and social levels. This model highlights the individual and collective dimensions of resilience, considering interactions between personal, social, and environmental spheres. It also shows how spiritual[2], cultural, and traditional dimensions nourish resilience processes, aiming for harmony between parts and the whole. Indeed, this model is fractal: each part contains all the others.

Fig. 2 *– The Temple-Structure (author Florent Pasquier)*



Here are some challenges posed by the 'Temple-Structure' model for achieving human and digital resilience:

* Complexity and Integration of Different Levels of Analysis: The proposed model articulates numerous dimensions (ontological, biological, energetic, emotional, mental, social, etc.) to capture resilience in all its complexity. Effectively integrating these different levels of analysis represents a significant challenge, both conceptually and methodologically.

* Practical Implementation Complexity: Since the model is based on a holistic and integrative vision, its application in concrete domains (education, organization, public policy, ecological music, alternative solutions, etc.) raises operational challenges. We need to develop suitable tools, methods, and systems to use this approach effectively.

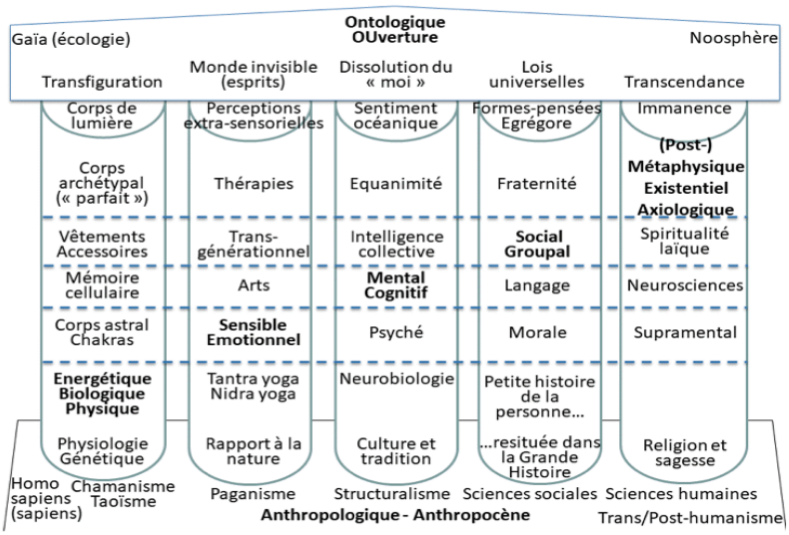
* Consideration of Individual and Cultural Specificities: Resilience has a strong subjective dimension, linked to individuals' experiences, beliefs, and cultural roots. The model must remain flexible and adaptable enough to integrate this diversity and avoid an overly normative approach.

[2] Pasquier, F. (2022). „From Spirituality to Technontology" in *Education. Journal of Systemics, Cybernetics and Informatics*, 20(6), 49–52. https://doi.org/10.54808/JSCI.20.06.49.

* Articulation Between Micro and Macro Levels: The model seeks to link individual and collective levels. Interactions between these different scales of analysis are complex, particularly in terms of mutual impacts and systemic dynamics.

* Empirical Validation and Development of Indicators: The transdisciplinary nature of the model requires empirical validation and the construction of relevant indicators to measure resilience. Ad hoc research and methodological innovations are necessary to meet this challenge.

Fig. 3 *– The Fractal Dimension of the Temple-Structure (author Florent Pasquier)*



2.3. Tools and Methods for Practical Implementation

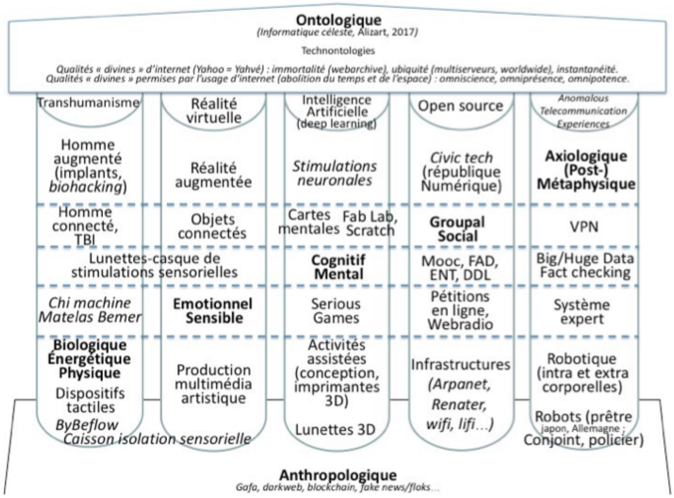
The first crucial step is a thorough analysis of the needs and specific application contexts. This involves precisely identifying the priorities, constraints, and leverage points of the different target audiences (individuals, organizations, communities, etc.) as well as the areas where the model will apply (education, businesses, public policies, etc.). This detailed analysis of real-world conditions will then guide the design of relevant tools and methods. In the case of digital tools, we can transpose this analysis into a corresponding diagram.

In this context, the design of evaluation and diagnostic tools is of major importance. We need to develop instruments capable of holistically measuring the various dimensions of digital resilience (individual, social, environmental[3],

[3] Pinheiro Lopes, S., & Pasquier, F. (2023). „Consciousness and Environmental Education: Transdisciplinary Urgencies from the Post-Pandemic Context". *Transdisciplinary Journal of Engineering & Science*, 14, 19–32. https://doi.org/10.22545/2023/00223.

etc.), based on the holagrammatic principles of the 'Temple-Structure' model. These tools should combine scientific rigor and accessibility for designers, allowing precise diagnosis while being easily usable by various stakeholders.

Fig. 4 *– The Temple-Structure Applied to Digital Tools (author Florent Pasquier)*

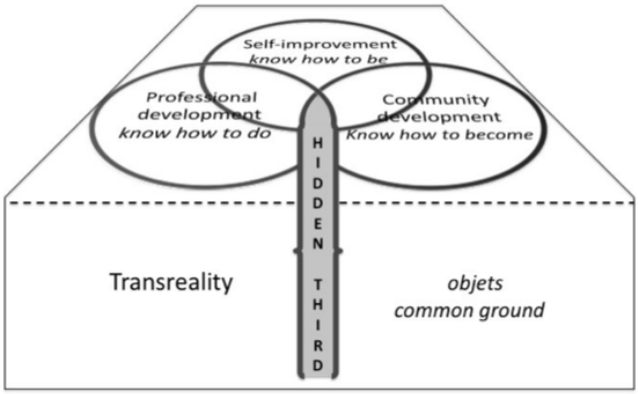


Thus, we aim to design adapted support and intervention methods: establishing training programs, workshops, coaching systems, etc., to deploy the model's principles among target audiences. We pay particular attention to integrating subjective and cultural dimensions, considering the diversity of individuals' and communities' experiences and roots. We employ participatory and co-creative approaches for this purpose.

The articulation between micro (individual) and macro (collective) levels of human and digital resilience is another major challenge. We conceive concepts to link these different scales of intervention, ensuring the coherence and complementarity of the actions taken. This requires the establishment of suitable bridges and coordination mechanisms, such as the theory of triple personal, professional, and collective development, to act reciprocally on transreality.

Experimentation and evaluation of the developed tools and methods are crucial to measure their effectiveness and identify necessary adjustments. We have implemented a continuous improvement approach to constantly adapt these systems to the evolving digital challenges with our students in new educational technologies, through the maintenance of a reflective learning journal. This iterative approach, involving many back-and-forths between theory and practice, ensures that proposed solutions remain relevant and adapted to field needs.

***Fig. 5** – Theory of Triple Development in Relation to Transreality (author Florent Pasquier)*



This work of developing tools and methods suitable for implementing the 'Temple-Structure' model for digital human resilience uses a collaborative approach, involving researchers, practitioners, and end users, to leverage the diverse expertise and perspectives needed to design truly effective and appropriate solutions.

2.4. An Example in Education and Training: From P2I to P4I

We illustrate our transdisciplinary approach to human and digital resilience with an example from the field of education. We have designed a pedagogy initially named 'Integrative and Implicative' (P2I)[4], then 'Integrative, Implicative, Intentional' (P3I), and now 'Integrative, Implicative, Intentional and Intuitive' (P4I).

This pedagogical progression aims to develop resilience skills in learners in the face of digital transformations, mobilizing not only cognitive and instrumental dimensions but also sensitive, emotional, and existential dimensions. Ultimately, it aims to train individuals capable of holistically adapting to digital challenges while preserving their personal integrity and relationship with the world.

This first part has proposed an innovative transdisciplinary approach to understanding human and digital resilience, articulating different levels of analysis and drawing on a variety of disciplines and traditions of thought. This perspective helps better grasp contemporary issues' complexity and consider individual and collective resilience pathways. The example of educational

[4] Pasquier, F. (2020). „Les nouveaux paradigmes éducatifs: Quelles nécessités et quelles possibilités ? Mise en œuvre et évaluation d'une pédagogie intégrative et implicative (P2i)". *Phronesis*, 9 (1), 70. https://doi.org/10.7202/1069709ar.

evolution illustrates the possibility of developing resilience skills in individuals by mobilizing their cognitive, sensitive, and existential dimensions. Such an approach opens promising perspectives for training citizens capable of harmoniously adapting to digital transformations, which we will now detail, while preserving their integrity and connection to the world.

3. The Ascendance of Artificial Intelligence and Deep Learning

The advent of artificial intelligence (AI) and deep learning (DL) has precipitated a profound transformation in contemporary society, fundamentally reshaping our interactions with technology and the surrounding world. However, the agglomeration of power within a few large technological conglomerates engenders significant concerns regarding platform hegemony, pervasive surveillance, and unsustainable environmental ramifications. In this milieu, the concept of digital resilience emerges as a pivotal paradigm, essential for fostering an inclusive, ethical, and sustainable digital ecosystem.

Deep learning, as a formidable technological innovation, possesses the potential to significantly contribute to the enhancement of digital resilience. Its applications can serve as catalysts for the development of alternatives to prevailing dominant platforms, thereby fostering innovation and diversity within the technological landscape. Deep learning can be harnessed to develop secure search engines and browsers that prioritize user privacy and data autonomy. These innovations offer secure and transparent alternatives to conventional platforms by leveraging distributed server networks[5], thereby mitigating the risks of surveillance and search result manipulation. Notable examples include decentralized search engines such as Searx and DuckDuckGo, as well as privacy-focused browsers like Brave and the Tor Browser, which implement robust mechanisms to block trackers and advertisements, effectively preventing data collection on users' browsing activities.

Moreover, deep learning can facilitate the creation of decentralized communication and collaboration tools that eschew reliance on centralized platforms, promoting data sovereignty and direct user interaction. Decentralized social networks empower users to retain control over their data and facilitate direct communication without intermediaries. Noteworthy instances include Mastodon and Diaspora. Similarly, open collaboration platforms enable collaborative project work devoid of dependency on singular corporate entities. Platforms such as GitHub and GitLab exemplify this approach.

In addition to these applications, deep learning can be utilized to design responsible and ethical AI systems that are conceived with an acute awareness of user needs and values, ensuring equitable and transparent AI interactions.

[5] This seems in similarity with the variety of the roles of neural networks (ex: Maalmi, R., Slama, A.B., Sahli, H., Trabelsi, H. (2022). „Auditory evoked potential-based hearing loss level recognition using fully convolutional neural networks". *Traitement du Signal*, Vol. 39, No. 2, pp. 611-616).

Explainable AI systems elucidate decision-making processes, which is imperative for fostering trust and transparency. Furthermore, inclusive AI systems are meticulously designed to ensure fairness and equity, accommodating diverse contexts and user requirements.

Nonetheless, it is imperative to acknowledge that deep learning, while a potent instrument, must be employed within a framework of ethical principles and social accountability. It is crucial to avert the perpetuation of existing biases and inequalities through AI systems and to ensure their contribution towards a more just and equitable society.

Moreover, the environmental impact of AI warrants critical attention. The data-intensive and computationally demanding nature of deep learning engenders substantial energy consumption and greenhouse gas emissions. Hence, there is an urgent imperative to innovate more efficient and sustainable deep learning methodologies, employing data compression techniques, optimized learning algorithms, and environmentally benign computing infrastructures.

In summation, deep learning[6] harbors significant potential to contribute towards a more resilient, inclusive, and sustainable internet. However, this potential can only be realized through responsible and ethical utilization, cognizant of the broader social and environmental implications. By synergizing technological innovation with ethical deliberation and collaborative effort, we can envisage a digital future that is beneficial to all stakeholders.

4. GAFAM vs. Planet Earth: How to Break Free from the Unsustainable Ecological Footprint of AI

The rise of generative AI has reinforced the monopolistic control of the digital landscape by GAFAM[7] (Google, Apple, Facebook, Amazon, and Microsoft). These tech giants exert tremendous influence, not only economically but also socially and environmentally. Their dominance poses significant challenges to citizens' rights, particularly in terms of digital privacy and environmental health. While the invasion of digital privacy through surveillance capitalism is being quite debated[8], the critical issue of the right, in an AI carbon emitting the world, to a healthy life in a clean environment has received

[6] Deep learning is considered here as a subcategory of machine learning (ex: Slama, A. B., Sahli, H., Mouelhi, A., Marrakchi, J., Trabelsi, H., & Sayadi, M. (2019). „Machine learning based approach for vestibular disorder diagnostic in videonystagmography". *Biomedical Research*, 30(4).

[7] The same trend seems to take place with BATX in China, even though the regain of control of the central State may slow it down.

[8] Zuboff, S. (2019). *The Age of Surveillance Capitalism: The Fight for the Future at the New Frontier of Power,* Profile Books, https://www.perlego.com/book/3708168/the-age-of-surveillanc e-capitalism-the-fight-for-a-human-future-at-the-new-frontier-of-power-barack-obamas-books-of-2019-pdf.

comparatively less attention[9]. This right is increasingly compromised by the techno-predatory practices of GAFAM, which often disguise themselves as 'green' initiatives but contribute substantially to ecological degradation.

4.1. Exponential Growth in Techno-Predation: The Energy Consumption 'Espresso' Analogy

The environmental impact of digital technologies, especially those driven by AI, can be dramatically illustrated through the indicator of energy consumption, and its growth with AI spreading. A standard Google search consumes as much electricity as brewing an espresso. This might seem negligible on an individual level, but the cumulative effect of billions of searches daily is significant. Furthermore, a more detailed Google search using the AI 'Gimini' summary feature consumes the equivalent energy of ten espressos, according to Google's own reports. More concerning is the energy usage of advanced AI applications like ChatGPT 4+, when coupled with a search engine, which can consume energy equivalent to brewing 100 espressos per query. These comparisons highlight the rapidly increasing ecological footprint of more sophisticated and resource-intensive AI applications, rapidly spreading through society[10] .

The exponential growth in energy consumption raises severe concerns about the sustainability of current technological practices. As AI becomes increasingly integrated into daily life, its energy demands grow exponentially. This growth is not linear but accelerates as AI technologies become more complex (generating fixed images, then video, then possibly 3D videos ….) and widely adopted[11]. The environmental cost of this digital revolution is a critical issue. Though, until 2023, little attention was paid to it by scholars, according to publications in the journal.

4.2. Market Self-Regulation: A Viable Solution?

A common argument suggests that the market can self-regulate to mitigate the ecological predation by tech giants. Advocates of market self-regulation argue that rising energy costs will naturally limit the expansion of GAFAM's offerings. They posit that as energy becomes more expensive, tech companies will be forced to curb production and end free services, thereby

[9] OECD (2024). *In tune with ethics: Responsible artificial intelligence and the music industry*. Retrieved July 4, 2024, from https://oecd.ai/en/wonk/ethics-music-industry.

[10] Vaidheeswaran A. (2024) *Watt's in our Query? Decoding the Energy of AI Interactions.* Retrieved June 15, 2024, from https://www.linkedin.com/pulse/watts-our-query-decoding-energy-ai-interactions-archana-vaidheeswaran-gvmuc.

[11] Luccioni, S., Jernite, Y., & Strubell, E. (2024). *Power Hungry Processing: Watts Driving the Cost of AI Deployment*, ArXiv, DOI: https://doi.org/10.1145/3630106.3658542.

transferring costs to users (raise the prices) potentially reducing consumption. Additionally, proponents claim that technological advancements will lead to greater eco-efficiency of the delivery of AI-based services. They argue that the initial growth in consumption will eventually be balanced by improved production methods and more efficient functioning of generative AI, thereby reducing its environmental impact.

However, historical evidence challenges this optimistic view. The rebound effect, where gains in efficiency lead to increased usage, has consistently undermined the expected benefits of eco-efficiency improvements. For example, the introduction of fuel-efficient cars did not reduce overall fuel consumption because it made driving cheaper, thereby encouraging more travel. Similarly, as digital technologies become more efficient and less costly, their usage proliferates, leading to greater overall consumption rather than reduction. This pattern suggests that reliance on market self-regulation and technological improvements alone is unlikely to address the ecological challenges posed by generative AI and other digital technologies.

Moreover, market mechanisms often fail to account for the full environmental costs associated with technological advancements. The externalities of digital technology production and usage – such as e-waste, resource extraction, and energy consumption – are rarely reflected in the market prices of these technologies. Without comprehensive regulatory frameworks and policies, or community initiatives and public engagement that internalize these externalities, market self-regulation remains an inadequate solution[12].

4.3. Liberation through Science: Insufficiency of Scientific Knowledge Alone

The notion that science alone can liberate society from the ecological predation of GAFAM is also flawed. Despite five decades of climate science research, there has been minimal societal change in response to the environmental crisis. This indicates that scientific knowledge, while crucial, is not sufficient on its own to drive systemic change. Efforts to bridge the gap between science and society often involve popular education, science outreach, and participatory research. These approaches aim to democratize scientific knowledge and engage the public in meaningful ways.

However, while these initiatives are necessary, they are not enough to overcome the deep-rooted structural and cultural inertia that hinders significant change. The persistence of unsustainable practices despite widespread scientific consensus on climate change underscores the limitations of relying solely on

[12] Martina Willenbacher, Torsten Hornauer & Volker Wohlgemuth (2022). "Rebound Effects in Methods of Artificial Intelligence," in Volker Wohlgemuth & Stefan Naumann & Grit Behrens & Hans-Knud Arndt (ed.), *Advances and New Trends in Environmental Informatics*, Springer, pp 73-85.

scientific knowledge. Effective change requires a more integrated approach that combines scientific insights with policy interventions, cultural shifts, and active public engagement.

One of the critical barriers to effective action is the disconnection between scientific knowledge, policy implementation, and social behaviors. Scientific findings often struggle to translate into actionable policies and behaviors due to political, economic, and social resistance. Additionally, the complexity and scale of environmental issues necessitate coordinated efforts across multiple sectors and levels of governance, which is challenging to achieve without substantial public and political will.

4.4. A Case Study in Joyful Digital Sobriety: Participatory Music Creation

An innovative approach to addressing these issues is demonstrated through a research-creation experiment to be conducted in Amsterdam (EASST, 2024)[13], focusing on digital sobriety and conviviality[14] in music. This participatory action research event combined low-tech musical instruments and the voices of participants to create a collective musical experience. This approach highlights the potential of combining scientific understanding with cultural practices to foster sustainable behaviors.

Observations and Digital Actualization in Music. Over the last century, there has been a marked increase in the consumption of recorded and streamed music, promoting individual rather than collective musical experiences. This shift reflects broader societal trends towards individualization and technological mediation in cultural activities.

Concurrently, community-based musical practices, such as neighborhood dances and collective singing, have significantly declined. This trend is exacerbated by the rise of generative AI in music production, which facilitates the creation of music without direct human involvement. This shift not only concentrates creative power in the hands of a few industrial players but also increases the ecological footprint of music consumption.

Experimentation: Sensory and Convivial Engagement. The Amsterdam event is to employ acoustic instruments and participant voices, integrating sensory elements like smoke generation to visualize pollution from AI usage. Participants are encouraged to harmonize together, reducing reliance on AI auto-tuning and consequently decreasing pollution generation by AI use. This real-time feedback loop demonstrates the environmental benefits of collective musical practice over technologically mediated individual alternatives. The event

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[13] Jollivet, P., Thouvenin, I., Duarte, A-B. (2024). *Translating the AI vs ecology controversy to the senses? A scientific mediation through a musical performance. Making and Doing Transformations*. EAAST Amsterdam.

[14] In the sense of: Illich, I. (1973). *Tools for Conviviality*. Marion Boyars Publishers Ltd.

emphasizes the importance of conviviality and sensory engagement in fostering sustainable practices.

In this experiment, the participants experienced firsthand the impact of their musical engagement on the environment. As they sang together and listened to each other to stay in tune, the need for technological intervention decreased, symbolized by a reduction in the artificial smoke generated. This tangible connection between human activity and environmental impact is aimed at providing a powerful illustration of how collective, low-tech convivial practices can mitigate ecological damage due to AI.

The integration of sensory experiences, such as the sight and smell of smoke, adds a visceral dimension to the abstract concept of digital pollution. This multisensory approach helps participants internalize the environmental costs of their digital behaviors in a way that purely cognitive understanding might not achieve. By making the invisible visible, the experiment fosters a deeper awareness and connection to the issue at hand.

5. Conclusion: Towards a New Paradigm of Science and Public Engagement?

This experiment in research-performance aims not to conclude with a single academic presentation but to inspire a series of participatory performances accessible to a general audience. The goal is to share scientific concepts in engaging ways and possibly redefine the practice of science itself. The real challenge lies ahead: attracting a participatory audience to engage with scientific issues, particularly in questioning the collective limitation of exponential energy consumption generated by ubiquitous and alluring AI technologies.

To address the ecological challenges posed by generative AI and other digital technologies, a multifaceted approach is necessary. This includes integrating scientific knowledge with cultural practices, policy interventions, and active public engagement. By fostering a deeper understanding of the environmental impact of digital technologies and promoting sustainable alternatives, it is possible to mitigate the ecological footprint of AI and move towards a more sustainable future.

The participatory science/art nature of some Amsterdam EASST sessions (Transforming engagement and communication through play and plays) highlights the potential for community-driven initiatives to effect change. The description stands: “Engaging actors across varying forms and levels of expertise comes with questions of power and possibilities. This combined panel considers how public engagement and science communication can be transformed by drawing on/using games, theatre and other creative modes”.[15]

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[15] Présentation of the « play » panel of the conference: https://nomadit.co.uk/conference/easst-4s 2024#14063.

By involving the public in meaningful and engaging ways, such initiatives can build a broader base of support for sustainable practices. This approach also underscores the importance of accessibility and inclusivity in scientific and environmental outreach. Making complex issues understandable and relatable to diverse audiences is crucial for fostering widespread action.

Moreover, similar approaches could be applied to other areas of digital consumption. For instance, participatory workshops could be used to explore the ecological impacts of online shopping, social media use, or video streaming. By drawing connections between daily digital behaviors and their environmental consequences, such initiatives could encourage more mindful and sustainable practices.

6. General Conclusion

As we navigate the complexities of the digital age, it is imperative to foster resilience that encompasses both human and technological dimensions. This article has outlined a transdisciplinary framework that integrates diverse perspectives to address the multifaceted nature of resilience. The rise of AI and deep learning, while offering transformative potential, also necessitates a careful consideration of ethical and environmental implications. By advocating for inclusive and sustainable technologies, and through collaborative, community-driven initiatives, we can work towards mitigating the ecological impacts of digital advancements. Ultimately, achieving a balance between technological innovation and ecological sustainability is essential for ensuring a resilient and equitable future for all.

Acknowledgment and conflicts of interest

The authors declare that they have no conflicts of interest with respect to the research, authorship, and/or publication of this article. Any errors or omissions are our own.

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