Információs Társadalom

[Information Society]

A SOCIAL SCIENCE JOURNAL

Founded in 2001

English Issue Vol. XXII, No. 2 (2022)

Published by INFONIA Foundation

Principal sponsor: Budapest University of Technology and Economics, Faculty of Economic and Social Sciences

Technical partner: SZTAKI

ISSN 1587-8694 (Print)
ISSN 2063-4552 (Online)
ISSN-L 1587-8694

Produced by Server Line Print & Design, Budapest

The journal Information Society (In Hungarian: Információs Társadalom, abbreviated as InfTars) aims to provide a platform for research and discussion of the theories and applications of Information Society Studies. Currently every second issue is published in English, the rest are in Hungarian.

The journal is fully Open Access and freely available at https://inftars.infonia.hu/

InfTars is indexed in both the *Web of Science Social Sciences Citation Index and Scopus*, and all titles are automatically submitted to *Crossref*.

Since Vol. VIII, No. 1 (2008) the journal has been included in the Thomson Reuters index (Social Sciences Citation Index, Social SciSearch, Journal Citation Reports/Social/Sciences Edition)

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Second, there will be an analysis on the mechanism through which radio and television alter the traditional anthropomorphic notion of 'experience' through the creation of phantoms and matrices. Third, there will be an exemplification of the consequences of humanity's progressive detachment from the awareness of its *praxis* through the Andersian notion of the 'Promethean Gap'.

MIHÁLY HÉDER, ERNŐ RIGÓ, DOROTTYA MEDGYESI, RÓBERT LOVAS, SZABOLCS TENCZER, FERENC TÖRÖK, ATTILA FARKAS, MÁRK EMŐDI, JÓZSEF KADLECSIK, GYÖRGY MEZŐ, ÁDÁM PINTÉR, PÉTER KACSUK,

The Past, Present and Future of the ELKH Cloud

This review article summarizes the history the Hungarian Scientific Cloud Infrastructure project. This research infrastructure was launched officially on 1 October 2016, funded by the Hungarian Academy of Sciences. With the support of ELKH, the infrastructure's capacity has been substantially boosted; the features and workflows that it offers to scientists were significantly expanded to celebrate the arrival of the year 2022. The article reviews the types of work Hungarian researchers implemented on the infrastructure, thereby providing an overview of the state of cloud-computing enabled science in Hungary.

LECTORI SALUTEM!

In the first paper of this issue, Csukás and Szabó investigate the Smart Cities strategies using the beautiful Budapest as a case study. Their research illuminates the technology adoption using the concepts of the double-, triple- and quadruple helix models.

Next, Julesz presents research on health equity. He maintains that it be maintained without an adequately functioning system of health data protection in telemedicine. He argues that while US and EU regulations on the matter do provide legal certainty, fighting the COVID-19 pandemic has created a new legal climate, with new priorities superseding, therefore endangering health data protection, which had been paramount beforehand.

Turning more philosophical, in our third paper, Krzanowski and Polak argue that the Internet is, and is acting as, an epistemic agent because it shapes our belief systems and our worldviews. They explain key concepts for this discussion and provide illustrative examples to support their claims. Furthermore, they explain why recognising the Internet as an epistemic agent is important for Internet users and society. Finally, they present examples where the Internet's epistemic agency acts at scale, affecting large portions of society rather than individuals.

Kwapińska explores conceptions of technological agency and evolution in Bernard Stiegler's general organology and Friedrich W. J. Schelling's universal organicism in our fourth paper. She argues that organicism proposes a more 'naturalised' approach to agency formation and a more 'organic' explanation of technology than general organology. General organology considers technological evolution from a human perspective, whereas universal organicism can accommodate a theory of technological evolution independently from its social dimensions. While technology already has a strong impact on our societies' organisation, recognising technological agency as at least partially independent serves to recognise them as non-human beings that impact politics.

Turning to education, Tóth and Horváth present the results of a survey in our fifth paper. They searched for the answer to the question of what opinions students held about exemplary interpersonal behaviour. According to the students, the main characteristics of the ideal interpersonal behaviour are decisive, directive, helpful and understanding; it is less characterised by doubt and emotionality. In terms of imposing vs compliant manner, opinions are rather divided. It is preschool teachers and teachers of lower primary school classes who prefer cooperation with the children the most. In contrast, teachers of the upper classes tend to emphasise the importance of directive behaviour.

In our sixth paper, Szabó et al. investigate the effectiveness of e-learning materials among university students using a variety of research methodologies (Groningen Sleep Quality Scale, psychomotor vigilance task, verbal fluency and digit span tests, NASA Task Load indeX and eye tracking). In their pilot study conducted in a laboratory environment, 15 participants were divided into three groups and assigned to study from prepared course pages using content-equivalent e-learning materials.

The results demonstrated that the applied research methodologies were appropriate for investigating the issue, allowing the pilot study to reveal a set of criteria encompassing students' preferences for course structures and e-learning materials.

We return to the domain of philosophy and technology in our sixth paper. Ursitti's article shows how the philosopher G. Anders developed his ontology of technology as described in his Outdatedness of Mankind, volumes I and II. First, there is a discussion on the role played by the machine in the Andersian philosophy of technology. Second, Ursitti analyses how radio and television alter the traditional anthropomorphic notion of 'experience' through the creation of phantoms and matrices. Third, there is an exemplification of the consequences of humanity's progressive detachment from the awareness of its praxis through the Andersian notion of the 'Promethean Gap'.

Finally, we turn to more practical. Héder et al. report on the history of the Hungarian Scientific Cloud Infrastructure project. This research infrastructure was launched officially on 1 October 2016 and funded by the Hungarian Academy of Sciences. With the support of ELKH, the infrastructure's capacity has been substantially boosted; the features and workflows that it offers to scientists were significantly expanded to celebrate the arrival of the year 2022. The article reviews the types of work Hungarian researchers implemented on the infrastructure, thereby providing an overview of the state of cloud-computing-enabled science in Hungary.

The editorial board wishes you a splendid time while reading this issue.

What are the conditions to become smart?

A systematic analysis of the smart city strategy and smart city development activities of Budapest

Smart cities (SCs) became a key mission in the European Union's biggest research programme (Horizon Europe). The urban transition to smartness, making smart decisions and strengthening capabilities for resilience are appreciating today, with such external shocks as the COVID-19 pandemic. Finding the way to become smart is more important than ever. Since literature is mostly engaged with excellent cases, in this paper we analyse the SC strategy of a less-well-performing city: Budapest in Hungary, Central Eastern Europe, using a case-study methodology. We reveal that in the case of Budapest the SC strategy uses a top-down approach that overweighs the deployment of technological solutions to manage urban sustainability issues rather than using a bottom-up and holistic approach. The framework conditions for implementing the SC strategy are rather neglected. In the case of the model for cooperation, Budapest adopts a double-helix model rather than a triple- or quadruple-helix model.

Keywords: *Central Eastern Europe, ICT, smart city projects, sustainable urban planning, case study*

Acknowledgement

Supported by the ÚNKP-21-3 new national excellence programme of the Ministry for Innovation and Technology, sourced from the National Research, Development and Innovation Fund.

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How to cite this article:

Csukás, Máté, Roland Zs. Szabó. "What are the conditions to become smart?". *Információs Társadalom* XXII, no. 2 (2022): 9–26.
https://dx.doi.org/10.22503/inftars.XXII.2022.2.1

1. Introduction

Despite words about the declining popularity and diminishing hype of smart cities (SCs) (Trapp 2018), having climate-neutral SCs became one of the five main mission areas of the European Union's large-scale research and development programme Horizon Europe (European Commission 2021). However, the widespread uptake of the concept is still far from its potential in Hungary and the Central Eastern European region, which is further challenged by the social and economic impact of the COVID-19 pandemic. Some particularities make it especially challenging for scientists and practitioners to engage with the vision of SCs.

Ever since fundamental controversies were reported by Hollands (2008) in the SC research, studies aiming to untangle the contradictory nature of the literature have been gaining ground in the scientific community. Mora and Bolici (2017), Mora, Deakin and Reid (2018) and Komninos and Mora (2018) unveiled the significant differences among SC research streams by capturing four distinct dichotomies that are present in scientific publications. Mora et al. (2019) introduced a rigorous case-study-based methodology to analyse SC developments. With their proposed research methodology, they tested the four dichotomies as divergent strategic principles of SC development, using leading cities as examples (Mora, Deakin and Reid 2019).

The implementation of SC developments ought to be realised with strategic methods (Komninos 2014; Angelidou 2015; Mora and Bolici 2016, 2017). The particularities of how these strategic principles should be considered are relatively well researched; however, there are only a few publications available on empirical research relating to Eastern European, especially Hungarian cases of SC development. In this paper, we replicate this validated scientific method and systematically analyse the SC strategy and development activities of one Hungarian example, the capital city, Budapest.

When researching SC developments, most of the available publications focus on either a specific technology solution or urban sub-systems, including components of SC models. The comparability and replicability of these researches are limited. On the other hand, papers analysing the overall city-wide context, or multiple cities, with comparable results are usually measuring the 'smart' performance of cities. These works primarily use existing or newly designed indicator systems, based on already available regional or urban data. As Z. Karvalics (2016) points out, a myriad of these indicator frameworks, with their city rankings, are available. However, they are more likely to create confusion and divergent understandings of the concept. Besides SC performance measurement and monitoring, Lukács and Csomós (2020) systematically analyse the presence of SC domains in the strategic documents of 21 Hungarian cities, based on the model of Giffinger et al. (2007). They point out that only three cities have a dedicated SC strategy, and the overall significance of the SC concept in the medium-term strategy of Hungarian cities is very low (15%). Lados (2016) analysed the SC attitudes of Hungarian cities and found various levels of maturity.

This paper aims to establish better linkages between the Hungarian and the international research into SC strategies and smart development activities. The differing definitions and numerous models cause inconvenience for both researchers and

practitioners in adopting the SC concept in a localised context. A standardised methodology and its application to an Eastern European example of SC development will hopefully be inspiring and create cohesion among the various research pathways. Furthermore, this paper will help practitioners in the least developed cities to create their own SC strategy and design meaningful development activity portfolios.

This paper may be useful to policymakers and urban managers as well as SC specialists involved in strategic planning processes, and mainly when they are designing portfolios of SC solutions for a city, undertaking benchmarking and peer learning activities. It could also be interesting to scientists who are engaged with systematic research into SC development activities, SC strategies and SC governance.

In the following, we give a detailed description of the divergent principles of strategic SC developments (dichotomies), identified by Komninos and Mora (2018), which will provide the research framework for the case-study analysis of Budapest. Then, in the methodology section, we give a transparent description of how we collected and analysed the data, followed by the results of the four dichotomies studied. In the discussion, we point out the similarities and the differences among cities that demonstrated SC excellence (especially Vienna). Afterwards, we make conclusions, define future research directions and draw attention to the limitations and validity of our research.

2. The Dichotomous Nature of Smart City Research

There are four different dichotomies identified by Komninos and Mora (2018) in the research of SCs. These strategic principles in each of the four cases not only differ from each other but are directly opposed. The existence of such phenomena makes it challenging for scientists to research strategies since there is no consensus on which way is best for the development of SCs. There is robust evidence available on the existence of such dichotomies in the literature (Mora et al. 2019).

Dichotomies	Strategic principles	Definition
Dichotomy 1: Technology-led or holistic	**Hypothesis 1.1:** Technology-led strategy	SC development must be driven by information and communication technology (ICT) solutions.
	Hypothesis 1.2: Holistic strategy	SC development should rather consider all other conditions for urban environments, built for human habitats.
Dichotomy 2: Top-down or bottom-up approach	**Hypothesis 2.1:** Top-down approach	Local governments must take the leading (governance) role in SC developments and provide strategic directions for all stakeholders.
	Hypothesis 2.2: Bottom-up approach	The civil society and key stakeholders other than the local government must build up SC developments, unbound by central regulation.

Dichotomy 3: Double or quadruple-helix model of collaboration	**Hypothesis 3.1:** Double-helix model of collaboration	SC developments can be efficiently realised within the narrow margin of traditional public–private relationships (double-helix structure).
	Hypothesis 3.2: Quadruple-helix model of collaboration	SC developments can be realised only with a platform-based inclusive approach that generates the necessary intelligence (quadruple-helix structure).
Dichotomy 4: Mono-dimensional or integrated intervention logic	**Hypothesis 4.1:** Mono-dimensional intervention logic	The mono-dimensional version of the SC entails the implementation of environmentally friendly solutions.
	Hypothesis 4.2: Integrated intervention logic	SC development must cover most urban domains, in an integrated manner.

Table 1. The four dichotomies of SC research and the divergent strategic principles (own edition based on Mora et al. (2019))

3. Methodology

The present study applies a case-study methodology to analyse the SC strategy of one city. The purpose of the study is to analyse a Central Eastern European case that has not been researched yet and is not regarded as an example of excellence. Considering the purpose of this study, we used a non-probability sampling type, convenience sampling, where the sample was drawn from the part of the population that was closest to hand. As the study is a sort of pilot testing for this type of population, it is the most useful one. The aim was to select a case-study city in which the transition process has proven to be unsuccessful yet. The sampling process took into account the following criteria: (1) larger cities (at a European level), with between 500,000 and 2,000,000 inhabitants, that (2) have an existing SC strategy.

We did a comparative analysis of the SC rankings which showed whether each candidate was an example of an unsuccessful case. Budapest has a resident population of 1,750,216 and has had an SC strategy since 2019, which makes it a late adopter of the concept. However, SC developments were already underway there in the last decade. The city ranked lower (77th) than its region's average ; only Bucharest ranked worse in 2020 (Csécsei 2020). The collection of data was conducted in multiple phases, to find online sources where digital records are available for the city of Budapest and its SC development activities. The main sources identified were: (1) Budapest Portál, the official online information system of the local government (Budapest Főváros Önkormányzata 2021), and (2) the Lechner Knowledge Centre's SC project repository (Lechner Tudásközpont 2021). Using these main sources, we identified and collected digital records, including press releases, web pages, policy documents, local government acts and so on. All the identified activities were collected in an Excel spreadsheet, where duplications were removed and the data was described with a pre-defined template. The processing and analysis of

the qualitative data were carried out in the QCA Map website's service. Besides the digital records for each activity, the coding procedure produced quantitative data on the SC domain it belongs to, the year of the activity, the type of activity (A: Community Building, B: Strategic Framework, C: Services and Applications (the type of service or application), D: Digital Infrastructure), the spatial level (City, District, Building, Home) and the organisations participating in the implementation. In the case of organisations, their type and administrative level were also determined. With the coding process, 111 activities (Annex 1) and 337 organisations (Annex 2) were identified. The annexes are accessible in an external file due to their size (Csukás 2022).

4. Results

4.1. Dichotomy 1: Technology-Led or Holistic Strategies

Budapest's SC development strategy gives much more weight to (1) deploying technological solutions ('Services and Applications'; 'Digital Infrastructure') than to managing urban sustainability issues. The city's strategy implements activities that use ICT components. In contrast with the technology-led focus, the city's strategic activities have a lesser focus on (2) the development of activities aimed at community building and the necessary strategic framework that supports the roll-out of those technological solutions. This strategy is therefore based on the services and application-focussed vision of SCs, with a high emphasis on technology, particularly ICT. Therefore, we do not consider it a holistic type that is more engaged with the development of socio-technical systems in which technology is a means, not an end itself. Figure 1. illustrates the distribution of SC development activities among the four categories, which ultimately determines the type of strategy.

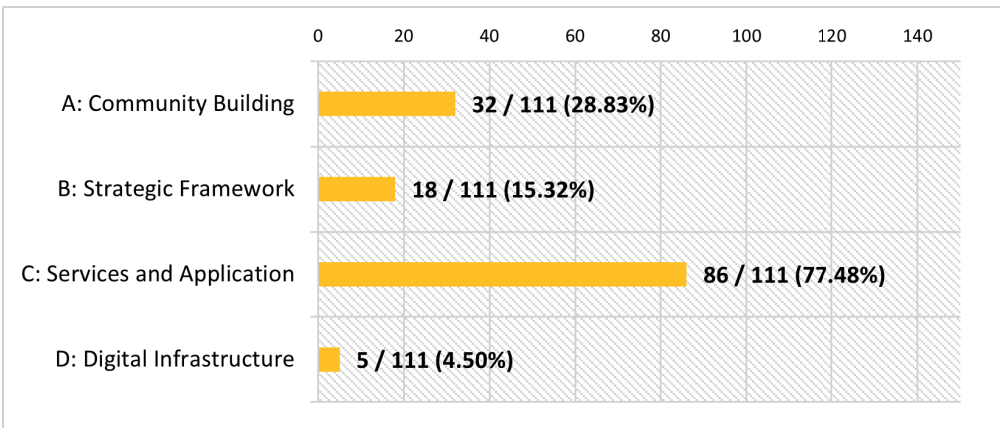

Figure 1. Budapest's SC development strategy: Number of activities by category (own edition)

The details of the statement above are further elaborated in Figure 2., which splits the categories according to their percentage and nominal share of activities. The first group includes those activities belonging to at least one of the first two categories – 'Community Building' and 'Strategic Framework' – both of which focus attention on the non-technological factors of SC development. In the comparison of the two groups, we identify that they are non-balanced – Group 2 has almost twice the number of activities of Group 1.

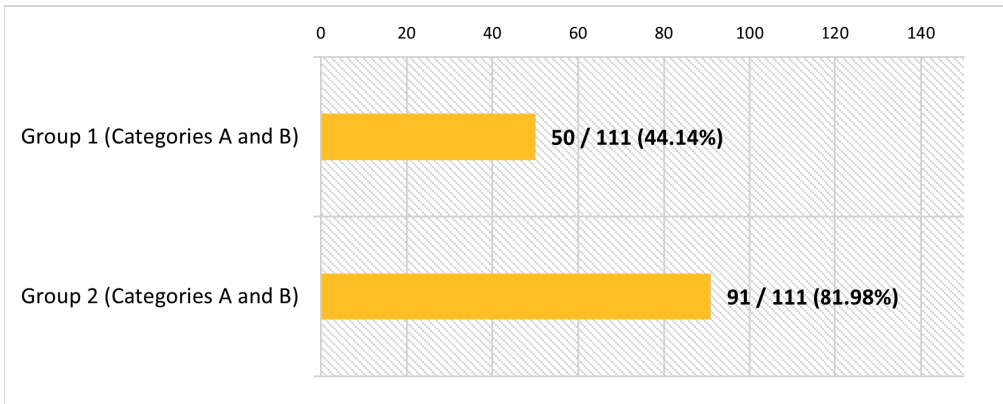

Figure 2. SC development activities of Budapest: Distribution of activities by groups of categories (own edition)

In Group 2, activities are concerned with technological developments. In the smart government domain, examples include integrations with electronic documentation systems, secondary data portals, connection to ASP application services or the Budapest GIS Portal. Many other activities are linked to the smart mobility domain, including the BKK Futár application, smart parking solutions, e-car charging infrastructure and sharing systems, and smart lampposts. There are also examples of electronic card systems in various districts and application-based solutions for tourists.

As an example of Group 1 activities, the CH4LLENGE project, co-funded by the Intelligent Energy Europe Programme of the European Union, with the participation of BKK Budapesti Közlekedési Központ Ltd, improved the capacities and knowledge of Budapest. The objective of the activity was to develop quality Sustainable Urban Mobility Plans, considering the most pressing challenges of participation, cooperation, measure selection, monitoring and evaluation. The final report of the project emphasised the role of institutional cooperation and strategic frameworks (CH4LLENGE Project 2021). The overall strategic framework for SC developments in Budapest is defined in the 'Smart Budapest Framework Strategy' approved by the Budapest City Council in 2019 (Budapest Főváros Önkormányzata 2019). On the other hand, there are various strategic frameworks aligned with it: the climate strategy of Budapest (2018), the Budapest 2030 urban development plan (2013), the Balázs Mór Plan for transport development strategy for the 2014–30 period. An example

of the [A] Community Building activities is the establishment of a climate-change platform in Budapest, with 33 member organisations. The objective of the platform is to expand the knowledge of the capital's decision-makers and the public about climate change, to ensure the long-term coordination of the activities related to this topic at the capital level and the conditions of professional communication related to climate change, as well as to define its framework effectively.

4. 2. Dichotomy 2: Top-Down or Bottom-Up Approach

This section provides an overview of the activities of the Budapest municipality in the governance of the SC as well as defining its objectives and characteristics. The municipality's strategy is defined in the document 'SMART BUDAPEST: The Smart City Vision of Budapest', which also details the dedicated role of each partner and the overall nature of the strategy. The strategy states that it is based on a new approach, which – in contrast with the traditional method of urban development documents – does not emphasise the necessary interventions in all the particular urban domains. It rather collects a criteria framework for 'smartness', which horizontally aligns with all urban domains and harmonises them. It eventually acts as a complex guide to achieving the long-term goals. It could be used in the preparation and decision phase of projects. On the other hand, it may also be used in embedding smartness into the integrated urban development strategies (Smart ITS). The final focus areas are (1) Initiator Urban Governance, (2) Smart People, (3) Smart Economy, (4) Sustainable Resources, (5) Smart Mobility and (6) Urban Quality of Life.

Budapest's SC development strategy shows a mixed picture of top-down and bottom-up approaches, mainly due to its special view on the strategic framework, as explained above. The local government of the capital of Budapest is a key driver and participant in SC development activities. Public companies and district municipalities related to the capital were involved in 62% of all activities. Those activities that happened without the participation of local public administration took up a rather lower share of 38%, which means that the bottom-up approach of the city's strategy is less significant. The framework strategy describes the role of different stakeholders in the implementation process. The actors are explicitly called (1) local governments and central government administration, (2) inhabitants and civil society and (3) market-oriented enterprises. Local government tasks are described as adopting SC principles into existing operations and executing new projects, with special emphasis on incentives and legislation. Civil society is encouraged to take on responsibilities and enforce smart principles in individual decisions. Members of the civil society are also expected to monitor, validate and provide feedback on planning and implementation of smart projects. The market-oriented enterprises' task is to engage with urban challenges by developing products and services.

The document defines its role as a guiding mechanism for all the stakeholders to support their cooperation and harmonise project activities. On the other hand, the strategy emphasises the special structure of Budapest's public administration, the two-tier system of local governments. This makes the city services more com-

plex; additionally, the Hungarian government implements several projects, within its jurisdiction, while key government services – where SC developments are common in excellent cases – are nationally centralised, leaving little space for the city to plan and implement actions. Taking into consideration the relatively high level of engagement of the city, one may expect strong leadership and a straightforward vision. However, the fragmentation of authority, the diverse interests of the various public bodies, the centralised service provision and the horizontal nature of the framework strategy make it challenging to classify it as a purely top-down approach. Figure 3. shows that, while the Budapest municipalities take the lead, the central government's role is relatively high in the SC development activities of Budapest.

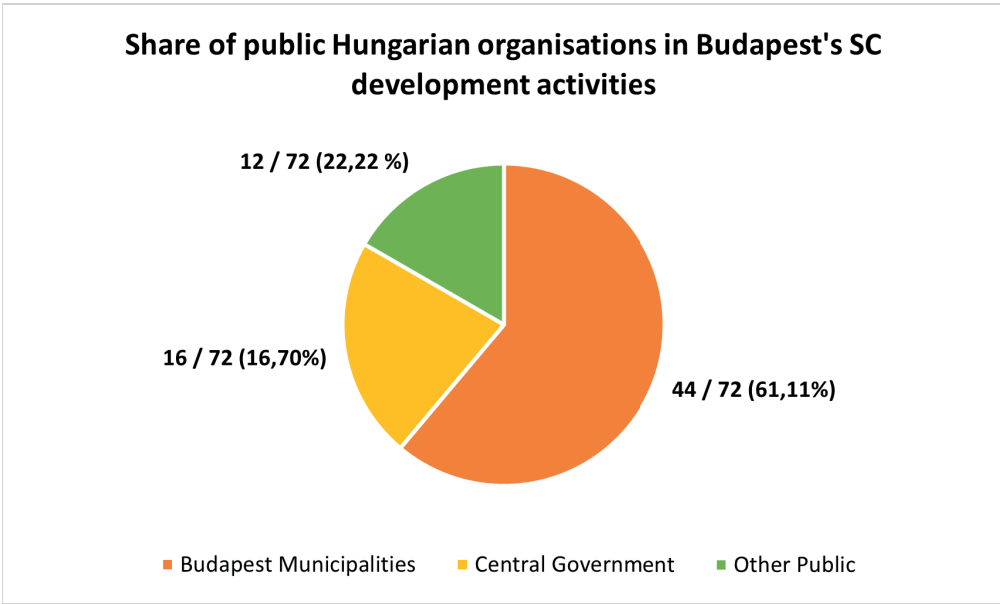

Figure 3. Share of public Hungarian organisations, based on their spatial level (own edition)

Budapest's SC framework strategy outlines a four-step planning process that begins with the (1) definition of SC, its focus areas and principles, based on the city's vision, and a review of international practices; continues with (2) assessment of the situation in each focus area, covering already implemented and ongoing SC projects, local and national sectoral plans, and identification of key stakeholders; is followed by (3) determination of objectives and intervention areas in the focus areas; and concludes with (4) preparation of mechanisms to enforce smart principles in the development areas.

Different target groups were engaged, using various methods. The working group responsible for developing the strategy consisted of personnel from the Mayor's Office and external experts, which determined it as a centralised development process. Urban challenges and good practices were identified by conducting workshops with

the participation of district local governments, where they also disseminated the methodology of the planning process. Another key stakeholder group, where similar workshops were conducted, was public service provider organisations (e.g., utility companies). In these cases, the working group also used the interview technique with representatives of the organisations, to enquire in depth about their opinions and recommendations. Despite these efforts to make the strategy creation process an open and inclusive one, there is no publicly available evidence found on these workshops and interviews; furthermore, activities related to gathering the opinions of the wider population are also missing.

Despite the thorough description of monitoring systems, measurement and indicators to evaluate the interventions in each focus areas, there are no responsibilities assigned to any organisations. Being a horizontal methodology to enforce smart principles in urban development, the strategy has no central organisations, where the necessary capacities and competencies are assigned. The strategy refers to the role and central role of Lechner Non-profit Ltd, which is a professional organisation that supports architectural and construction work and performs other professional information technology (IT) tasks. It created a Smart City Development Model – Methodological Guide TÉMOR, a City Evaluation and Monitoring System for Hungarian cities. However, this organisation has national jurisdiction and is directly linked with the Prime Minister's Office and therefore the Hungarian government. Another key organisation mentioned is related to the Digital Welfare Program 2.0 (the Hungarian government's digitalisation strategy), which is similarly linked to the central government. There is no specific local government organisation with the role of coordination, internal and external stakeholder management, project initiation, communication, etc. Nevertheless, the framework dedicates a central, leadership role to district local governments. There are also mentions of the pivotal role of knowledge generation and knowledge sharing (know-how) among members of communities, and institutional experience sharing. However, the strategy does not describe the mechanisms, sources or any particulars about such activities, for instance, organising cooperation events, stimulating the ecosystem and involving new stakeholders. The legislated environment and the regulations are also not sufficiently developed.

4. 3. Dichotomy 3: Double or Quadruple-Helix Model of Collaboration

Budapest's SC ecosystem for collaboration in development activities is analysed and visualised using the freeware Gephi software. The participating organisations are classified based on their affiliation in the quadruple-helix model. As Figure 4. shows, the most active organisations are within the 'Government' category, with 133 organisations (39.47%), while the second most active sphere is 'Industry', with only two fewer participants, 131 organisations (38.86%). The third one is 'Research', which comprises the higher-education institutions, with 41 organisations (12.17%). The fourth most active sphere is 'Civil Society', with 32 organisations (9.50%). This data suggests that Budapest uses a double-helix collaborative model, with the main

participation coming from government and industry, as an engine behind the city's strategy for SC development activities.

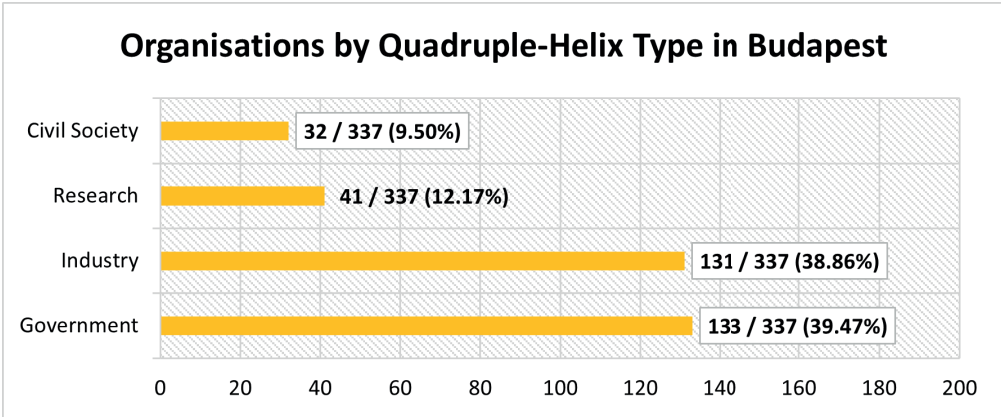

Figure 4. Organisations by quadruple-helix type in Budapest's SC development activities (own edition)

Figure 5. shows the network graph of the participating organisations in the ecosystem. The organisations mapped during the coding process are represented as nodes with a diameter that is directly proportional to the number of activities they participated in. Every edge connects the organisations that have collaborated in implementing at least one activity. Some organisations carried out activities on their own, and these cases are defined as self-loops in the software. The stronger the degree of collaboration between two organisations, the thicker the edge connecting them. The graph uses the Fruchterman Reingold layout, which is a classical one, developed in 1984 (used in Gephi software). For the sake of managing duplicate collaborations between two organisations, we used the simple 'sum' method for weighting. The edges are all 'undirected' ones. Colours are assigned according to the organisation types, as the legend on the right side illustrates.

The data suggests that Budapest's SC strategy holds onto the belief that SC developments can be efficiently realised within the narrow margin of traditional public–private relationships. Therefore, the collaboration's model is a double-helix structure. In this specific case, this means that the roles of the research organisations and universities are underappreciated; there are great opportunities for municipalities to engage with research actors on the topic of SC development activities. The potential for various instances of mutually beneficial cooperation is currently underexploited. The city's framework strategy declares that the road to smartness could be achieved through validation of 11 horizontal principles, which might be interpreted in any level of planning. The 'cooperative' principle describes that one of the most important indicators for measuring the smartness of Budapest is the degree of interconnectedness of its urban actors. With regards to the status of a central institution, the strategy states that the municipalities play a pivotal role in urban governance. It is the public sphere's (e.g., local governments') re-

sponsibility to build partnerships, be proactive and coordinate urban actors. A key practical challenge is the management of activities that affect several administrative boundaries.

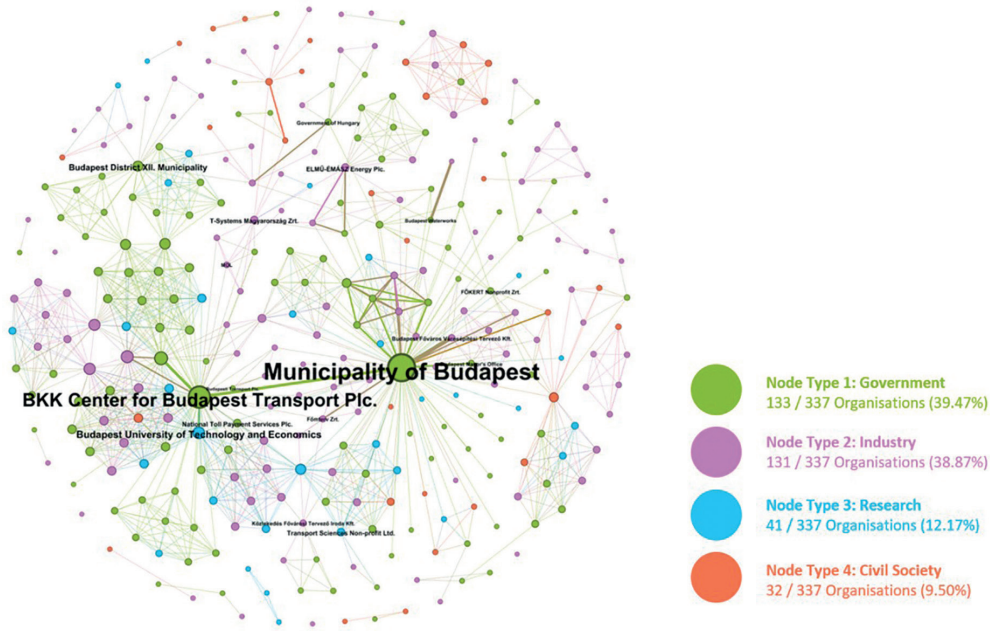

Figure 5. The SC development ecosystem of Budapest's strategy[1] (own edition)

Civil society, being the least represented organisation type, holds a rather high share, compared to the international examples of excellent cases. As an example, Budapest's local government and several local district governments introduced the institution of participatory budgeting, which had dedicated to it an important role in empowering citizens and incentivising their engagement with local urban development activities. However, this significant participation is to be interpreted not only as a consequence of the city's intention to strengthen the role of the civil society but as proof of the existence of notable grassroots activities.

4. 4. Dichotomy 4: Mono-dimensional or Integrated Intervention Logic

The available data in the analysis shows in Figure 6. that in the activity category of 'Services and Applications' Budapest's SC strategy has an integrated approach,

[1] In labelling the nodes of the visualisation, the official English names of the organisations were used. When they were not available, we used the original Hungarian names, to help with searching for them via search engines.

which means that SC development activities cover most urban domains, in an integrated manner. It focusses on various domains of applications, not solely on the implementation of environmentally friendly solutions. Most of the activities are connected to 'E-Government' (25/86, 29.07%), 'Mobility and Transport' (23/86, 26,74%), 'Health and Social Inclusion' (20/86, 23,26%), 'Education' (18/86, 20.93%) and 'Air' (17/86, 19.77%).

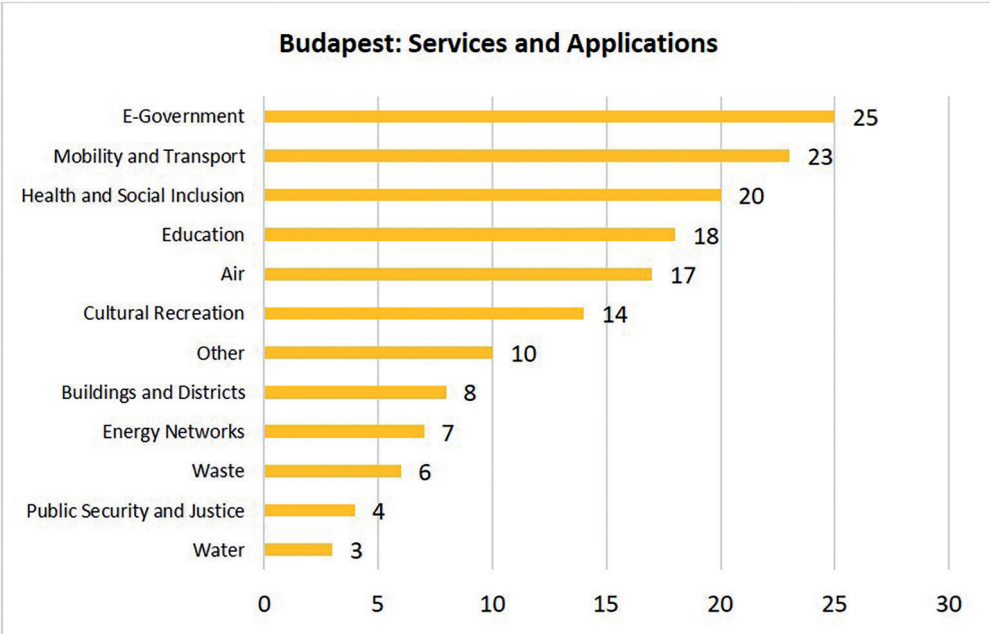

Figure 6. Budapest's SC development strategy: Activities by application domain (own edition)

Considering this data, the activity portfolio of the city fits well with the European understanding of SCs. This aligns with the current city management's policy focus of a climate strategy that aims to address the environmental sustainability issues that are pressuring the needs of the citizens. Among the services and applications, we find a variety of solutions – e.g., dynamic simulation models to optimise the operational and maintenance conditions of the city's waterworks, development of geographical information systems (GIS), e-mobility and micro-mobility solutions, open data utilisation portals to share public data assets with the general public and make use of them, community food sharing platforms, an online platform for the management of citizen reports about public space problems and sharing these items with the competent authorities, deployment of UV-B radiation sensors, providing citizens with real-time information on public transport, and a smart grid pilot project with the extensive engagement of households with smart metering solutions.

5. Discussion

For researchers and the general public, it would seem inappropriate, or at least irrelevant in contrast to other pressing issues, to discuss the current situation of SCs in Hungary or the Central Eastern European region. In many cases, the COVID-19 pandemic further marginalised the SC development activities of less-well-performing cities since some of them reported having challenges with operating even the very basic urban services such as public transportation. Nevertheless, we should remind ourselves that SCs are fundamentally not only all about fancy multi-million-dollar ICT projects. The concept emerged as a comprehensive framework to minimise the contemporary inefficiencies of urban systems, and maximise the quality of life for citizens. Amid the challenges of this new pandemic, the resilience of urban systems is being tested, and the need for smartness is becoming even more urgent than before.

As mentioned in the introduction, to embrace smartness, local governments are provided with directives, and financial incentives in the European Union, to plan smart activities. However, the unpreparedness of municipalities prevents them from accessing additional resources to develop urban services, and they decline even further in competitiveness. Lukács and Csomós (2020) reported that 15% of Hungarian cities with at least 10,000 inhabitants (140 cities) barely mention 'smartness' in their most important medium-term development programme. Are these results generalisable among Eastern European peers and the EU-15 countries, or is it only a Hungarian phenomenon? Cities need more support in tools and capacities to embed the concept into their mid-term plans.

Showing the characteristics of Budapest, the supposedly most advanced case in the country, we find the findings of the analysis to be more informative if we compare them with the case of Vienna, which is already reported in the international literature as an example of excellence. The comparison between the neighbouring countries is otherwise an often-used benchmark in public media. In contrast to Budapest, Vienna uses a holistic SC strategy approach, which means that technological development is aligned with human, social, cultural, economic and environmental factors. Furthermore, Vienna keeps a balance between top-down and bottom-up approaches, and the city government promotes a bottom-up development process. There is another sharp difference between the two cities. Regarding the models of cooperation, Budapest uses a double-helix approach, while Vienna uses a triple-helix one. The share of academia in Budapest's SC development activities is lower (12.17%) compared to its peer (19.61/%). Another key difference is the share of government organisations: 39.47% in the case of Budapest and 19.61% in the case of Vienna. The dominance of government organisations also means a lower share of industry organisations in Budapest (38.87%, in contrast to Vienna's 56.47%). Yet another interesting finding is that the share of the civil society is almost double in Budapest what it is in the other city. The composition of services and applications (C) is quite similar in the two cases. All this data suggests that, compared to an excellent case, Budapest's SC development activity uses different strategic principles in Dichotomies 1, 2 and 3. This suggests that the differences in performance might

be originating from the adaptation of these different principles, because the activity portfolio of the two cities is much alike in terms of the applied domain. The question arises, then, do cities like Budapest want to compare themselves to Vienna, if such fundamentally different approaches are present in the SC strategy? Or, rather, is the performance in smartness correlated with the type of strategic principles that cities adopt? This is a future direction for research.

Looking at the SC development activities of Budapest, we can state that the current European partnerships created benefits and challenges as well. One special example of failure originates from an international cooperation project, funded by the European Commission, called Cities4People (Cities4People 2021). Within the project, the local government and the BKK (competence centre for transport) worked together with several shared mobility solution companies, such as the Lime Lime Network B.V. which operates shared electric scooters. The service provider proved to be inadequate in terms of taxation, generated huge tension in urban mobility, and, parallelly, mainly served the needs of tourists, instead of the residents. The service has even been banned in various districts by the local governments.

Considering the very low engagement of the medium-term strategies of Hungarian cities with the SC concept, it is vital to provide easy-to-understand and standardised methodologies for researchers and practitioners. Besides the fundamental differences we found in the different strategic approaches of an excellent and less successful city, there are other key issues to be considered that are not at all technological or ICT related in their nature but, rather, involve strategic management, institutional challenges and planning problems, which are hindering the transition to smartness. A key difference is that the Urban Innovation Labs is missing. Every city is unique, and adaptation of novel technological solutions requires special skill and knowledge; otherwise, the 'boxed' products of the industry create tension and lead to further unsuccessful cases. The observation of excellence cases suggests that specialised competence centres are established, separately – e.g., Forum Virium Helsinki speeds up innovation in Helsinki, with pioneer work in the field of open data and SC development (Forum Virium Helsinki 2021). It uses the 'agile smart city development' concept (which originate from business and management science) to make Helsinki the most functional SC in the world. As another example, Urban Innovation Vienna was established as a competence centre for future urban issues in Vienna. It contributes the knowledge gained there to open discourse with local experts so that proactive and creative strategies can be drawn up for Vienna.

Therefore, this paper proposes, the key enabling factors to support the transition to smartness are not only technological ones but, in most cases, management, organisational and planning issues. If we accept that the local governments take the leading role in the transition, they must acquire the necessary organisational mechanisms to absorb and diffuse innovation. Unless a dedicated organisation with the necessary skills, expertise, competence and authority exists, the transition to smartness will be more likely to create problems than to solve existing urban challenges. As a new initiative, the Budapest Public Foundation for Enterprise Development's'Smart Budapest Idea Competition' has the potential to fill in such a gap in the future in Budapest.

As mentioned before, in the COVID-19 pandemic cities have been struggling to operate basic services; however, their resilience is being tested in these times, and the capacity of the city management is evaluated in terms of success or failure to recover quickly from difficulties, saving as many lives as possible. The capabilities of local governments to improve their efficiency and make more use of existing resources embodies smartness. Installation of fancy gadgets, and participation in low impact and unjustified, purely monetarily attractive international projects are not the way forward. However, the capability of making smart decisions is not a commodity that can be bought from industry; rather, the transition to an SC fundamentally carries within itself radical change, which might trigger resistance from those it affects.

Another key issue raised by this paper is connected to SC rankings and their indicator systems. It is important to measure the performance of cities in the framework of the SC concept. However, researchers should not be solely engaged with the development of such indicator systems unless they are directly linked with SC development activities, and those activities are clearly with the change of status range of certain performance areas (Bukovszki et al. 2019). In most cases, these rankings are indistinguishable from other competitiveness rankings. Attention needs to be focussed on what cities actually do within the SC context.

6. Conclusions and Future Research Directions

In this paper, we analysed the SC strategy of the Hungarian capital Budapest, which is considered to be an example of a less-well-performing city. Budapest's SC development strategy focusses on technological solutions. This means that the framework conditions for implementing the strategy – organisational background, authority, management, platforms for cooperation and so on – are rather neglected. The strategy uses a top-down approach; however, the two-tier administrative system and the key role of the central government make it a special case where the two approaches are mixed. In the case of the model for cooperation, Budapest adopts early on a double-helix model of collaboration: the most active organisations are government and industry ones, while the share of research is rather low. The presence of the civil society is relatively high compared to Vienna; however, in absolute terms, it is still low. Additionally, SC development activities cover most urban domains in an integrated manner; the city fits well with the European understanding of SCs, focussing on environmentally friendly solutions. The strategic principles used in Budapest's approach to SC transition are significantly different from a number of excellent cases such as Vienna, which might be the reason for the difference in performance. However, the correlation between a set of strategic principles used in cities and their performance is a future direction for research. Budapest lacks a specialised organisation, with the necessary skills, authority and capacities to engage with urban innovation, which on the other hand is present in various excellent cases. This might be another explanatory factor in the search for the different performance, which needs further investigation, too.

7. Limitation and Validity

It is important to note that the multiple-case-study selection process and the number of replications always determine the external validity of the study and the extent to which the results are generalisable. The extent of iteration is highly dependent on the confidence the researcher wants to achieve; 'the greater certainty lies with the larger number of cases' (Yin 2012, 58). Besides, analytical generalisation is also affected by two contextual conditions: the geographical distribution of the selected cases and their size. A more heterogeneous sample would determine a broader generalisation of the results. Budapest, as one case in the Central Eastern European region, is good for a pilot to assess the capability of the methodology that has proved to be working well for excellent cases. For further generalisation, other cases need to be tested in the region. Data availability also has a limitation on the research. Furthermore, the weight of each activity is not considered.

References

Angelidou, Margarita. 'Smart cities: A conjuncture of four forces.' *Cities* 47 (2015): 95–106. https://doi.org/10.1016/j.cities.2015.05.004

Budapest Főváros Önkormányzata. *Smart Budapest: Okos Város Keretstratégia*. Budapest: Budapest Főváros Városépítési Tervező Kft, 2019. https://budapest.hu/Documents/V%C3%A1ros%C3%A9p%C3%ADt%C3%A9si%20F%C5%91oszt%C3%A1ly/Smart%20Budapest%20Keretstrat%C3%A9gia%202019.pdf

Budapest Főváros Önkormányzata. 'Budapest Portál.' Accessed 1 February 2021. https://budapest.hu/Lapok/default.aspx

Bukovszki, Viktor, Diána Apró, Ahmed Khoja, Natalie Essig, and András Reith. 'From assessment to implementation: Design considerations for scalable decision-support solutions in sustainable urban development.' In *IOP Conference Series: Earth and Environmental Science*, 290, 012112. Prague, Czechia: Central Europe towards Sustainable Building, 2019. https://doi.org/10.1088/1755-1315/290/1/012112

Cities4People. 'About us.' Accessed 21 March 2021. https://cities4people.eu/hu/about/

CH4LLENGE Project. 'Addressing the four key challenges of sustainable urban mobility planning.' Accessed 12 March 2021.
http://www.sump-challenges.eu/

Csécsei, Nóra. 'Smart City Index 2020: Budapest among the most underdeveloped cities in the region.' Accessed 5 May 2020.
https://dailynewshungary.com/smart-city-index-2020-budapest-among-the-most-underdeveloped-cities-in-the-region/

Csukás, Máté. 'Database of activities and organisations, involved with the Smart City Strategy of Budapest.' Unpublished raw data.
https://unicorvinus-my.sharepoint.com/:w:/g/personal/mate_csukas_uni-corvinus_hu/EeLJw2vSGvhBoQGKg0i-pFwB-evg6hfYs-f_yOPB5CFu6A (2022)

European Commission. 'EU mission: Climate-neutral and smart cities.' Accessed 12 December 2021.
https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/missions-horizon-europe/climate-neutral-and-smart-cities_en

Forum Virium Helsinki. 'Co-creating urban futures.' Accessed 11 February 2021.
https://forumvirium.fi/en

Giffinger, Rudolf, Christian Fertner, Hans Kramar, Robert Kasasek, Natasa Pichler-Milanovic, and Evert Meijers. 'Smart cities – Ranking of European medium-sized cities.' Vienna, 2007. https://doi.org/10.1016/S0264-2751(98)00050-X

Hollands, Robert G. 'Will the real smart city please stand up? Intelligent, progressive or entrepreneurial?' *City* 12, no. 3 (2008): 303–20.
https://doi.org/10.1080/13604810802479126

Komninos, Nicos, and Luca Mora. 'Exploring the big picture of smart city research.' *Scienze Regionali*, 2018.
https://doi.org/10.14650/88815

Komninos, Nicos. *The Age of Intelligent Cities: Smart Environments and Innovation-For-All Strategies*. New York City: Routledge, 2014.

Lados, Mihály. 'Smart city models in Hungary.' In *New Ideas and New Generations of Regional Policy in Eastern Europe*, 1–46. Pécs, 2016.

Lechner Tudásközpont. 'Smart City Project Database.' Accessed 10 February 2021.
http://okosvaros.lechnerkozpont.hu/en

Lukács, Renáta, and György Csomós. 'Az okosváros-komponensek megjelenésének vizsgálata a magyar városok 2014-2020-as településfejlesztési stratégiáiban.' *Tér-Gazdaság-Ember* 8, no. 1 (2020): 25–33.
https://m2.mtmt.hu/api/publication/31122766

Mora, Luca, and Roberto Bolici. 'The development process of smart city strategies: The case of Barcelona.' In *Re-City: Future City – Combining Disciplines*, 155–81. Tampere University of Technology, School of Architecture, 2016.

Mora, Luca, and Roberto Bolici. 'How to become a smart city: Learning from Amsterdam.' In *Smart and Sustainable Planning for Cities and Regions: Results of SSPCR 2015*, edited by Adriano Bisello, Daniele Vettorato, Richard Stephens, and Pietro Elisei, 251–66. Cham: Springer International Publishing, 2017.
https://doi.org/10.1007/978-3-319-44899-2_15

Mora, Luca, Mark Deakin and Alasdair Reid. 'Smart-City Development Paths: Insights from the First Two Decades of Research.' In *Smart and Sustainable Planning for Cities and Regions*, 403-427. Bolzano: International conference on Smart and Sustainable Planning for Cities and Regions, 2017.
https://doi.org/10.1007/978-3-319-75774-2_28

Mora, Luca, Mark Deakin, and Alasdair Reid. 'Strategic principles for smart city development: A multiple case study analysis of European best practices.' *Technological Forecasting and Social Change* 142, no. July (2019): 70–97.
https://doi.org/10.1016/j.techfore.2018.07.035

Mora, Luca, Mark Deakin, Alasdair Reid, and Margarita Angelidou. 'How to overcome the dichotomous nature of smart city research: Proposed methodology and results of a pilot study.' *Journal of Urban Technology* 26, no. 2 (2019): 89–128.
https://doi.org/10.1080/10630732.2018.1525265

Trapp, Henci. 'Lecsengett a smart city hype?' *GyártásTrend*, 25 January 2018.
http://gyartastrend.hu/varoslako/cikk/lecsengett_a_smart_city_hype

Yin, Robert K. *Applications of Case Study Research*. Thousand Oaks: Sage, 2012.

Z. Karvalics, László. 'Okos Városok: A Dekonstrukciótól a Hiperkonstrukcióig.' *Információs Társadalom* 16, no. 3 (2016): 9.
https://doi.org/10.22503/inftars.xvi.2016.3.1

Health equity and health data protection related to telemedicine amid the COVID-19 pandemic

The correlation between health equity and health data protection in the area of telemedicine has been put into relief during the COVID-19 pandemic. Indeed, the right to health data protection is not only a personal right but also a human right. Health equity cannot be maintained without an adequately functioning system of health data protection in telemedicine, yet, in many countries, health equity remains a mere dream. The United States and the European Union are the flagships of both health equity and health data protection, with HIPAA (in the US) and the GDPR (in the EU); however, some gaps do exist, as demonstrated by the practice of telemedicine during the COVID-19 pandemic. While US and EU regulations on telemedicine do provide legal certainty, fighting the COVID-19 pandemic has created a new legal climate, with new priorities superseding health data protection, which had been paramount beforehand.

Keywords: *telemedicine, health equity, health data protection, COVID-19 pandemic, human rights, personal rights.*

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How to cite this article:

Máté Julesz. "Health equity and health data protection related to telemedicine amid the COVID-19 pandemic".
Információs Társadalom XXII, no. 2 (2022): 27–38.
https://dx.doi.org/10.22503/inftars.XXII.2022.2.2

1. Introduction

Health equity and health data protection are strongly correlated in the area of telemedicine. The quality of health equity in telemedicine is largely affected by the observation of data protection rules and principles. There is no legal certainty without ethics, and ethics are reflected in the law in effect. Ethical norms orientate not only lawmakers but also legal practitioners.

Health equity can be made a reality not only if a legal foundation is established but also if there is wide acceptance of the laws in society. Health equity should be guaranteed for all – the poor as well as the better-off. If there is a social discrepancy, health equity cannot be maintained. Health equity presupposes data protection being respected by all. When certain social actors erode data protection for their own purposes, other groups of people will suffer abuse of their rights. Where rights tied to health data are abused because of deficiencies in telemedicine, health inequity comes about.

The ethical 'good' is not necessarily identical to the notion of 'lawfulness'. A derogation from the basic international principles of health data protection may be justified either by laws related to the COVID-19 pandemic or by social ethics. It is not only health equity that requires social coherence. The law on health data protection also demands it. Strictly abiding by the laws is not always ethical: *summum jus = summa injuria*. However, when the social actors are inclined to obey the laws and to respect the health data protection regulations, there is a great chance to create a society with immanent health equity.

It is important to protect all patients' health data; no one is entitled to a higher level of protection by law than others. A right to health data protection is a personal right enjoyed by a living patient that vanishes after death. According to Hungarian court practice, if a patient has initiated a civil lawsuit for infringement of their right to health data protection, their heirs may continue the legal procedure after the patient's death. This suggests that health equity presupposes a state of law where health data protection is guaranteed by the telemedicine system and also by the judiciary as a last resort.

2. Health equity and telemedicine in light of the COVID-19 pandemic

Authors from the United States have underlined the following problem: 'economically disadvantaged Americans have the greatest need to take advantage of telemedicine to minimise unneeded contact for medical care as they are already in high-risk groups on a number of other fronts. Regarding work, they are more likely to work in essential public services' (Khilnani, Schulz and Robinson 2020, 399). This sort of problem arises in every country in the world, and it is one of the main sources of health inequity amid the COVID-19 pandemic.

Recent research conducted in Canada has demonstrated that western rural Canadians prefer in-person medical consultations to telemedicine. This is the case even though most western rural Canadians enjoy access to telemedicine (Rush et al. 2021, 10).

A similar problem arises in other countries as well, including Hungary. Most rural Hungarians today, as before the pandemic, will take a coach to meet their physician personally rather than enjoying the advantages of telemedicine. In countries where telemedicine is not accessible to all, the hardship is even greater. The Canadian phenomenon is observed in various societies and cultures.

There is a certain level of intrinsic inequality in the information positions of the physicians and patients. The patients find themselves in a vulnerable situation when disclosing their health data. The physicians' responsibility for data protection is not merely of a legal but also of an ethical character. The physician's duty to protect other people, who are in contact with the contagious patient, may overwrite the patient's right to health data protection.

Recently, US authors have emphasised the importance of health equity in connection with telemedicine during the COVID-19 pandemic. Access to broadband Internet, the ability to pay for telemedicine and many other factors have been determining health equity during the pandemic (Ortega et al. 2020a, 369). Other US authors have argued that '[t]he COVID-19 pandemic has exposed the magnitude of US health inequities – which the World Health Organization defines as "avoidable, unfair, or remediable differences" in health' (Berkowitz, Cene and Chatterjee 2020). Lynch has observed that '[t]he COVID-19 pandemic has revealed starkly and publicly the close interconnections between social and economic equality, health equity, and population health' (Lynch 2020, 983).

In China, from July 2018, the government has introduced regulations on telemedicine (Iong 2020, 595) and it is now free of charge. In the US, Medicare reimburses the costs of healthcare provided through telemedicine (Ortega et al. 2020a, 369). Other countries, such as the UK, Germany, Canada, India and Hungary, also promote it in light of the COVID-19 pandemic. Hopefully, these developments will be upheld after the current situation.

In relation to the COVID-19 pandemic, authors from all over the world have pointed to the 'loss of health insurance, jobs and homes, which increases risk for mental and physical morbidity and all-cause mortality' (Shadmi et al. 2020, 2). All that harms health equity in various ways in the countries under examination. For example, in this study, the co-authors from Brazil state that rich white people have imported SARS-CoV-2 from abroad and then infected less well-off Black workers in Brazil (Shadmi et al. 2020, 3). The Chinese co-author is satisfied with the health measures taken by the Chinese government. The US co-author stresses the problem of uninsured homeless people and that of the prison population of 2.3 million because the prison healthcare system is 'understaffed and ill-equipped' (Shadmi et al. 2020, 10), and the co-author from Colombia focusses on the relevance of 'telemedicine for higher-risk groups, with the aim of reducing their unnecessary contact with the health system' (Shadmi et al. 2020, 13).

In Hungary, health equity is by and large ensured by the state. All the relevant human rights documents are in effect in the country. Nevertheless, there are ethnic minorities (e.g. the Roma), jobless people, underpaid employees, retirees with a small income and other social groups who have never enjoyed full health equity during the recent history of Hungary. Telemedicine is not accessible to these people

or at least not fully accessible. The lack of access to broadband Internet is one of the disadvantaging factors. In Hungary, an unusual number of healthcare services are free; however, it is in private healthcare that a truly standard level of care is provided. After healthcare professionals' salaries were raised in 2021, they had to decide whether to work exclusively in the public or in the private healthcare sector because it was not permitted to work in both. Those who have chosen the public healthcare sector earn a considerable salary, while Hungarian patients who use private healthcare are those that can well afford it. Most socially vulnerable patients turn to public healthcare providers, thus enlarging the gap between the level of healthcare for the rich and that for the less well-off.

Telemedicine has been vital during the COVID-19 pandemic; however, health illiteracy and digital illiteracy mean that it is rather available to better-off and younger social groups (Julesz 2020, 29; Pikó and Kiss 2019, 108). Health inequity arises from this phenomenon, and it is not the only factor at play. In Hungary, it is mostly baby boomers who suffer from digital illiteracy. Those of advanced age hardly ever use the Internet. Their main means of telecommunication with their doctor is the telephone, though this is often insufficient for telemedicine. Spanish authors have concluded that '[i]f face-to-face care cannot be offered, telehealth interventions should be guaranteed, whenever possible facilitating contact by video call rather than by telephone' (Sanchez-Guarnido et al. 2021, 9). This assertion was made in connection with occupational therapy for mental health; however, it applies to a variety of areas of medicine, except for such interventions as surgery or other cases of physical intervention. Győrffy et al. point out that quite a few patients conceal or exaggerate symptoms. This can be better recognised through a video connection than via telephone (Győrffy et al. 2020, 989). Balogh et al. argue that telemedicine has become common in primary healthcare during the COVID-19 pandemic and that its advantages should be maintained after the pandemic but that the length of consultations via telephone ought to be reasonably limited (Balogh, Diós and Papp 2020, 1431).

In the US, authors have argued that 'those groups most vulnerable during the COVID-19 pandemic – older adults and those with pre-existing conditions – are also two groups that have historically been more likely to suffer from digital inequalities' (Khilnani, Schulz and Robinson 2020, 398). Other authors from the US have arrived at the result that during a major increase of telemedicine visits in March and April 2020 in the US, it was mainly patients aged 20 to 44 years who used telemedicine, particularly for urgent care (Mann et al. 2020, 1132). The COVID-19 pandemic makes telemedicine necessary to guarantee equal access to healthcare for all. However, health equity for the elderly and the poor exists on the whole in the law but not in reality. Those who cannot purchase the required technology cannot enjoy the advantages of telemedicine. They have to appear in person and expose themselves to potential infection. The waiting lists are long, and telemedicine can only cut them short for those experienced in the digital world. The tendency detected in the US applies in Hungary as well, though the living standards and the quality of the healthcare provided are not comparable.

According to Ortega et al., '[l]inguistic barriers are a recognized source of health inequities for ethnic minority communities whose health communication needs

cannot be adequately met in the majority language' (Ortega et al. 2020b, 1530). In Hungary, this sort of problem did not arise during the COVID-19 pandemic because ethnic minorities in Hungary generally (also) speak Hungarian. Nevertheless, these communities are legally permitted to use their first language in healthcare. However, in practice, they do not. In telemedicine, members of these groups intending to use their first language would certainly meet difficulties due to the lack of health professionals who speak minority languages.

In many countries, health inequity is produced by the scarcity of medical practitioners in the face of a growing population, among other factors. This sort of health inequity can be surmounted by training residents via telemedicine platforms, among other solutions. This is a great opportunity to teach them how to perform medical interventions and observe social distancing at the same time. For example, in Peru, ophthalmology residents have successfully been taught how to do cataract surgery via Cybersight, Orbis International's telemedicine platform (Geary et al. 2021, 8). Although the authors give an account of a success story, I believe that in-person resident–patient contact needs to be ensured to train future medical practitioners even during the COVID-19 pandemic. In the case of undergraduate medical students, e-education may be a way out because of the huge number of students concerned. In Hungary, medical students who enjoyed online education during the worst times of the COVID-19 pandemic have since had the opportunity to make up the leeway and take practical classes in the summer.

3. Telemedicine and health data protection

Telemedicine has gained in importance due to COVID-19. The pandemic prompted lawmakers to regulate the legal and professional ethical framework for telehealth. In Hungary, a large number of legal norms have been put in place to keep telemedicine within the borders of the state of law. The protection of sensitive health data and the special legal features of the doctor–patient relationship make it important to meticulously regulate the functioning of telemedicine. The regulations follow the inter- and supranational legal norms in effect in Hungary.

As stipulated by section 52 of the Preamble of the General Data Protection Regulation of the European Union (GDPR): 'Derogating from the prohibition on processing special categories of personal data should be allowed when provided for in European Union or Member State law', especially for the purposes of 'prevention or control of communicable diseases and other serious threats to health'. This regulation offers a certain level of freedom to Member States, such as Hungary, to place public health before personal health data protection, on condition that it is necessary and proportional to prevent the spread of COVID-19. Becker et al. argue that '[i]n a pandemic, such regulations can derogate from data subjects' rights and provide a legal basis for processing beyond the existing legal framework' (Becker et al. 2020, 5).

The right to health data protection is a human right. According to Article 6 of the Convention for the Protection of Individuals with regard to Automatic Processing of Personal Data of the Council of Europe: 'personal data concerning health [inter alia]

… may not be processed automatically unless domestic law provides appropriate safeguards'. Article 8 of the Charter of Fundamental Rights of the European Union declares: 'Everyone has the right to the protection of personal data concerning him or her. Such data must be processed fairly for specified purposes and on the basis of the consent of the person concerned or some other legitimate basis laid down by law.'

Telemedicine provides an ample source of health data. There is a fine line between a legally permitted derogation from data protection and a violation of law. In Hungary, health services provided through telemedicine should be properly documented in the Electronic Health Cooperation Service Space. This requirement is a *sine qua non* of health data protection. An illegal breach of the patient's right to health data protection may lead to both civil and criminal liabilities. The patient may seek damages and bring the case before a criminal court, although the establishment of criminal liability rarely occurs in Hungarian judicial practice. According to section 219 of the Hungarian Criminal Code: 'Any person who, in violation of the statutory provisions governing the protection and processing of personal data in Hungary or in the European Union, for profit or causing serious disadvantage: a) is engaged in the unauthorized and inappropriate processing of personal data or b) fails to take measures to ensure the security of data is guilty of a misdemeanour punishable by imprisonment not exceeding one year. … Any misuse of personal data shall be punishable by imprisonment not exceeding two years if committed in connection with special data.'

Leite et al. are of the following opinion: 'Public administrations around the world, such as Australia, the USA and the UK, are investing in telemedicine to manage COVID-19, with the specific aim to reduce the volume of patients interacting with emergency departments' (Leite, Hodgkinson and Gruber 2020, 484). The same authors underline the importance of data privacy and protection (Leite, Hodgkinson and Gruber 2020, 483). The Hungarian Act on Health Data Protection is in harmony with the GDPR (EU). The constitutional 'state of danger' in effect in Hungary narrows patients' right to health data protection with regard to COVID-19, though this is proportional and necessary in the time of a pandemic. In Hungary, there are limitations to how the health data obtained from the Electronic Health Cooperation Service Space can be used. Unnecessary and disproportional use of health data is strictly forbidden. The constitutional 'state of danger' is not an excuse for the Hungarian state to abuse patients' health data, and this is so in other countries as well.

Abeler et al. believe that '[w]eakening data protection might be preferable to the far-reaching restrictions of personal freedom and to the economic costs of the current lockdown' (Abeler et al. 2020, 1). The authors consider that a contact tracing system would be useful to warn a person who has been in contact with an infected person to self-quarantine. The authors find it secure because 'the necessary data could be processed in a way that would effectively preclude the central server from identifying users' (Abeler et al. 2020, 2). Bradford et al. argue that 'exposure tracing and notification is a proportionate response to the coronavirus public health threat that justifies some intrusion on the privacy rights of individuals' (Bradford, Aboy and Liddell 2020, 21). In my view, data collection does not run counter to the GDPR

(EU) if it happens with the intention of containing the COVID-19 pandemic. In the European Union, the national regulations on data protection may differ from each other on the condition that they do not violate the common basic EU principles of data protection.

Those basic EU principles of data protection are as follows: the health data must be processed lawfully and transparently; there is no room for data processing without a specific purpose; and only health data necessary for this specific purpose should be processed. Further, the health data should be protected against unlawful, unauthorised and unnecessary data processing. The Hungarian app has been criticised in relation to the aspect of data protection, mainly by party politicians; however, I believe that the basic principles of data protection have not been infringed in practice. Detailing the technological conditions of telemedicine is not a goal of this article.

In the US, the Health Insurance Portability and Accountability Act of 1996 (HIPAA) regulates the processing of information related to healthcare. While the US Department of Health and Human Services (HHS) Office for Civil Rights and healthcare providers found public video call platforms insecure for telehealth before the outbreak of the COVID-19 pandemic, the COVID-19 era has changed that office's opinion, and, as a consequence, healthcare providers have also changed their position. Skype, Zoom, GoToMeeting and many other platforms may now be used (Pool, Akhlaghpour and Fatehi 2021, 74). However, in terms of health data protection, some other public video platforms are still considered to be insecure and are not authorised by the Office for Civil Rights as a telehealth platform (Pool, Akhlaghpour and Fatehi 2021, 75). Bassan is of the opinion that '[h]ealth information accumulated in time of pandemic is highly valuable for those who profit based on it: health providers, health and medical device vendors, health insurance companies, health devices manufacturers, pharmaceutical companies, telecommunication and technology companies whose products may be used to provide telehealth, and advertisers' (Bassan 2020, 7). Bassan points out that 'privacy policies' and 'terms of conduct' set up by companies not covered by HIPAA but still providing platforms for telehealth do not guarantee health data protection (Bassan 2020, 7). In the US, management of electronic protected health information is regulated by HIPAA. Other US authors have concluded that '[w]ith the transition to a postpandemic phase, the key transformation of telehealth systems is to shift from crisis mode (where the use of stopgap or unproven technologies has been permitted) to sustainable, secure systems that properly preserve data security and patient privacy' (Wosik et al. 2020, 961).

Bhardwaj has pointed to the following problem: 'In the telemedicine framework, a standout among the most significant issues is the exchange of electronic patient information (EPI) between patient and a doctor that are remotely connected. A minute change to EPI may result in a wrong diagnosis for the patient' (Bhardwaj 2021, 2915). This is why new methods need to be developed.

From the perspective of scientific researchers, US authors have reasoned that 'we can imagine a unifying multinational COVID-19 electronic health record waiting for global researchers to apply their methodological and domain expertise' (Cosgriff, Ebner and Celi 2020, e224). Another US author has argued: 'HHS should encour-

age health researchers to use the increased data provided by telehealth services to train AI [artificial intelligence] software that can further improve not only the telehealth services, but also other clinical care, healthcare operations, and research' (Hoffman 2020, 15; see also Héder 2020). In my opinion, health data protection, as a general rule, outweighs scientific aims; however, if those data could help contain the COVID-19 pandemic, a proper anonymisation would counterbalance derogation from general data protection rules. Section 4 paragraph 2(d) of the Hungarian Act on Health Data Protection allows data processing for scientific purposes. Section 4 paragraph 4 makes it legal only if justifiably necessary for the purposes of scientific research. Nevertheless, health data processing is always legal when the patient concerned or the patient's legal representative gives informed consent. In light of the COVID-19 pandemic, the last point is an exception, since masses of patients are concerned, and a great many of them are not in a state to exercise their right to self-determination.

The COVID-19 era has brought significant changes to the social, economic and scientific functioning of all countries. Nevertheless, the political functioning has not changed radically. In Hungary, data protection had become a battleground between civil society and government long before the outbreak of the COVID-19 pandemic. The pandemic put health data protection into relief, and it further increased the debate between civil society and government. In the list of the deceased due to COVID-19 published online by the government, it has been possible to link certain data to a specific person, though the rule of law has been observed. In some of those cases, concurrent information retrieved from tabloids have aided in this recognition.

4. Pros and cons of telemedicine

Telemedicine is largely based on legal and ethical cooperation between healthcare providers and patients. Telemedicine has not only primary advantages (e.g. social distancing) but also secondary ones (e.g. avoidance of informal payments). When I take into account the advantages of telemedicine, I arrive at the conclusion that, for various reasons, the secondary advantages prevail over the primary ones.

The primary advantages are that:

- the doctor–patient relationship does not always necessitate physical contact between doctor and patient;
- the cost of healthcare provided through telemedicine is usually lower because there are no additional expenditures, such as the cost of travel, meals and accommodation;
- telemedicine can reach rural areas that have previously fallen outside the scope of healthcare; and
- telemedicine makes it possible for physicians who are on sick leave because of COVID-19 to continue working from home.

There are also certain secondary advantages, namely that:

- telemedicine forwards new technologies and promotes digital literacy;
- digital nomads can enjoy a higher level of occupational health;

- the Internet of Things is an unavoidable step on the path of human digital evolution;
- the distance between doctor and patient mostly excludes informal patient payments, which are illegal in Hungary;
- patients will spend more money on necessary and useful healthcare devices than on purchasing legal gifts for physicians;
- patients become educated in healthcare to a certain degree, for example learning how to take blood pressure and how to measure oxygen saturation;
- both patients and doctors save precious time by curtailing futile chatting, although the doctor does still need to talk to the patient in order to establish the diagnosis and, in terms of health psychology, it is also important to inform and comfort the patient;
- the general health culture of society will be improved because of patients' increased personal involvement in caring for themselves; and
- timeworn medical practices will be more or less replaced by millennial physicians' digital response to current problems.

Besides the pros, however, cons also emerge, such as that:

- patients may be objectified;
- digital connections may replace interpersonal relationships;
- doctors' altruism and empathy towards patients may be diminished;
- only well experienced physicians will be able to offer medical advice via telemedicine, with fresh doctors needing to wait and learn despite having little opportunity to gain physical experience; and
- a generation gap between older and younger physicians might hinder the efficacy of healthcare provision.

5. Conclusion

Western-type health equity and health data protection are fairly new phenomena in Hungary. Both were imported from the European and American legal cultures. A Western type of health data protection was incorporated into the Hungarian legal system in the second half of the 1990s. Health equity is still under development in Hungary. The right to health data protection is a personal right of the patient, which may be overwritten by the healthcare provider's duty to protect others. Health equity and health data protection have been going hand in hand in the field of telemedicine during the COVID-19 pandemic. The digital illiteracy of the elderly might hinder the use of telemedicine, which is of high importance and not only during the pandemic. Regardless of party politics, the steps made by the Hungarian lawmakers during the COVID-19 pandemic have promoted the use of telemedicine, ameliorated the level of health equity and, meanwhile, protected the citizens' health data.

References

Abeler, Johannes, Matthias Bäcker, Ulf Buermeyer, and Hannah Ziellessen. 'COVID-19 contact tracing and data protection can go together.' *JMIR Mhealth and Uhealth* 8, no. 4 (2020): Article Number e19359. https://doi.org/10.2196/19359

Balogh, Sándor, Erzsébet Diós, and Renáta Papp. 'Beneficial effects of the COVID-19 pandemic on general practitioners: Remote consultation and telemedicine are opportunities for rationalization.' *Orvosi Hetilap* 161, no. 34 (2020): 1431. https://doi.org/10.1556/650.2020.34M

Bassan, Sharon. 'Data privacy considerations for telehealth consumers amid COVID-19.' *Journal of Law and the Biosciences* 7, no. 1 (2020): Article Number lsaa075. https://doi.org/10.1093/jlb/lsaa075

Becker, Regina, Adrian Thorogood, Johan Ordish, and Michael J. S. Beauvais. 'COVID-19 research: Navigating the European General Data Protection Regulation.' *Journal of Medical Internet Research* 22, no. 8 (2020): Article Number e19799. https://doi.org/10.2196/19799

Berkowitz, Seth A., Crystal Wiley Cene, and Avik Chatterjee. 'Covid-19 and health equity – Time to think big.' *New England Journal of Medicine* 383, no. 12 (2020): Article Number e76. https://doi.org/10.1056/NEJMp2021209

Bhardwaj, Rupali. 'An improved reversible and secure patient data hiding algorithm for telemedicine applications.' *Journal of Ambient Intelligence and Humanized Computing* 12, no. 2 (2021): 2915–2929. https://doi.org/10.1007/s12652-020-02449-2

Bradford, Laura, Mateo Aboy, and Kathleen Liddell. 'COVID-19 contact tracing apps: A stress test for privacy, the GDPR, and data protection regimes.' *Journal of Law and the Biosciences* 7, no. 1 (2020): Article Number lsaa034. https://doi.org/10.1093/jlb/lsaa034

Cosgriff, Christopher V., Daniel K. Ebner, and Leo Anthony Celi. 'Data sharing in the era of COVID-19.' *Lancet Digital Health* 2, no. 5 (2020): e224. https://doi.org/10.1016/S2589-7500(20)30082-0

Geary, Amelia, Qing Wen, Rosa Adrianzén, Nathan Congdon, R. Janani, Danny Haddad, Clare Szalay Timbo, and Yousuf M. Khalifa. 'The impact of distance cataract surgical wet laboratory training on cataract surgical competency of ophthalmology residents.' *BMC Medical Education* 21, no. 1 (2021): Article Number 219. https://doi.org/10.1186/s12909-021-02659-y

Győrffy, Zsuzsa, Sándor Békási, Noémi Szathmári-Mészáros, and Orsolya Németh. 'Possibilities of telemedicine regarding the COVID-19 pandemic in light of the international and Hungarian experiences and recommendations.' *Orvosi Hetilap* 161, no. 24 (2020): 983–992. https://doi.org/10.1556/650.2020.31873

Héder, Mihály. 'A criticism of AI ethics guidelines.' *Információs Társadalom* 20, no. 4 (2020): 57–73. https://dx.doi.org/10.22503/inftars.XX.2020.4.5

Hoffman, David A. 'Increasing access to care: Telehealth during COVID-19.' *Journal of Law and the Biosciences* 7, no. 1 (2020): Article Number lsaa043. https://doi.org/10.1093/jlb/lsaa043

Iong, Man Teng. 'Telemedicine in China: An enlightenment from COVID-19.' *Medicine and Law* 39, no. 4 (2020): 595–602.

Julesz, Máté. 'Telemedicine and COVID-19 pandemic.' *Információs Társadalom* 20, no. 3 (2020): 27–38.
https://dx.doi.org/10.22503/inftars.XX.2020.3.2

Khilnani, Aneka, Jeremy Schulz, and Laura Robinson. 'The COVID-19 pandemic: New concerns and connections between eHealth and digital inequalities.' *Journal of Information Communication & Ethics in Society* 18, no. 3 (2020): 393–403.
https://doi.org/10.1108/JICES-04-2020-0052

Leite, Higor, Ian R. Hodgkinson, and Thorsten Gruber. 'New development: "Healing at a distance"—telemedicine and COVID-19.' *Public Money & Management* 40, no. 6 (2020): 483–485.
https://doi.org/10.1080/09540962.2020.1748855

Lynch, Julia. 'Health equity, social policy, and promoting recovery from COVID-19.' *Journal of Health Politics, Policy and Law* 45, no. 6 (2020): 983–995.
https://doi.org/10.1215/03616878-8641518

Mann, Devin M., Ji Chen, Rumi Chunara, Paul A. Testa, and Oded Nov. 'COVID-19 transforms health care through telemedicine: Evidence from the field.' *Journal of the American Medical Informatics Association* 27, no. 7 (2020): 1132–1135.
https://doi.org/10.1093/jamia/ocaa072

Ortega, Gezzer, Jorge A. Rodriguez, Lydia R. Maurer, Emily E. Witt, Numa Perez, Amanda Reich, and David W. Bates. 'Telemedicine, COVID-19, and disparities: Policy implications.' *Health Policy and Technology* 9, no. 3 (2020a): 368–371.
https://doi.org/10.1016/j.hlpt.2020.08.001

Ortega, Pilar, Glenn Martinez, and Lisa Diamond. 'Language and health equity during COVID-19: Lessons and opportunities.' *Journal of Healthcare for the Poor and Underserved* 31, no. 4 (2020b): 1530–1535.
https://doi.org/10.1353/hpu.2020.0114

Pikó, Bettina, and Hedvig Kiss. 'Several characteristics of smartphone and the social network use based on an online survey among young people.' *Információs Társadalom* 19, no. 1 (2019): 108–122.
https://dx.doi.org/10.22503/inftars.XIX.2019.1.5

Pool, Javad, Saeed Akhlaghpour, and Farhad Fatehi. 'Health data privacy in the COVID-19 pandemic context: Discourses on HIPAA.' *Studies in Health Technology and Informatics* 279 (2021): 70–77.
https://dx.doi.org/10.3233/SHTI210091

Rush, Kathy L., Cherisse Seaton, Eric Li, Nelly D. Oelke, and Barbara Pesut. 'Rural use of health service and telemedicine during COVID-19: The role of access and eHealth literacy.' *Health Informatics Journal* 27, no. 2 (2021): Article Number 14604582211020064.
https://dx.doi.org/10.1177/14604582211020064

Sanchez-Guarnido, Antonio José, Esther Domínguez-Macías, José Antonio Garrido-Cervera, Roberto González-Casares, Silvia Marí-Boned, Águeda Represa-Martínez, and Carlos Herruzo. 'Occupational therapy in mental health via telehealth during the COVID-19 pandemic.' *International Journal of Environmental Research and Public Health* 18, no. 13 (2021): Article Number 7138.
https://doi.org/10.3390/ijerph18137138

Shadmi, Efrat, Yingyao Chen, Inês Dourado, Inbal Faran-Perach, John Furler, Peter Hangoma, Piya Hanvoravongchai, Claudia Obando, Varduhi Petrosyan, Krishna D. Rao, Ana Lorena Ruano, Leiyu Shi, Luis Eugenio de Souza, Sivan Spitzer-Shohat, Elizabeth Sturgiss, Rapeepong Suphanchaimat, Manuela Villar Uribe, and Sara Willems. 'Health equity and COVID-19: Global perspectives.' *International Journal for Equity in Health* 19, no. 1 (2020): Article Number 104. https://doi.org/10.1186/s12939-020-01218-z

Wosik, Jedrek, Marat Fudim, Blake Cameron, Ziad F. Gellad, Alex Cho, Donna Phinney, Simon Curtis, Matthew Roman, Eric G. Poon, Jeffrey Ferranti, Jason N. Katz, and James Tcheng. 'Telehealth transformation: COVID-19 and the rise of virtual care.' *Journal of the American Medical Informatics Association* 27, no. 6 (2020): 957–962. https://doi.org/10.1093/jamia/ocaa067

The Internet as an Epistemic Agent (EA)

We argue that the Internet is, and is acting as, an EA because it shapes our belief systems, our worldviews. We explain key concepts for this discussion and provide illustrative examples to support our claims. Furthermore, we explain why recognising the Internet as an EA is important for Internet users and society in general. We discuss several ways in which the Internet influences the choices, beliefs, and attitudes of its users, and we compare this effect with those of psychological conditioning and brainwashing techniques. Finally, we present examples where the Internet's epistemic agency acts at scale, affecting large portions of society rather than individuals.

Keywords: *Internet, epistemic harm, epistemic agency, ontological epistemic primacy, epistemic autonomy*

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How to cite this article:

Krzanowski, Roman, Pawel Polak. "The Internet as an Epistemic Agent (EA)". *Információs Társadalom* XXII, no. 2 (2022): 39–56.
https://dx.doi.org/10.22503/inftars.XXII.2022.2.3

1. Introduction

The Internet is a fact of life for more than four billion people,[1] and it is almost unthinkable to go off grid (e.g., Nuwer 2017). The Internet is generally considered to be immensely beneficial to society at large. And this is true. Yet, this is not the full story of the Internet. There is a hidden, darker side to it. This paper looks at the Internet's epistemic agency and its nefarious impact on our worldview.

We posit that the Internet is a proactive, dynamic EA because it actively shapes our worldviews.[2] Due to the epistemic agency of the Internet, we are experiencing an epistemological crisis with uncertain outcomes (e.g., Waltzman 2017; Zuboff 2019). The 'nature' of our knowledge, how our beliefs are rationalised and justified (i.e., our epistemic foundations), and who or what shapes such beliefs, and for what purpose no longer fits with the traditional models for learning and knowledge acquisition, or our cultural practices. Our sources of knowledge have become less transparent, and we are gradually losing our epistemic agency and ontological primacy (terms explained later in the paper) as epistemic agents (EAs).

In the beginning the Internet was designed to be the grand equaliser, bringing knowledge and democracy to the masses (Dvorak 2016; Ross 2017). However, as the Internet complex began to unravel, the initial objectives started to dissolve (Frey 2011; LaFrance 2014; Weinberger 2015; Dvorak 2016; Clarke 2021). It is an open question as to why this happened. Was it by design or was it just a sort of natural drift, much like with the early promises of radio and television (see, for example, Wu [2016])? With such a complex phenomenon as the Internet, there was probably no single contributing factor but rather a confluence of them. As we mentioned, the Internet is not just a piece of technology but, rather, a larger complex that comprises networking technology, academia, research centres, politics, and economics.

The Internet for some, or even most, of us is about Facebook, Twitter, personal trainers, TikTok, Wikipedia, Amazon, and so on and so forth. Sure, the Internet is all of this, but the Internet is primarily and fundamentally a technological, economic, legal, and political complex of software and hardware for transferring, harvesting, analysing, and manipulating data about its users' experiences and innermost ideas and shaping their behaviours, both individually and collectively. Unbeknown to the users, this is done for economic and political gain. In other words, the Internet is a tool for behavioural modification on an individual or collective (at a scale) level – and this is the cause of the epistemic crisis (e.g., Wu 2016; Kaiser 2019; Snowden 2019; Wylie 2019; Zuboff 2019). There follows a selective list of studies documenting the epistemic agency of the Internet, but this is just the proverbial tip of the iceberg: (Zhang et al. 2013; Dutton et al. 2013; Castells 2014; Wood and Douglas 2015; Furedi

[1] Some 4.95 billion people around the world are thought to use the Internet as of January 2022 (DataReportal 2022).

[2] Worldview is a complex of cognitive, conscious attitudes, postulates, and normative assumptions that determines an agent's beliefs. Depending on the domain, the precise definition of 'worldview' may differ in details (e.g., Funk 2001; Gray 2011; Pinxten 2015). In this paper the term 'worldview' denotes a comprehensive set of beliefs that determine an agent's decisions or attitudes. Beliefs include the agent's position on religion, nature, societal issues, ethics, science, culture, God, moral order, and truth, to list just a few examples. See more about worldviews in Section 4.

2017; Huizer et al. 2017; Specktor 2018; European Parliament Directorate-General for Parliamentary Research Services 2019; Allen 2019; Wylie 2019; Zuboff 2019; Ecker et al. 2022).[3]

The epistemic crisis that we are experiencing can be perceived through epistemological fracturing and the reconfiguration of our worldviews.[4] Indeed, we are witnessing tribalisation, political extremism, a general lack of consensus, and widespread social isolation (e.g., Waltzman 2017; Wylie 2019; Zuboff 2019). At the heart of this epistemological crisis is the Internet and its epistemic agency.

How can we claim that the Internet is an EA? After all, we usually associate epistemic agency with a person or some sort of organisation such as a school or church, not with a network of inanimate artefacts, even such a complex one as the Internet. However, epistemic agency may also be understood differently; it can be attributed to inanimate objects, like the Internet, that shape our beliefs. We argue that the Internet complex has epistemic agency, or that it is acting as an EA, because it actively shapes our worldviews. In the following paragraphs, we explain the key concepts for this discussion and provide illustrative examples to support our claims, which are not abstract philosophical musings but, rather, demonstrable facts.

We also want to avoid any over-interpretation, or indeed misinterpretation, of our arguments. We do not want to be viewed as neo-Luddites, techno-anarchists, acolytes of a flat Earth society, or something similar. Our arguments and conclusions are rooted in facts and logic, as we strive to demonstrate. We will also explain why recognising the Internet as an EA is so important for us and society in general.

By the end of this paper, the reader will hopefully see the Internet – in terms of not just the technology and services offered to public but also other dimensions that are hidden from its users, such as the political clout it wields, the economy it supports, and its societal reach and impact – in a new light. More specifically, we want the reader to recognise the Internet for what it really is rather that what it is presented as.

This paper also attempts to bring the discussion about the Internet's impact on society and humanity at scale into the philosophical discourse. Simply put, the Internet has quickly become an existential problem for us, and we need to state clearly

[3] We need to recognise that we are not users, or even clients, of the Internet. We are sources of raw behavioural data to be harvested by the Internet complex (e.g., Wylie 2019; Zuboff 2019) before being transformed by software into behavioural futures that can be sold at auction in the form of User Profile Information (UPI). UPI presents a virtual model of our worldview, our likes, dislikes, fears, and preferences. It reflects our past choices and decisions, our moods, and our judgements, and it serves as a predictive model of our behaviour. As studies have demonstrated, UPI may be used to model and then influence our decisions (e.g., Wylie 2019; Zuboff 2019). This virtual model of our worldview is what allows companies to control the information that is provided to us and thereby influence us. Changing our online and offline attitudes is what the Internet complex was designed to do.

[4] We are far removed from the prior claim that our worldviews are completely ours, such that no one is trying to influence what we think and how we think. However, the scale of the manipulation that came with the Internet is unprecedented because of its reach and the industrial, political, and scientific complex behind it. A rather crude computing-related analogy could be to say that we are born with a basic operating system installed. The user interface, our worldview, is built upon this. Other people, teachers, friends, colleagues, books, school, and religious institutions used to shape this worldview, but now it is the Internet and its algorithms.

that this is no longer a technological problem per se, so technology will not solve it. The role of the Internet in society warrants a deep Platonic analysis of its roots and consequences, but the first step is to recognise and define the problem we are facing and its philosophical dimensions, and understanding the Internet's epistemic agency is at the roots of this problem. The task for philosophers is to understand the philosophical assumptions of the Internet and show how we can shape them in such a way that the Internet will serve the long-term well-being of humanity. We call this challenge *philosophy in technology*.

To avoid a critique of incompleteness, we need to restate what is in and what is outside the scope of this study. Our focus is on an argument that the Internet has become, or is, an EA, in a specific sense of epistemic agency as explained in the text; an EA that is actively shaping our worldview. We leave out from the discussion the questions of the importance of the Internet epistemic agency in comparison to other traditional sources of our beliefs and opinions like school, press, TV, books we read, academia, experts, radio, friends, teachers, church, people of authority or that we regard as authorities. These questions should be studied, but, it would seem, only if, and only after, we recognise that the Internet is an EA; and this is what we do in this paper. Thus, here we do not investigate the position of the Internet versus traditional EAs. We do, however, provide some suggestions on conducting such a study.

The argument for the epistemic agency of the Internet is presented in five sections. In Section 2 we define what epistemic agency is in generic terms. In Sections 3 and 4 we discuss how we conceptualise the epistemic agency of the Internet and what its epistemic role is. In Section 5 we summarise the discussion. We conclude the paper with some suggestions for further studies of the Internet epistemic function.

2. Epistemic Agency

2.1. What is epistemic agency?

The term epistemic agency is most commonly used to denote the ability of a human agent to choose, reflect upon, and freely form beliefs (e.g., Elgin 2013; Olson 2015; Puzzo 2015; Moore 2016). This is how we commonly define our epistemic agency. We are all epistemic agents in the sense that we are responsible for our worldviews, and our epistemic agency is founded on free access to information and, maybe primarily so, by our own critical thinking skills, especially our reasoning and judgement faculties. While the existence of our epistemic agency is often denied and trivialised (e.g., Kornblith 2012; Ahlstrom-Vij 2013; Puzzo 2015), it plays a critical role in shaping our knowledge and beliefs about the world (i.e., our worldviews) and the ideas and concepts we live by. (There will be more about this later.)

While our beliefs are to a large degree moulded by our schools, parents, society, culture, the media, and religious organisations and their ministers, as rational creatures we have critical faculties for evaluating these influences. We also possess an implicit or explicit understanding of the role and *modus operandi* of the various factors shaping our worldviews. Indeed, the precise function of our

epistemic agency is to reflectively (and critically) engage with the world, namely the people and organisations that influence us. The extent to which we care to exercise this agency, as opposed to just passively internalising external messages, is a separate question.

2.2. Epistemic Agency and Worldviews

Epistemic agency is closely related to our worldviews, but why? It is because a worldview is shaped by our beliefs, knowledge, and experience. It is what our epistemic agency creates, the lens through which we perceive and value the world (Funk 2001; Fisher 2010). A worldview informs questions such as 'What is the ultimate reality? What is truth? What is the nature of human beings? What is the purpose of life? What is morality, and what is its basis? What are moral values?' Essentially, our worldview guides our decisions. Our relationship with the world is determined by this worldview. For example, if we think that the end of the world is nigh, we may go somewhere to await its occurrence, as has been the case several times (e.g., Richardson 1998; Heaven's Gate 2010). If we believe that education is useful, we will study. If we believe that friendship is of value to us, we will seek to make and retain friends.

We need to know how our worldviews have been shaped, as well as by whom and for what purpose. Was it to help us to live better? Or was it to further someone else's objectives, ones that are not known to us? Is it serving our needs, or is it serving someone else's? We need to know where our worldviews are coming from.

If your worldview is incorrect, your perspective on the world will be erroneous, and you will inevitably make bad judgements and personally harmful decisions. Some examples can help here. Take the metaphor of the horseless carriage (Zuboff 2019; Visel 2007): When people first saw automobiles, they regarded them as horseless carriages. They thought of these self-propelled vehicles as upgraded horse buggies and missed their revolutionary potential.[5] With such a perspective, they could never have imagined the role that automobiles play in our lives today.

Thus, when you see the world, or part of it, through inadequate existing metaphors, and we all live by metaphors (e.g., Lakoff and Johnson 1980), your judgements and decisions will be flawed, inadequate, and erroneous. We need suitable metaphors to live by – we need the right worldview. Thus, to restate the original point, you do not want to be in the situation where you do not know where your worldview is coming from, who is shaping it, what kind of values it instils in you, and what kind of decisions it favours, especially when they could be wrong. You therefore want to know who or what is shaping your beliefs, and here enters the Internet.

So, this is how we function as EAs and how we commonly understand epistemic agency. The Internet is an EA, albeit in a different sense.

[5] Similar miscalculations were made about other developments like phones, computers, and mobile devices.

3. The Internet as an EA

3.1. Epistemic Agency of the Internet

As mentioned earlier, the term epistemic agency is most commonly used to denote the ability to choose, reflect upon, and freely form the beliefs that comprise our worldview. However, epistemic agency may also refer to the passive or active capacity of a system, organisation, artefact, or technology to impact or influence a person's beliefs and worldview (e.g., De Mul 1999; Schlosser 2019). The Internet has epistemic agency in the latter sense, so it is an EA in the sense that it influences our beliefs, views, and choices (e.g., Wylie 2019; Zuboff 2019).

There are ample examples of the Internet's epistemic agency (e.g., Mineo 2017; Kaiser 2019, Wylie 2019; Zuboff 2019). The mechanisms that the Internet uses for its epistemic agency are nothing short of brainwashing, such as 'devices' like perspecticide, echo chambers, filtering, personalisation, astroturfing, fake news, deep fakes, and cognitive hacking, to name but a few. The scale of these activities and their destructive effects on society are difficult to fathom for a non-technical person (e.g., Gibbs 2014; King et al. 2017; Snow 2018; Kaiser 2019; Wylie 2019), which covers most of the public. Later sections explain these mechanisms in more detail.

3.2. The Internet and Epistemic Harm

Indeed, the Internet's epistemic purpose is not to improve our well-being but rather to instil someone else's values and beliefs in us (e.g., Kaiser 2019; Wylie 2019), all with the sole purpose of making us less critical, more obedient, less reflective, and more susceptible to external persuasion. This is what we call epistemic harm.[6] In fact, the Internet as an EA attempts to dissolve our individual worldviews and replace them with the ones that favour the Internet epistemic agency positions and objectives.

Once we are deprived of our own epistemic capacities, which help us to acquire reliable information and make good judgements, the Internet can proceed to control our choices, decisions, views, and beliefs in ways we do not realise.[7] The change of the worldview is only gradual and is usually imperceptible to us. With the Internet permeating even the most intimate aspects of our lives (e.g., Wylie 2019; Zuboff 2019), we urgently need to comprehend and recognise its epistemic role.

The concept of epistemic harm is nothing new; the negative impact of poor-quality information on a human agent has been discussed since Plato's dialogues. However, with the ubiquitous presence of the Internet, for civic societies, epistemic harm caused by the Internet has grown into an existential problem; public awareness of it has unfortunately only begun forming recently.

[6] Steup and Neta (2020) define epistemic harm as '[o]bstructing an agent's cognitive success'. In this paper epistemic harm denotes intentional changes to an agent's worldview that negatively impact, directly or indirectly, an agent's ability to successfully cope with reality.

[7] This attempt is not entirely novel, but it acquired a more sinister and ominous meaning with the Internet (e.g., Herman and Chomsky 1998).

We may still question whether the impact of the Internet is really as harmful to us and society as suggested here despite the fact that we witness rampant tribalisation, political extremism, a general lack of consensus, and widespread social isolation on a country-wide scale. Lunatic fringe groups, the dispossessed, the narrow-minded, the emotionally disturbed, the confused, the malevolent, the maladjusted, the malicious, and the anti-social will be always with us – this is what makes us humans, and we need to deal with it. Nevertheless, most democratic societies have been able to work out some common set of principles, a common worldview if you will, that allows them to function in a way that benefits most members of these societies. Once this common worldview disintegrates, however, so will our democratic societies.

This happens when the fringe becomes the mainstream and starts dictating to others what they should do, and this is what the Internet facilitates. It enhances the fringe perspectives and brings them into the mainstream, thus claiming parity with mainstream views. The worldview that benefited most people gets distorted and pushed into the background. It gets fragmented, and a fragmented society loses its coherence and common sense and descends into internal squabbling, with morally bankrupt or mentally unstable leaders often being elected. Technically, we refer to this as digital disruption to democracy. Cases of democratic processes being subverted have been well documented and researched (e.g., Crabtree 2002; Botsman 2018; Gorodnichenko et al. 2018; Sustain 2018; Anderson and Rainie 2020; Anderson 2020; Dumbrava 2021). This is what we call *epistemic harm* because it is a distortion of our epistemic foundations, our worldview, in a way that is detrimental to our well-being as individuals and society.

3.3. Epistemic Autonomy, Epistemic Distance, and Our Ontological Status

So, why is this all so bad? It is bad because with the Internet as an EA, at least in the sense we explained earlier, we lose, either partially or fully, our ontological status as primary EAs and together with this our *epistemic autonomy* (i.e., our ability to form our own beliefs and justifications).[8] Losing our ontological status as primary EAs means that we do not scrutinise sources of knowledge through our own reasoning faculties but rather accept and internalise knowledge that has been digested and prepared for us by someone or something else (could it be artificial intelligence (AI) algorithms?), in this case the Internet complex. With our ontological status and autonomy slipping away, our *epistemic distance* from reality increases (Nilsson 2021).[9] To put this in plainer words, we no longer reason for ourselves, and our contact with reality is mediated by some *opaque interface* (i.e., the Internet), so we lose ownership of our worldview.

[8] '[T]he epistemically autonomous person demands direct, or first-order, reasons why something is true, and does not merely rely on reports about their existence. Epistemically autonomous individuals are epistemically self-reliant and are responsible for the justification of their beliefs' (Matheson and Lougheed 2021, 2).

[9] Epistemic distance is used here to denote the (conceptual) separation of the information source from the EA. The distance increases when between the source and an agent there exist several systems or processes that mediate information transfer (e.g., Nilsson 2021). There are other definitions (theological) of epistemic distance, but they are of no import to this discussion (e.g., Hick 1990).

By losing epistemic agency, an agent loses epistemic autonomy. The agent's decisions are then made by someone else to fulfil someone else's objectives, which may be hidden from the acting agent. Going further, losing epistemic autonomy leads to loosing autonomy in general as an agent. Agents without epistemic and general autonomy are slaves incapable of reasoning for themselves. In giving up epistemic autonomy, we lose our ontological status as primary EAs and become second-class citizens. Knowledge is power, and this power is drifting away from us.

The Internet introduces further epistemic distance between human agents and the world. In most cases, we receive mediated information, and the pros and cons of the traditional media (e.g., television, radio, newspaper, etc.) are well known, so we have become accustomed to using them.

Talk of losing ontological primacy and increasing epistemic distance may seem rather empty. Are these claims true, and if so, to what extent? Let us look at some of the 'devices' the Internet's agency is using on us. These examples should make our claims about ontological primacy and epistemic distance more obvious and justifiable.

4. The Internet Mechanisms Shaping Our Worldview

To justify our claims about the negative role of the Internet, we need concrete facts. We now supply a partial list of the means through which the Internet complex 'shapes' our worldviews. The methods are nothing short of brainwashing, and indeed, they are brainwashing techniques *par excellence*. The Internet is a digital Pavlov, with us as the conditioned dogs. We may have previously come to a realisation that the Internet is a sort of Bentham panopticon on steroids,[10] but we surely never thought we would also get Pavlov and Skinner in the mix,[11] especially with free services, for example, from Google or Meta. The list is given below.

4.1. Perspecticide

When users are constantly fed with divergent views and opinions, they lose their own perspectives and the capacity to know what they actually know. Such methods have been used on prisoners of war, cult leaders, and political opponents. A person subjected to perspecticide loses his or her own views and opinions and stops thinking independently. A person in this state is easy to manipulate (Saeed 2018; Wylie 2019).

[10] Jeremy Bentham, an English philosopher, created the concept of a prison that serves a conceptual model for a modern surveillance state (Ethics Center 2017).

[11] Ivan Pavlov was a physiologist who is regarded as the father of conditioning (Windholz 1997), while Burrhus Frederic Skinner was an American psychologist who is regarded as the father of modern behaviorism (Cherry 2020).

4.2. Echo Chambers

An echo chamber is an environment in which a person is only in contact with views and information that confirm his or her own viewpoint. This person then forms the distorted view that his or her opinions are shared by more people than they actually are. Echo chambers have the potential to increase bias and hinder any reception of shared views or perspectives. This leads to societies fragmenting and damage being done to democratic processes (Heshmat 2015; Damore 2017; Echo Chambers 2019; Nguyen 2020; GFC Global 2022). One of the effects of echo chambers is the so-called confirmation bias. By witnessing only those opinions that agree with your own, you accept them as being true. In the echo chambers of the Internet, you mostly see what you already believe in.

4.3. Filtering, Filter Bubbles, and Information Bubbles

The information you are presented with when searching online is selected based on your search history, the websites you have visited, and your apparent likes or dislikes. The aim of this is to present you with websites that you are more likely to click on and visit. Thus, someone asking the exact same search question may get different search results. What you receive is search results that have been narrowed down according to algorithms that monitor your Internet activity, which you do not have access to because they are proprietary, in order to entice you to visit certain sites. Thus, you are effectively locked out of accessing new information because such websites may have been deemed outside the scope of your search history. You are basically in a filter bubble. This practice is common in Internet search algorithms and impossible to avoid – you eventually always see yourself. For example, when searching for political commentaries, you will tend to find only those that may be more in line with your own thinking, making it difficult to view and evaluate other perspectives. In this way, rather than enlarging your knowledge and informing your opinions, the Internet is limiting and narrowing them (Morozov 2012; Pariser 2012; Ronson 2016; Carr 2020; GFC Global 2022).

4.4 Astroturfing

Astroturfing is a controlled information campaign to create the false impression of grassroots support for a certain action, movement, or initiative. Modern astroturfing uses Internet resources like email, social media, and instant messaging to disseminate information. While it may appear that such information is coming from multiple sources, it may actually be emanating from a few systems, or even just one, frequently through bots (Monbiot 2011; Bienkov 2012; Astroturfing 2022).

4.5. Cognitive Hacking

Cognitive hacking manipulates people's attitudes and beliefs by disseminating misinformation. Cognitive hacking explores people's emotional vulnerabilities and fears to alter their perceptions of facts, persons, or political situations. It may be directed at individuals or groups of individuals. Cognitive hacking extensively uses personal profiles compiled by social media platforms, such as Facebook/Meta, Instagram, and so on. Wylie (Wylie 2019) described the cognitive hacking campaigns orchestrated by Cambridge Analytica (Cybenko et al. 2002; Wigmore 2017; Wylie 2019; Kaminska 2020; see also Dabrowa 2020).

4.6. Deepfakes

Deepfakes are manipulations of synthetic media that result in realistic, but entirely false, representations of persons, events, situations, or conversations. The purpose of deepfaking is to misrepresent facts and spread misinformation, and it is commonly used to disseminate celebrity pornographic videos, revenge porn, and fake news, as well as to perpetrate hoaxes, bullying, and financial fraud. It may also be classified as cognitive hacking or weaponised (mis)information (Kietzmann et al. 2020; Somers 2020; Witness 2021).

4.7. Weaponised Information

Weaponised information involves the use of false information to shape the beliefs and views of a targeted person or group. It can be used to change the target's perception of events and situations or his or her attitudes and beliefs towards certain individuals or groups (see e.g., Voelz 2015; Waltzman 2017; Defending Democracy 2018; Deloitte 2022).

Mechanism	Impact on worldview
Perspecticide	When users are fed with divergent views and opinions, they lose their own perspectives and the capacity to know what they actually know.
Echo chamber	Increasing bias and hindering the adoption of any shared views or perspectives leads to the fragmentation of societies and the destruction of democratic processes.
Filtering, filter bubbles, and information bubbles	As you are locked out of new information on sites outside the scope of your search history, you eventually always come to see yourself. For example, when searching for political commentaries, you will tend to find those that concur with your own views, making it difficult to view and evaluate other perspectives. Instead of enlarging your knowledge and informing your opinions, the Internet limits and narrows them.

Astroturfing	A controlled information campaign creates the false impression of grassroots support for a certain action, movement, or initiative.
Cognitive hacking	Cognitive hacking manipulates people's attitudes and beliefs by disseminating misinformation. It exploits people's emotional vulnerabilities and fears to alter their perceptions of facts, persons, or political situations.
Deepfakes	Deepfakes manipulate synthetic media to create realistic but false representations of persons, events, situations, or conversations with the aim of misrepresenting the facts and spreading misinformation.
Weaponised information	Weaponised information is false information that is used to shape the beliefs and views of a targeted person or group. It can change the perception of events, situations, or people and alter attitudes and beliefs towards a targeted individual or group.

Table 1. The Internet as an EA (own editing)

Table 1. summarises the methods through which the Internet as an EA affects our beliefs and worldviews.

In-depth analysis of the mechanisms by which these methods change the ways we conceptualise the world would be the subject of behavioural science research and is out of the scope of this study.

5. The Argument Revisited

Our claim has been that the Internet is an EA. We have shown that the Internet acts to change and control our worldviews (i.e., our epistemic positions), which is what an EA *ipso facto* does. The argument can be summarised as follows:

(a1) Whatever affects our worldview is an EA.

(a2) The Internet affects our worldview.

Thus

(c) The Internet is an EA.

The claim (a1) is from the definition (Section 2). The claim (a2) we justified by showing how the Internet epistemic agency functions in three steps (Sections 3 and 4). First, the Internet explicitly uses mind-control techniques based on behavioural modification (see e.g., Zuboff 2019) principles – such as perspecticide, echo chambers, filtering, personalisation, astroturfing, fake news, deepfakes, and cognitive hacking – with the clear intention of affecting our attitudes, beliefs, and worldviews. Second, the concrete results of these techniques can be witnessed through tribalisation, political extremism, a general lack of consensus, and widespread social isolation in our political and private lives. Third, we have demonstrated that the Internet's agency affects our epistemic resources and epistemic

functions, so it clearly plays an epistemic role (i.e., has epistemic agency) justifying the conclusion (c).

6. Conclusions

We began with the claim that the Internet is a proactive, dynamic EA that is shaping our beliefs and worldviews. To justify this claim, we defined the sense in which the Internet is an EA and the methods it employs to shape our beliefs and worldviews. We also provided real-world examples resulting from the Internet's epistemic agency. Of course, much more could be said about the Internet and its role in shaping our views, but with the facts presented here, we believe that we have proven our case.

In the Introduction we stated that this discussion is an argument for the Internet epistemic agency, in a sense explained in the text. So, it would be only natural to ask now how its epistemic agency compares itself with other traditional sources shaping our beliefs. Is the Internet just one of them? Or, does it play a predominant, or not very critical, role in the game of worldviews? Did the traditional methods of shaping our beliefs lose their lustre? Or, who is the most important EA in the marketplace of ideas now? What are the role and the ratio of this influence in the full doxastic attitude map, compared to other EAs' influence? Or, what can we tell about the consequences of this influence? [12]

While we do not explore these questions in this study, we point to the selected sources that may be the starting point for such research. The hard quantitative data on the roles played by different EAs vs the Internet would be hard to find (the problem is rather difficult to quantify because of its multidimensionality and obtrusiveness), but one may look at several examples of the impact of the Internet on worldviews as compared to 'old', more traditional methods to see the efficacy of the Internet agency vs 'old agents'. See, for example, Gorodnichenko (2018) on an impact of social media on Brerix and US elections. See Cybenko et al. (2002); Wigmore (2017); Wylie (2019) ; Kaminska (2020) ; and Dabrowa (2020) on the impact of Cambridge Analytica on several political campaign across the world.

We have also left out from the study the discussion of causal pathways in which the Internet epistemic agency affects our worldview. But, as we have said, this is a task for clinical psychologists.

Here are a few additional takeaways from this discussion: (1) Large-scale mind control is nothing new, but the Internet has upped the ante to an unprecedented degree and made it Big Business. (2) Our epistemic agency is at the foundation of our autonomy and freedom, and we cannot afford to lose it, but the Internet as an EA has put our epistemic autonomy and ontological primacy at risk. (3) Our epistemic agency should be protected and guaranteed in law because it is a *sine qua non* for preserving democratic societies. (4) The Internet actively changes our worldviews, and this is an intentional act on the part of those managing the major Internet sys-

[12] Some questions in the list were suggested by an anonymous reviewer.

tems (GAFA (Google, Amazon, Facebook, Apple)[13] etc.). Protecting epistemic agency is crucial for further developing our scientific and technological civilisation based on the concepts of rationality and shared common values.

We need to continue asking questions about the Internet and its epistemic function if we do not wish to get lost in the information maelstrom of the Internet. We need to question how the Internet impacts the cohesion of our societies in terms of fracturing and reconfiguring our worldviews. Instead of shattering our commonality, can the Internet be used to promote shared understandings that foster common ground, collaboration, and cooperation? Can we create such shared interests with regard to epistemology and reality, such as things we all depend upon for our mutual survival and well-being? Does the notion and value of truth change with the Internet, and what will it be like in future? Of course, the list of possible questions is much more extensive.

References

Ahlstrom-Vij, Kristoffer. 'Why we cannot rely on ourselves for epistemic improvement.' *Philosophical Issues* 23, No. 1 (2013): 276–296. https://doi.org/10.1111/phis.12014

Allen, Mickeel. 'Technological influence on society.' Accessed March 2022. https://www.bctv.org/2019/11/07/technological-influence-on-society/

Anderson, Dan. 'Many tech experts say digital disruption will hurt democracy.' Accessed March 2022. https://www.elon.edu/u/news/2020/02/21/many-tech-experts-say-digital-disruption-will-hurt-democracy

Anderson, Janna, and Lee Rainie. 'Many tech experts say digital disruption will hurt democracy.' Accessed March 2022. https://www.pewresearch.org/internet/2020/02/21/many-tech-experts-say-digital-disruption-will-hurt-democracy/

Bienkov, Adam. 'Astroturfing: What is it and why does it matter?' Accessed February 2022. https://www.theguardian.com/commentisfree/2012/feb/08/what-is-astroturfing

[13] GAFA - An abbreviation for four Big Tech companies Google, Amazon, Facebook, Apple.

Botsman, Rachel. 'Dawn of the techlash.' Accessed March 2022. https://www.theguardian.com/commentisfree/2018/feb/11/dawn-of-the-techlash

Carr, Nicholas. *The Shallows: What the Internet Is Doing to Our Brains*. New York: W. W. Norton & Company, 2020.

Castells, Manuel. 'The impact of the Internet on society: A global perspective.' Accessed February 2022. https://www.bbvaopenmind.com/en/articles/the-impact-of-the-internet-on-society-a-global-perspective/

Cherry, Kendra. 'B.F. Skinner biography.' Accessed March 2022. https://www.verywellmind.com/b-f-skinner-biography-1904-1990-2795543

Clarke, Sean L. 'How the promise of the Internet was a lie.' Accessed March 2022. https://medium.com/@seanlandonclarke/how-the-promise-of-the-internet-was-a-lie-2c33736cbb6e

Crabtree, James. 'The Internet is bad for democracy.' Accessed March 2022. https://www.opendemocracy.net/en/article_822jsp/

Cybenko, George, Annarita Giani, and Paul Thompson. 'Cognitive Hacking: A Battle for the Mind.' *IEEE Computer* 35, no. 8 (2002): 50-56.

Dabrowa, Paul. 'Cognitive hacking as the new disinformation frontier.' Accessed April 2022. https://www.aph.gov.au/DocumentStore.ashx?id=b454cd90-d836-43c5-af27-05fea0cf8dd1&subId=692042

Damore, James. 'Google's ideological echo chamber.' Accessed April 2022. https://s3.documentcloud.org/documents/3914586/Googles-Ideological-Echo-Chamber.pdf

DataReportal. 'Digital around the world.' Accessed March 2022. https://datareportal.com/global-digital-overview#:~:text=A%20total%20of%205%20billion,12%20months%20to%20April%202022

Deloitte. 'Combating weaponized misinformation: Future of risk in the digital era.'Accessed March 2022. https://www2.deloitte.com/us/en/pages/advisory/articles/weaponized-information.html

De Mul, Jos. 'The informatization of the worldview.' *Information, Communication & Society* 2, no. 1 (1999): 69–94.

Defending Democracy. 'Defending democracy: Civil and military responses to weaponized information.' Accessed March 2022. https://libguides.uky.edu/breakingnews/weaponizedinfo

Dumbrava, Costica. 'Key social media risks to democracy. EPRS (European Parliamentary Research Service).' Accessed March 2022. https://www.europarl.europa.eu/RegData/etudes/IDAN/2021/698845/EPRS_IDA(2021)698845_EN.pdf

Dutton, William H., Ginette Law, Gillian Bolsover, and Soumitra Dutta. 'The Internet trust bubble: Global values, beliefs and practices.' Accessed March 2022. https://www3.weforum.org/docs/WEF_InternetTrustBubble_Report2_2014.pdf

Dvorak, John C. 'The false promises of the Internet.' Accessed March 2022. https://www.pcmag.com/opinions/the-false-promises-of-the-internet

Echo Chambers. 'Source watch.' Accessed February 2022. https://www.sourcewatch.org/index.php?title=Echo_chamber

Ecker, Ullrich K. H., Stephan Lewandowsky, John Cook, Philipp Schmid, Lisa K. Fazio, Nadia Brashier, Panayiota Kendeou, Emily K. Vraga and Michelle A. Amazeen. 'The psychological drivers of misinformation belief and its resistance to correction.' *Nature Reviews Psychology* no. 1 (2022): 13–29. https://doi.org/10.1038/s44159-021-00006-y

Elgin, Catherine Z. 'Epistemic agency.' *Theory and Research in Education* 11, no. 2 (2013): 135–152.

Ethics Center, The. 'Ethics explainer: The panopticon.' Accessed March 2022. https://ethics.org.au/ethics-explainer-panopticon-what-is-the-panopticon-effect/

European Parliament Directorate-General for Parliamentary Research Services, Brey, P., Gauttier, S., Milam, P. 'Harmful internet use. Part II, Impact on culture and society.' Accessed March 2022. https://data.europa.eu/doi/10.2861/391152

Fisher, Barbara J. 'Exploring worldviews: A framework.' *TEACH Journal of Christian Education* 6, no. 1 (2012): 50-56. https://doi.org/10.55254/1835-1492.1029

Frey, Thomas. 'Eight false promises of the Internet.' Accessed March 2022. https://futuristspeaker.com/business-trends/eight-false-promises-of-the-internet/

Funk, Ken. 'What is worldview?' Accessed March 2022. https://web.engr.oregonstate.edu/~funkk/Personal/worldview.html

Furedi, Frank. 'How the Internet and social media are changing culture.' Accessed March 2022. https://www.aspen.review/article/2017/internet-social-media-changing-culture/

GCF Global. 'What is an echo chamber?' Accessed March 2022. https://edu.gcfglobal.org/en/digital-media-literacy/what-is-an-echo-chamber/1/

Gibbs, Samuel. 'Facebook apologises for psychological experiments on users.' Accessed March 2022. https://www.theguardian.com/technology/2014/jul/02/facebook-apologises-psychological-experiments-on-users

Gorodnichenko, Yuriy, Tho Pham, and Oleksandr Talavera. 'Social media, sentiment and public opinions: Evidence from #Brexit and #USElection.' Accessed March 2022. https://doi.org/10.1016/j.euroecorev.2021.103772

Gray, Alison J. 'Worldviews.' *Journal of Psychiatry* 8, no. 3 (2011): 54–57.

Heaven's Gate. 'Heaven's Gate cult members found dead.' Accessed March 2022. https://www.history.com/this-day-in-history/heavens-gate-cult-members-found-dead

Herman, Edward S., and Noam Chomsky. *Manufacturing Consent*. New York: Pantheon Books, 1998.

Heshmat, Shahram. 'What is confirmation bias?' Accessed February 2022. https://www.psychologytoday.com/intl/blog/science-choice/201504/what-is-confirmation-bias

Hick, John. *Philosophy of Religion*. Englewood Cliffs: Prentice-Hall, 1990.

Huizer, Erick, Syed I. Shah, James Arroyo, Unoma N. Okorafor, and Rebecca MacKinnon. 'A brave new world: How the Internet affects societies.' Accessed March 2022. https://www.internetsociety.org/wp-content/uploads/2017/08/MeetingSummary.BraveNewWorld.pdf

Kaiser, Brittany. *Targeted*. London: Harper Collins, 2019.

Kaminska, Izabella. 'Cognitive hacking as the new disinformation frontier.' Accessed April 2022. https://www.ft.com/content/52535b2b-cb23-4ab6-ac66-2859cf9d1ae9

Kietzmann, Jan., Linda W. Lee, Ian P. McCarthy, and Tim C. Kietzmann. 'Deepfakes: Trick or treat?' *Business Horizons* 63, no. 2 (2020): 135–146.

King, Gary, Jennifer Pan, and Magaret E. Roberts. 'How the Chinese government fabricates social media posts for strategic distraction, not engaged argument.' *American Political Science Review* 111, no. 3 (2017): 484–501.

Kornblith, Hilary. *On Reflection.* Oxford: Oxford University Press, 2012.

LaFrance, Adrienne. 'The promise of a new Internet.' Accessed March 2022. https://www.theatlantic.com/technology/archive/2014/06/the-promise-of-an-alternative-internet/372501/

Lakoff, George, and Mark Johnson. *Metaphors We Live By*. Chicago: University of Chicago Press, 1980.

Matheson, Jonathan, and Kirk Lougheed. 'Introduction: Puzzles concerning epistemic autonomy.' In *Epistemic Autonomy*, edited by Jonathan Matheson and Kirk Lougheed, 1–19. London: Routledge, 2021.

Merriam-Webster Dictionary online. 'Astroturfing.' Accessed March 2022. https://www.merriam-webster.com/dictionary/astroturfing

Mineo, Liz. 'Surveillance is the business model of the Internet, Berkman and Belfer fellow says.' Accessed March 2022. https://news.harvard.edu/gazette/story/2017/08/when-it-comes-to-internet-privacy-be-very-afraid-analyst-suggests/

Monbiot, George. 'The need to protect the Internet from "astroturfing" grows ever more urgent.' Accessed March 2022. https://www.theguardian.com/environment/georgemonbiot/2011/feb/23/need-to-protect-internet-from-astroturfing

Moore, James W. 'What is the sense of agency and why does it matter?' *Frontiers in Psychology* 7 (2016). https://doi.org/10.3389/fpsyg.2016.01272

Morozov, Evgeny. *The Net Delusion: The Dark Side of Internet Freedom*. London: PublicAffairs, 2012.

Nilsson Johan. 'Shaping epistemic distance: Producing and withholding knowledge in market research.' *Journal of Cultural Economy* 14, no. 1 (2021): 101–116. https://doi.org/10.1080/17530350.2020.1772850

Nguyen, Thi C. 'Echo Chambers and Epistemic Bubbles.' *Episteme* 17, no. 2 (2020): 141–161. https://doi.org/10.1017/epi.2018.32

Nuwer, Rachel. 'For many people, going without the Internet even for a few hours is unthinkable. But if it did stop working, the impact might not be what you'd expect.' Accessed March 2022. https://www.bbc.com/future/article/20170207-what-if-the-internet-stopped-for-a-day

Olson, Dustin. 'A case for epistemic agency.' *Logos and Episteme* VI, no. 4 (2015): 449–474.

Pariser, Eli. *The Filter Bubble: How the New Personalized Web Is Changing What We Read and How We Think*. London: Penguin Books, 2012.

Pinxten, Rik. 'Worldview.' In *International Encyclopedia of the Social & Behavioral Sciences* (Second Edition), edited by James D. Wright, 753–757. New York: Elsevier, 2015. https://doi.org/10.1016/B978-0-08-097086-8.12228-7

Puzzo, Anrew. *Against Epistemic Agency.* (master's thesis , Queen's University, Kingston, CND 2015). Accessed April 2022. https://qspace.library.queensu.ca/bitstream/handle/1974/13727/Puzzo_Andrew_201509_MA.pdf;sequence=1

Ronson, Jon. *So You've Been Publicly Shamed*. New York: Riverhead Books, 2016.

Ross, Simone. 'Whatever happened to the Internet's promise?' Accessed March 2022. https://techonomy.com/whatever-happened-to-the-internets-promise/

Saeed, Kim. 'Loss of identity: Examples of perspecticide from narcissistic abuse.' Accessed March 2022. https://kimsaeed.com/2018/08/15/loss-of-identity-examples-of-perspecticide-from-narcissistic-abuse/

Schlosser, Markus. 'Agency.' Accessed April 2022. https://plato.stanford.edu/archives/win2019/entries/agency/

Snow, Jackie. 'Last year, social media was used to influence elections in at least 18 countries.' Accessed March 2022. https://www.technologyreview.com/2017/11/14/3847/last-year-social-media-was-used-to-influence-elections-in-at-least-18-countries/

Snowden, Edward. *Permanent Record*. New York: Metropolitan Books, 2019.

Somers, Meredith. 'Deepfakes, explained.' Accessed March 2022. https://mitsloan.mit.edu/ideas-made-to-matter/deepfakes-explained

Specktor, Brandon. 'Is the Internet changing the way people feel about religion?' April 2022. https://www.livescience.com/61439-internet-use-changing-religion-tinkering.html

Steup, Matthias, and Ram Neta. 'Epistemology.' Accessed May 2022. https://plato.stanford.edu/archives/fall2020/entries/epistemology/

Sustain, Cass. 'Is social media good or bad for democracy?' Accessed March 2022. https://sur.conectas.org/en/is-social-media-good-or-bad-for-democracy/

Richardson, James T. 'Doomsday cult.' In *Encyclopedia of Religion and Society*, edited by William H. Swatos Jr. , Hartford: Altamira Press, 1998. Accessed March 2022. http://hirr.hartsem.edu/ency/doomsday.htm

Visel, Dan. 'Horseless carriage.' Accessed March 2022. http://futureofthebook.org/blog/tag/horseless-carriage-metaphor-dymaxion/

Voelz, Glenn J. *Rise of Iwar*. New York: Strategic Studies Institute, 2015.

Waltzman, Rand. 'The weaponization of information: The need for cognitive security.CT-473. Testimony presented before the Senate Armed Services Committee, Subcommittee on Cybersecurity.' Accessed March 2022. https://www.rand.org/content/dam/rand/pubs/testimonies/CT400/CT473/RAND_CT473.pdf

Witness. 'Backgrounder: Deepfakes.' Accessed March 2022. https://www.mediafire.com/file/de9zn618yxr0xzy/Backgrounder_Deepfakes_202103_EN.pdf/file

Wu, Tim. *The Attention Merchants*. London: Atlantic Books, 2016.

Weinberger, David. 'The Internet that was (and still could be).' Accessed March 2022. https://www.theatlantic.com/technology/archive/2015/06/medium-is-the-message-paradise-paved-internet-architecture/396227/

Wigmore, Ivy. 'Cognitive hacking.' Accessed March 2022. https://whatis.techtarget.com/definition/cognitive-hacking

Windholz, George. 'P. Pavlov: An overview of his life and psychological work.' *American Psychologist* 52, no. 9 (1997): 941–946.

Wood, Michael J., and Karen M. Douglas. 'Online communication as a window to conspiracist worldviews.' *Frontiers in Psychology* no. 6 (2015). Accessed March 2022. https://www.frontiersin.org/article/10.3389/fpsyg.2015.00836

Wylie, Christopher. *Mindf*ck*. London: Profile Books, 2019.

Zhang, Zhen, Jianxin Zhang, and Tingshao Zhu. 'Relationship between Internet use and general belief in a just world among Chinese retirees.' *Cyberpsychology, Behavior and Social Networking* 16, no. 7 (2013): 553–558. https://doi.org/10.1089/cyber.2012.0542

Zuboff, Shoshana. *The Age of Surveillance Capitalism: The Fight for a Human Future at the New Frontier of Power*. London: Profile Books, 2019.

Technological Evolution and the Political Agency of Artificial Intelligence from the Perspective of General Organology and Universal Organicism

The question of political agency with respect to artificial intelligence (AI) is becoming increasingly relevant insofar as we can observe efforts to regulate it. Some policy proposals link the problem of the advance of AI to the concept of technological evolution. However, it is still not quite clear what they mean by this concept. This paper explores conceptualisations of technological agency and evolution in Bernard Stiegler's general organology and Friedrich Schelling's universal organicism. I argue that organicism proposes a more 'naturalised' approach to agency formation and a more 'organic' explanation of technology than general organology. General organology considers technological evolution from a human perspective, whereas universal organicism can accommodate a theory of technological evolution independently from its social dimensions. While technology already has a strong impact on the organisation of our societies, recognition of technological agency as at least partially independent serves to recognise them as non-human beings that impact politics.

Keywords: *AI, agency formation, technological evolution, potency of matter, organology, organicism*

Acknowledgement

I thank Iain MacKenzie and Ben Turner whose feedback have shaped this paper. I am also grateful to Conor Heaney for his support over the writing process. I also thank the organisers of the third Budapest Workshop on Philosophy of Technology 2021 for all the work they have done to make this great event happen despite the pandemic.

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How to cite this article:

Kwapińska, Kamila. "Technological Evolution and the Political Agency of Artificial Intelligence from the Perspective of General Organology and Universal Organicism". *Információs Társadalom* XXII, no. 2 (2022): 57–71.
https://dx.doi.org/10.22503/inftars.XXII.2022.2.4

Politics of Artificial Intelligence (AI)

Technical and social milieus are now densely entangled. However, the political implications of relationships between humans and AI are still unclear. Although new technologies are being integrated into societies with the sense of awe and excitement that typically accompanies scientific discoveries that can improve human productivity, we also can observe a change in political attitudes that counters such optimistic views. This change in attitude comes not from within 'green politics', which has a tradition of being against the excessive use of technology – often anti-growth and anti–natural extraction, but from the capitalist, technocratic spectrum. In 2016 Obama's administration published two reports on *Preparing for the Future of Artificial Intelligence* where we can read a consideration of evolutionary methods in defining AI (U.S. Executive Office of the President National Science and Technology Council Committee on Technology 2016, 7). AI is presented as something that should be regulated precisely because it could be risky to leave it to intertwine with societies spontaneously. Interestingly, this rhetoric strengthens in the *Artificial Intelligence Act* published by the EU Commission in 2021. The proposal acknowledges that AI 'is a fast-evolving family of technologies' and while it aims to safely integrate them into 'a wide array of economic and societal benefits across the entire spectrum of industries and social activities', it also highlights 'the new risks and negative consequences for individual and societies' (EU European Commission 2021, 2). This legal framework encompasses a flexible set of mechanisms to 'enable it to be dynamically adapted as the new technology evolves and the new concerning situations emerge' (European Commission 2021, 4). It might be too early to say that there is a consensus across the political spectrum on the urgency of the politics of AI or defining technological evolution, but we can no longer deny that such politics or definitions are necessary.

The question is – how should we conceive of the politics of AI? I argue that to talk about such politics we have to first consider the agency of AI, and it is worth theorising it from the perspective of technological evolution since this narration is already present in the legal pieces produced by Obama's Whitehouse and the EU. Conceptualising the agency of AI does not aim to take away legal responsibility from those behind its design and implementation. Future civilisational development is as much dependent on technology as technological evolution is dependent on humankind. It is paramount that we analyse the agency of AI and technological evolution in a quasi-independent way. Policymakers seek to regulate not only creators or traders of technology but also AI itself. Regulations should account both for people's responsibilities and for the technological agency to effectively manage the organisation of future societies.

In this political context the organic approaches – in this paper I consider Bernard Stiegler's general organology and Friedrich W. J. Schelling's universal organicism – hold strong explanatory value. They both consider how different levels of organisation (e.g., biological and technical) impact each other, and are concerned with how agency can emerge in such processes. They are distinctive for two reasons. Firstly, they view agency as something that is *not opposed* to nature, either through

the sacred (given by a divine, supranatural source), the social (socially constructed) or through the technological (technologically created intelligence) insofar as it is constituted *with* nature. In organology, agency has a psychosocial-technical-natural cause where these three levels constitute the same plane (Stiegler 2017, 130). In organicism, it simply has a natural cause (Grant 2008, 162). Similarly, technology is considered as having a natural origin. Organology goes beyond the traditional approaches to technology in humanism, post-humanism, and transhumanism because it does not take technology to be distinct from human nature. Therefore, it is neither techno-optimist like transhumanism nor techno-pessimist like post-humanism (Stiegler 2020, 313). It simply takes technology to be a natural and evolutionarily contingent part of life. Organic approaches also reject techno-theism, which treats technology as a universal political project. Any political agenda that is based on a belief that technology will save us by improving the agency of humanity *against* the forces of nature is based on a false assumption that technological development can transcend nature. Secondly, they both offer an evolutionary approach to technology. While legislative proposals regarding technological development depict AI as if it undergoes evolutionary processes, there seems to be no clarity regarding what it means. This paper addresses the process of agency formation from an evolutionary perspective. It examines how technicity participates in the evolution of humankind, and whether we can consider technological evolution autonomously from humans. Organic approaches look at evolution through the notion of organisation. How does technology influence the trajectory of evolution through the organisation of systems that they embody? How do the different levels of political life – the psychosocial, natural, and technical impact organisation of societies? We can find answers to these questions in how technology relates to the potency of matter in the evolutionary processes. Organic approaches provide theoretical frameworks to consider the intersection of matter, evolution, and technology with regards to processes of organisation in a system. While general organology explains how human evolution and a process of agency formation are always technically conditioned, universal organicism gives theoretical space for consideration of the agency of AI and technical evolution that is autonomous from humans. This paper argues that universal organicism is better suited for consideration of organic evolution of technicity as it allows for conceptualisation of the agency of non-human beings.

General Organology and the Agency of AI

The question of agency is not the focus of general organology, but it provides a theory of the formation of autonomy. For Stiegler, autonomy can be defined only in relationship to the concept of heteronomy. He writes that there is 'no autonomy other than as the adoption of heteronomy' (Stiegler 2013, 25). Autonomy is constantly composed of heteronomy (Stiegler 2013, 2). This is because general organology emphasises that we cannot consider a subject outside of its ground of becoming – a subject is always dependent on the technical condition of a milieu. General organology can be defined as 'a method of thinking, at one at the same time technical, social, and psychic becom-

ing, where technical becoming must be thought via the concept of technical system as it adjusts and is adjusted to social systems, themselves constituted by psychic apparatuses' (Stiegler 2017, 130). Therefore, we can understand heteronomy as a technical condition of becoming in a social system. General organology views social, natural, and technical processes as constitutive for human and technical evolution. At some point of history, retention of knowledge (and memory) began to 'operate *outside* of living organisms themselves, neither in their genes nor in their brains but in artefacts', which is referred to as a process of exosomatisation (Bishop and Ross 2021, 113). Evolutionary biological (endosomatic) organogenesis is accompanied by exteriorisation of non-biological (exosomatic) organs – technical prosetheses (Bishop and Ross 2021, 117). In Stiegler's thought the formation of autonomy has to be defined in relation to these dependencies. For a becoming subject, autonomy and heteronomy have a relationship of composition rather than opposition (Stiegler 2021, 242). Agency emerges as a transformation of the adoption of dependencies, in which the subject *acts as cause in this process*. A subject gains agency by adopting a technical dependency 'on the condition ... that it is adopted intelligently, reflexively and with care' (Lemmens 2017, 292). If autonomy is necessarily related to dependencies, then agency is not the self-standing attribute of an agent but must be part of the processes of causation that cannot be separated from its organological plane of becoming. This specific understanding of the emergence of agency opposes the view that it is gained as an *effect of* a supranatural force that is external or transcendent to it. Nevertheless, the organological mode of thinking rejects the idea that the technological in itself can act as a cause for a transformative, and therefore singularising, process that could lead to agency formation.[1] Even if it views the technical level as parallel to the natural and the social, the specificity of social becoming makes it impossible for AI to engage in the formation of autonomy.

There are two tendencies of social becoming. The first one, drive, provokes dependence and is shaped by short-circuits. The second one, desire, is curative, adopts dependencies into autonomy, and is shaped by long-circuits (Stiegler 2013, 25). Processes of adoption, leading to singularisation, are defined only by the curative long-circuits of desire which give meaning to life. Desire, a process of meaning making, amounts to 'symbolic practices that maintain symbolic techniques and technologies' (Stiegler 2014, 12), which in turn shape modes of existence. Hence the process of desire has to create symbolic meaning with enough of a difference to support singularisation. Although desire is a natural part of life for a human subject, Stiegler argues that it is impossible for AI. AI is ingrained in the short-circuits of informational and communication technologies which are based on calculability. In contrast, singularity, as Stiegler argues, is 'in essence that which cannot be compared to anything else – is irreducibly incalculable' (2014, 12). Technologies which categorise singularities, that is, reduce them to the calculable, can only simulate actual processes of desire or drive. Therefore, information-based technologies such as AI can only provoke dependence.

[1] In Stiegler's perspective singularisation is different from how transhumanist approaches define it. Singularisation can be read as individuation through objects of desire, which has no proximity to Ray Kurzweil's definition of singularity. For Stiegler there are two types of singularity: 'infinite and incalculable objects projected by interpersonal caring and its technologies' (such as art, justice, virtue) and 'parental and educational "cultivation"' of people (Lampe 2017, 4).

However, technics as such do not disable the possibility of establishing curative structures. For Stiegler, all human practices are embedded in technics, here understood as transmitters of knowledge that exist on a pre-individual level. For example, a process of singularisation like a spiritual ritual is a form of technical memory that can form subjectivity. Spiritual technics can result in a singularising experience insofar as they can enable consistencies through sacred objects (Turner 2019, 57).[2] Idealisation of sacred objects causes processes of desire that transform an existence. Idealisation is a form of infinitisation of an object in relation to which a finite existence is defined. An existence singularises by relating to a sacred object of desire which is idealised (for example through a relation of one's love towards god.) The problem of AI not being able to singularise lies not in its technical ground per se but in the incapacity for entering the plane of consistence through desire, and the inability to participate in the process of socialisation that accompanies transformative, transindividual processes. Subsequently, *AI does not exist; it only subsists*. Stiegler defines existence as singularisation, which means agency formation through relation to objects of desire. The problem of AI is situated not in its technicity but in the incapacity for entering the plane of consistence that is *dialogical*.

The machine could not have been constructed without the transmission of knowledge; however, it does not mean that AI can engage in dialogue. Stiegler emphasises the social aspect of logos: '*logos* is always *dia-logos* within which those who enter the dialogue co-individuate themselves – trans-form themselves, *learn* something – by dialoguing' (Stiegler 2013, 18). This is important insofar as the dialectical character of logos in Stiegler's thought contributes to the formation of social organisation. Circuits of transindividuation (meaning a transmission of knowledge) are 'formed in dialogism' (Stiegler 2013, 68). Technical objects participate in social life through organological relationships, yet AI does not socialise. Its participation is receptive, not dia-loguing, and it does not transform it. Stiegler argues that as soon as logos is involved in the industrialised form of desire it becomes a reason in the form of a calculation – a *ratio* (Stiegler 2013, 61). The knowledge that it bears does not bring new meaning and does not rearrange the dependencies that might constitute its socialisation. AI can transmit knowledge, but it does not learn by co-individuation, it does not participate in socialising, and it cannot transform with desire.

AI has no capacity to create a meaningful, transformative difference to a socio-political system. It has no agency in organisational processes. Stiegler emphasises that it is always the social that is the organisational level:

> General organology defines the rules for analysing, thinking, and prescribing human facts at three parallel but indissociable levels: the psychosomatic, which is the endosomatic level, the artifactual, which is the exosomatic level, and *the social, which is the organizational level.* [emphasis mine] It is an analysis of the relations between organic organs, technical organs, and social organisations (Stiegler 2017, 130).

[2] In Stiegler's thought such objects of desire are not limited to religious objects.

The inability of AI gaining agency comes down to the capacities of processes that it performs but are constrained by its matter. We can see the extension of this argument – *only the social remains as the organisational plane of a system that is capable of transformation and making a difference* – in how Stiegler systematises the organological functions of matter in evolution. Processes of social evolution are here understood as the transmission of knowledge across generations that in the context of technological evolution can be formulated as the potency and organisation of matter. The potentiality of matter 'makes possible the constitution and accumulation of a hyper-material memory' (Stiegler 2020, 279). As indicated beforehand, technics and technology serve as transmitters of knowledge (as a form of exteriorised memory) in processes of transindividuation. They are epiphylogenetic – in addition to genetics and epigenetics. From this perspective, hyper-materialism distinguishes between four different types of matter:

1. Inert or inorganic matter (steel, silicon etc.);
2. Organic matter (organic, endosomatic organs);
3. Organized inorganic matter; (robots, AI, exosomatic organs, and artifactual level of evolution, etc.);
4. Disorganized and reorganized matter ('human brain and body, educated and trans-formed by social artefacts, along with those plants and animals that have been created through agricultural selection'). (Stiegler 2020, 279)

Matter is here viewed through its potential to support memory transition in evolution; however, inorganic matter is classified from the perspective of human evolution. AI is a form of organised inorganic matter which takes part in processes of evolution as an exosomatic organ. The potentiality of its matter plays a role in evolution only insofar as it shapes other forms of matter, such as disorganised and reorganised matter, via the social level of organisation. They have no capacity to organise but through the social. Technics are instrumental – they are a tool for the transmission of knowledge which conditions evolutionary processes – but do not have an autonomous agency. In general organology the technical organ is always an organ, a tool, rather than the organisational. This is not to say that it cannot have a strong influence on the trajectory of human evolution. It has influence, but not agency.

Stiegler's hyper-materialism aims to reject a conventional, substantial understanding of matter. He dismisses Aristotelian hylomorphism by moving away from a distinction between form and matter (Stiegler 2020, 269). Hylomorphism, from its definition, is a schema that treats form and matter as separate aspects that constitute an object. 'An object's final cause, its function determines what a thing is for and (…) represents not only the functional telos of technical artefacts but can be seen in the telos of the natural world' (O'Hara 2019, 226–227). In hyper-materialism, instead of being shaped into form by its final cause, telos (its function), matter 'makes possible the constitution and accumulation of a hyper-material memory' (Stiegler 2020, 269). Hyper-matter can actively form matter, as a transmitter of information, thereby contradicting the hylomorphic schema. This active potentiality of matter plays a certain role in evolution, as it accumulates memory. We can especially see this in the example of organised inorganic matter that is materialised

technics (Stiegler 2020, 269). Moreover, according to Stiegler, technics condition human becoming on an individual level (psychic individuation processes), but also support processes of collective individuation in which case we can view technics to be a complex exorganism. The complex exorganism is the collection of 'systematically cohering simple organisms' (Ross 2018, 272). 'For the simple exorganism that we are, this exterior milieu amounts to the psychosocial milieu of the collective individuation processes to which we belong' (Ross 2018, 272). The complex exorganism conditions collective and technical transindividuation at the same time as possessing possibilities set up by that environment (Ross 2018, 272). Technics take part in the evolutionary interplay between natural, psychosocial, and social levels. While technics condition evolutionary processes of systems that they embody, it does not seem that technological evolution can be considered independently from human evolution.

The interpretational limitations of general organology for understanding the agency of AI therefore present themselves as follows:

1. Agency can only be conceived of as human.
2. AI only subsists.
3. The potency of hyper-matter is limited to its undertakings in human evolution.

Having these limitations in mind we can now move on to *universal organicism* to establish how they can be overcome by a different organic approach.

Universal Organicism and Processes of Agency Formation

The crucial difference between general organology and universal organicism lies in how the core concept for these philosophies – an organ – is defined. Where in organology we could only find a physical organ, in Schelling's organicism an organ is both physical and metaphysical. The concept of universal organism in Schelling's philosophy can be read as a name for the whole system of nature and an organ is understood as anything in that system of nature. An organ is any element constitutive of the universal processes of becoming. In German Romanticism the Aristotelian *organum*, instead of being a tool, became an *organic formative force* (Weatherby 2016, 6). An organ passes knowledge around a system, but at the same time it modulates the system in accordance with changing functions in the recursive process of re-creation (actualisation) of the universal organism.[3] Metaphysically, an organ is what Yuk Hui calls *the third.* It is the point in which we can see unity and difference as

[3] In Schelling's thought we can differentiate three types of knowledge. Transcendental knowledge is a form of complete abstraction; it is a knowledge of knowledge in which mind struggles to establish itself as an object of thought, therefore being unreal and unattainable. The second form of knowledge is epistemological and concerned with perception of things and ideas. The third type of knowledge is a synthesis of the two previous ones, what he calls an Intellectual Intuition, where the universal and the individual give us possibility to grasp complex facts. In Schelling's philosophy of nature, we can view the universal aspect of knowledge as the original evolving and productive force of nature which results in the concrete objects for thought (ideas, things) of natural products (Dewing 1910, 159–162). Knowledge being passed around the system of nature relates to any productive component of communication between its parts; it can be viewed as a necessary force for evolutionary unfolding of the system.

one, where 'oppositions are considered [non-dialectically] (…) as the motor towards resolution, as what drives the ascent to a higher order of organisation' (Hui 2016, 77). An organ is therefore not only physical – real organic matter that emerges due to chemical, and electromagnetic forces – but also metaphysical – the principle of the construction of matter itself (Hui 2016, 80). An organ is not in addition to a level of organisation as in general organology; the structure of the system itself is composed by organs. Organs must relate to a universal organism through their functions; however, they are not simply bearers of their functionality. They also prevent a system from resolution into chaos/disorder, as they provide a system of correlations that facilitates the transmission of knowledge. The principle of organisation is the *continuity of organic functions* (Schelling 2004, 53). As Schelling frames it: 'the actuality of the dynamical process for every individual product is conditioned by communication, which takes place in the universe to infinity' (Schelling 2004, 186).

The second decisive difference can be found in the concept of nature and its productive forces. For Schelling, nature is the encompassing, universal term in which the social and the technical are included rather than being viewed as parallel systems. Nature acts as a cause and effect of itself (Hui 2019, 63). Because of that we can theorise a more natural and less rigid approach to the process of agency formation; both organic and inorganic matter have the potential for self-causation in evolutionary processes as they embody the same natural productive forces. In contrast, for Stiegler different forms of matter anticipate their role within evolution depending on their material basis. An emphasis on the material medium for technics translates into how processes of evolution unfold, as the transmission of knowledge is dependent on the potentialities of the type of matter by which it is transferred. Schelling argues that matter and all other natural products (such as technical drive) have an immaterial basis. The self-construction of matter relies on processes of communication that run through a system of nature. The formation of agency is not reducible to matter itself (Grant 2008, 13). Agency is no longer attributed to a rigid object (Grant 2008, 8) but is established structurally in relation to overall natural productivity. It is associated with activity that grounds it through natural productivity; as a non-somatic action, it is a condition of intensification in a broader system. A process of agency formation happens in the process of recreation of a natural product in actualisation of a system of nature, and therefore it can be manifested even in a simple struggle to self-preserve. This de-somatisation of the process of agency formation in universal organicism overcomes constrictions of matter that we can observe in Stiegler's thought. However, in universal organicism self-production of matter is also limited to some extent. Matter shows its autonomy only insofar as it is constrained by the organisation of a system. The environment sets possibilities of its becoming. If in general organology autonomy is always an adoption of heteronomy, in universal organicism we can also never experience an absolutely independent body or action, as each organ(ism) is always determined by processes of the universal organism.

A natural understanding of agency can be also found in how Schelling understands matter as non-rational but something which *desires* through its inherent intensity of self-creation.

> Indeed, everywhere where there is appetite and desire, there is already in itself a sort of freedom; and no one will believe that desire, which determines the ground of every particular natural being, and the drive to preserve oneself not in general but in this defined existence, are added on to an already created being, but rather that they are themselves that which creates. (Schelling 2006, 43)

Nothing *subsists* in nature (Schelling 2004, 18), as everything becomes by desire of difference. Every component of the system of nature is treated as having organisational capacities insofar as difference necessarily changes the structure of the system. Such change sets the possibilities of becoming for the environment to which the rest of the system has to adjust. Although there are different degrees of potentiality of matter and its organisational capacities, metaphysically the model of becoming is the same – a recursion from difference to difference to allow the system to ascend to a higher level of organisation. In general organology, subsistence means reproduction with no meaningful difference in which productivity as such is not enough to exist. For Schelling, a technical drive to infinitise is not processually different from humans' desire as both have the same structure and natural genesis. They might be qualitatively different, but its finite form can only act as a difference from the infinity of natural production. In this view every actualisation of AI in each single moment is a manifestation of the infinite productivity of nature limited by its existence.

In universal organicism we can conceptualise technological evolution that is natural and at least partially autonomous from human evolution. A formative autonomous drive of self-creation towards autonomy can be both organic and technical. Organic and technical processes are also always co-dependent and complement each other. For example, *mechanism* is a necessary part of evolution. Schelling explains evolution as a product of nature's productivity, which creates an infinity of multitudes (dispersion of nature). A product of nature is in a constant state of formation, in an infinite metamorphosis. Progress requires a unification of contradiction; an evolution is always also accompanied by involution. Involution is a contractive force – it is an infinity of a mechanical aggregation in nature (Schelling 2004, 187). For example, it can be seen at play in the formation of one organism through the impact of the mechanical forces of the environment on a body (externally) but also mechanical processes in a body (internally.) However, in no moment of time can we distinguish these two forces absolutely and treat them as separate determinants (Schelling 2004, 187). Schelling writes that 'for the moment, a being only conceived in evolution – [is] a being oscillating between evolution and involution' (2004, 188). According to Hui, in Schelling 'mechanism is a "regressive series of causes and effects"' (2016, 80). Mechanism is a generalisation of all mechanical forces of nature that impact organic sensibility and epigenesis in processes of formation. This understanding of mechanism comes from natural evolutionary productivity. It is a necessary part for evolutionary progression; however, this progression is not necessarily limited by any social processes. Schelling also writes about a natural, technical drive that can be illustrated as a process of crystallisation (Schelling 2004, 135). Schelling associates the technical drive with products of nature from inorganic matter to animals. It is

worth noting here that he disputes Cartesian definitions of animals as machines precisely because of their sensibility (Schelling 2004, 136). Sensibility is a predominant tendency in an animal that balances out the regressive mechanical forces. It is an important point to take for theorising agency with respect to non-human beings. In a universal organism there are no absolute distinctions between inorganic/organic matter, technical/organic drives, autonomy and dependency. An emphasis on the independent functionality of beings, their capacity to self-create, is a measure of their autonomy within a system. This autonomy does not grow proportionally with the measure of sensibility, as purposiveness is also present in a technical drive. Here, these abilities are also given to non-human and even inorganic beings.

Universal organicism broadens what actions can be understood as purposive and partially autonomous through the formative drive and organisational effects of the non-organic, which includes the technical tendencies. In contrast to Stiegler, Schelling argues that self-formation is caused by an agent without participation in the social. Universal organicism grounds agency formation in nature to a further extent. Self-creation, desire, and drive are not understood as exclusively human. AI can have organisational consequences for systems in which it is present as it possesses a form of non-human agency. So, can we claim that AI exists, without submitting to the fear of it taking control over people in some dystopian scenario? A purposeful existence of inorganic matter does not necessarily pose a threat to humanity but, rather, makes us aware that natural systems cannot really be without it. Nature as a system including inorganic matter survives because it can purposefully and creatively adjust as it struggles to self-preserve. An increase of sensibility does not mean a decrease of technicity. A non-human agency does not necessarily deconstruct what it means to be a human. By moving away from the socially supported process of agency formation that characterises Stiegler's thought, Schelling's philosophy overcomes the three limitations of general organology outlined at the end of the previous section. The response can now be formulated as follows:

1. Non-human beings have agency.
2. AI can exist.
3. The potency of matter is metaphysical, but we can observe it in any form of productivity of nature (natural production of difference).

We should therefore consider universal organicism as a complementary theory to general organology. Stiegler's thought discusses the natural, technical human condition and Schelling's philosophy can help us conceptualise this form of technicity in nature that shapes the autonomous agency of AI.

A Natural Approach to Technology

As the outlined current socio-political context shows, it is necessary to conceptualise the agency of AI and its evolution now even if only to regulate it with a clear understanding. We have to recognise its agency and semi-autonomous development because it already has a strong impact on how our societies and ecosystems organise. Humanism, which is concerned with the issue of whether AI is different from

or similar to our minds, or when it will become so, presents a counterproductive narrative. There is an underlying assumption that its artificiality is what is stopping it having agency in socio-political life. Natural and evolutionary approaches to technology overcome the gridlock of humanist analysis. Although general organology lays analytical tools for understanding technology from evolutionary and natural perspectives, and the social as always necessarily technical, it still follows the tendency to associate agency exclusively with human beings. Schelling's organicism suggests that the system of nature should always serve as a centre of analysis and that we can theorise a non-human agency in such a context.

Humanist theories seem to have reached an impasse with regards to technology. Conversations around how technology can transcend our human and natural limitations or how it can destroy our humanity treat technology as an alienating product that must necessarily alter the essence of our existence. It is true that technological development changes how we interact with each other and nature; however, we tend to forget that technology is a part of the system of nature. I argue that it is worth moving away from humanist approaches to technology that view humans as a centre of this discussion and that instead we should place there a system of nature understood as the encompassing ground for all forms of existence. General organology and universal organicism are examples of such theories; however, we can link them to other approaches, for instance cybernetics and James Lovelock's Gaia hypothesis. In his view the earth is a self-regulating (or self-organising) system in which the organic and the inorganic are equally important; tightly connected by exchanges of information, the regulation is done by 'the whole thing, life, the air, the oceans, and the rocks' (Lovelock 2000, XV). I believe that Lovelock's understanding of the natural system and the vital role of its regulation by inorganic and organic matter can be read as a description of reality in which technology has the agency to affect life without a necessary mediation through the social and the human. Taking natural systems as self-regulating should not, however, be read as an attempt to mystify nature. This was the main criticism of Gaia's theory, which stopped it from being taken as serious science despite a number of peer-reviewed journal publications that accompanied the pop-scientific version (Lovelock 2000, XVII). Taking nature as the ground of all becoming, as this paper proposes, is an invitation for constructive evolutionary theories that can accommodate an understanding of the agency of AI as a non-human being. Although organicism and organology have some foundational similarities with cybernetics, they should be taken as distinctive theories because they describe processes of organisation in different ways. In my view, organicism suits theorising political issues better than cybernetics as an organic approach to reality is less limited to machinic descriptions.

Following Hui's works, we can also see that organic approaches contribute to the scholarship on the issues of AI by redefining how should we understand intelligence (2021, 340). Hui argues that intelligence should be understood as a recursive and reflective movement that can overcome the contingency of reality. Such an understanding of intelligence is organismic rather than mechanistic, because reflection can resolve accidents that are not prescribed within the rules of algorithms. Hui emphasises that this type of recursivity amounts to new epistemology, where intelli-

gence derives 'its own rules from empirical facts instead of depending on hardcoded rules: it does not simply apply the universal to the particular' (2021, 344). This understanding of intelligence overcomes the dualism that has shaped the criticism of machines 'since the eighteenth century[,] namely the irreducible differences between mechanism and organism' (Hui 2021, 342). Organic, recursive intelligence was introduced by the cybernetic paradigmatic change by Norbert Wiener (2021, 342). According to Hui, it is this move that is characteristic of change between weak AI and strong AI – the change from the linear mechanic reasoning of AI that lacks reflective judgement (e.g., Turing machine) to the one that recognises the 'multiple orders of magnitude, for example, (…) the structural coupling between the artificial intelligence simulated by the Turing machine and the world outside of it on the other' (2021, 344). Organic approaches that are here introduced demonstrate such a recursive understanding of intelligence on multiple orders; however, they cannot be equated with cybernetics.

In general organology we could see that circular movement of intelligence in the process of agency formation when the short-circuits and long-circuits of social becoming recur between the becoming subject and the contingencies of life, while only the adoption of technical dependencies can lead to a process of singularisation. The recursion also takes place in the technically conditioned evolution in the process of exteriorisation of memory into technological objects (external organs) that then in turn support the processes of collective transindividuation serving as transmitters of knowledge (Hui 2021, 350). This is also the reason why the organic philosophies are useful in explaining the political dimensions of technological evolution. As Hui notes after Simondon, in the recursive movement technology is shaped by political regulation, but it also in turn transforms the social reality of everyday life (2021, 341). In Schelling's universal organicism the totality of nature (reality) is constructed in a recursive process of nature's productivity, and everything (including intelligence) is shaped by that process. As argued above, the communication and knowledge about the system of nature flows through all of its levels, from organ to organ, where each of them can be viewed as any constitutive component of a system. Perhaps, if we follow Hui's interpretation, such broad understanding of intelligence in natural actants, like plants and animals, is weak because it operates on a poorer symbolic level (2021, 350). Nevertheless, Schelling's recursive notion of agency formation in nature that is based on a process of communication between organs is enough to claim that such non-human agency is at all possible, even if it demonstrates a minimum degree of what we could conceive of as intelligence while applying the criteria of how well contingency can be overcome.

Conclusions

General organology and universal organicism do not view agency as something supranatural. Agency is constructed by an agent in relation to the dependencies of a milieu. Although in Stiegler's interpretation agency is formed specifically in social processes of transformation, the social level of becoming cannot be dissociated from

the natural and the technical. Nevertheless, it is the social level that can produce a difference which changes the organisation of a system and so it is the organisational level that possesses agency. In Schelling's interpretation, all orders of nature (including technical and metaphysical) have organisational capacities and produce difference. Any form of matter has the potential to develop agency irrespective of what level it engages in. Universal organicism proposes a 'naturalised' approach to agency formation and a more 'organic' approach to technology. This is especially due to its conceptualisation of an 'organ' which, instead of being a tool, the exterior organ of a human, provides a structure of universal organism. Any form of matter is conceived of as an independent agent in the construction of the entirety of a system, and the intensity of natural forces precedes processes of materialisation. In this radically naturalised approach, the capacity of agency formation and 'existence' is a possibility for any form of being, regardless of their engagement in social practices.

This paper's exploration of conceptualisations of agency formation and technological evolution in organic philosophies is to present them as practical frameworks with respect to analyses of the contemporary world. Organic philosophies here discussed take technology as a natural fact of life. They recognise the role of technology in shaping social reality but do not automatically fall into techno-theist or techno-phobic tendencies. From the perspective of organic approaches, it is no longer helpful to theorise the social, the natural, and the technological as separate domains, if we want to account for the political consequences of AI. Although in this paper I have outlined some of the theoretical limitations of general organology, it is nevertheless a valuable position to employ when elucidating questions regarding the politics of technology precisely because it exposes how the human process of agency formation is always technically conditioned. General organology as a theory focuses on how the technical undertakings of human evolution can erode the structure of social organisations and the environment, and in my opinion it is the best contemporary philosophy that explains that. However, as it does not recognise the possibility of the agency of AI, I argue that a Schelling-inspired form of universal organicism is better at explaining the issue of the evolution of technological objects (such as AI) that are at least partially autonomous. We should therefore use these organic approaches separately or complementarily to one another, as explanatory frameworks for the specific issues.

References

Bishop, Ryan, and Daniel Ross. 'Technics, time and the internation: Bernard Stiegler's thought – a dialogue with Daniel Ross.' *Theory, Culture & Society* 38, no. 4 (2021): 111–133. https://doi.org/10.1177/0263276421990435

Dewing, Arthur. 'The significance of Schelling's theory of knowledge.' *The Philosophical Review* 19, no. 2 (1910): 154–167. https://doi.org/10.2307/2177793

EU European Commission. *Proposal for a Regulation of the European Parliament and of the Council Laying Down Harmonised Rules on Artificial Intelligence (Artificial Intelligence Act) and Amending Certain Union Legislative Acts*. 2021/0106 COD, 2021. Accessed 05.02.2022. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0206

Grant, Iain Hamilton. *Philosophies of Nature After Schelling*. London and New York: Continuum International, 2008.

Hui, Yuk. 'Algorithmic catastrophe – Revenge of contingency.' *Parrhesia* 23 (2015): 122–143. https://parrhesiajournal.org/parrhesia23/parrhesia23_hui.pdf

Hui, Yuk. 'The parallax of individuation: Simondon and Schelling.' *Angelaki* 21, no. 4 (2016): 77–89. https://doi.org/10.1080/0969725X.2016.1229427

Hui, Yuk. *Recursivity and Contingency*. London: Rowman & Littlefield International, 2019.

Hui, Yuk. 'On the limit of artificial intelligence.' *Philosophy Today* 65, no. 2 (Spring 2021): 339–357. https://doi.org/10.5840/philtoday202149392

Lampe, Kurt. 'From metaphysics to ethics (with Bernard Stiegler, Heraclitus, and Aristotle).' In *Contemporary Encounters with Ancient Metaphysics*, edited by Abraham Jacob Greenstine, and Ryan J. Johnson, 323–330. Edinburgh: Edinburgh University Press, 2017.

Lemmens, Pieter. 'Social autonomy and heteronomy in the age of ICT: The digital pharmakon and the (dis)empowerment of the general intellect.' *Foundations of Science* 22 (2017): 287–296. https://doi.org/10.1007/s10699-015-9468-1

Lovelock, James. *Gaia: A New Look at Life on Earth*. Oxford: Oxford University Press, 2000.

O'Hara, Michael. 'Transversing states: A reflection on digital technology and Simondon's critique of hylomorphism.' *Culture, Theory and Critique* 60, no. 3–4 (2019): 223–236. https://doi.org/10.1080/14735784.2019.1677485

Ross, Daniel. 'Introduction.' In *The Neganthropocene* by Bernard Stiegler, translated by Daniel Ross (pp. 7–34 (endnote 22)). London: Open Humanities Press, 2018.

Schelling, Friedrich Wilhelm Joseph. *First Outline of a System of the Philosophy of Nature*. Albany: State University Press of New York, 2004.

Schelling, Friedrich Wilhelm Joseph. *Philosophical Investigations into the Essence of Human Freedom*. Albany: State University Press of New York, 2006.

Stiegler, Bernard. *What Makes Life Worth Living: On Pharmacology*. Cambridge: Polity Press, 2013.

Stiegler, Bernard. *The Re-enchantment of the World: The Value of Spirit Against Industrial Populism*. London and New York: Bloomsbury, 2014.

Stiegler, Bernard. 'General ecology, economy, and organology.' In *General Ecology: The New Ecological Paradigm*, edited by Erich Hörl, and James Burton, 129–151. London and New York: Bloomsbury, 2017.

Stiegler, Bernard. *Nanjing Lectures 2016–2019*. Edited and translated by Daniel Ross. London: Open Humanities Press, 2020.

Stiegler, Bernard. 'Elements for a Neganthropology of Automatic Man.' Translated by Daniel Ross. *Philosophy Today* 65, no. 2 (2021): 241–264. https://doi.org/10.5840/philtoday2021414397

Turner, Ben. 'From resistance to invention in the politics of the impossible: Bernard Stiegler's political reading of Maurice Blanchot.' *Contemporary Political Theory* 18, no. 1 (2019): 43–64. https://doi.org/10.1057/s41296-018-0212-9

U.S. Executive Office of the President National Science and Technology Council Committee on Technology. *Preparing for the Future of Artificial Intelligence*. October 2016. Accessed 05.02.2022. https://obamawhitehouse.archives.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/preparing_for_the_future_of_ai.pdf

Weatherby, Leif. *Transplanting the Metaphysical Organ: German Romanticism between Leibniz and Marx*. New York: Fordham University Press, 2016.

Pedagogue students' opinions on ideal teacher interaction

Based on Leary's interpersonal model (Interpersonal Circumplex), Wubbels elaborated the scheme of interpersonal behaviour that was completed by questionnaires (Questionnaire on Teacher Interaction (QTI)). Our research involved 336 students of four teacher training institutions of the Carpathian Basin. In our survey, we searched for the answer to the question of what opinions students held about the ideal interpersonal behaviour. The reliability of the Hungarian version of the QTI query proved to be similar to that of the English version. According to the students, the main characteristics of the ideal interpersonal behaviour are decisive, directive, helpful and understanding; it is less characterised by doubt and emotionality. In terms of imposing and compliant manner, opinions are rather divided. It is preschool teachers and teachers of lower primary school classes who prefer cooperation with the children the most, while teachers of upper classes tend to emphasise the importance of directive behaviour.

Keywords: *teacher training, interpersonal behaviour, QTI query*

Acknowledgement

This research has been supported by the project titled '1/0117/19: Position, identity and education of minorities – societal self-realization strategies of the Hungarian minority in Slovakia'.

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How to cite this article:

Tóth, Péter, Kinga Horváth. "Pedagogue students' opinions on ideal teacher interaction". *Információs Társadalom* XXII, no. 2 (2022): 72–92.
https://dx.doi.org/10.22503/inftars.XXII.2022.2.5

1. Introduction

In terms of the successfulness of teaching and education, the teacher's activity, and within that his/her interpersonal behaviour and interaction skills and dispositions, is of decisive importance (Berliner and Calfee 2004; Brekelmans et al. 2002; den Brok et al. 2004). Several authors point to the importance of elaborating measuring tools by means of which the pupils become able to assess their teacher's interpersonal behaviour while the teacher can evaluate his/her own (Goh and Fraser 1998; Koul and Fisher 2005; Wubbels et al. 2006; Passini et al. 2015).

Interaction can be understood as a two-way, interpersonal communication that elicits cognitive and/or emotional impacts and is directed at influencing the parties' behaviour and actions (Amidon and Hough 1967; Dunkin and Biddle 1974; Mehan 1979).

In relation to classroom communication, we can basically distinguish between three trends: the behaviourist logical-empiric one with a quantitative approach, the intuitive interpretative one with a qualitative approach and the one based on personality theories.

The first trend strives to categorise speech events and determine their regularity, which manifests in coding the functions of social interaction and the analysis of classroom interactions (Erickson 2006; Flanders 1977).

The relation side of communication constitutes the intuitive and interpretative trend with a qualitative approach of classroom communication in which researches applying sociological and ethnographic approaches have evolved. The sociological trend examines specific speech–behaviour patterns, the ritual phenomena (Jordan and Henderson 1995; Erickson 2006). By examining the teacher/student roles, it has been proved that teacher–student interactions, and thus the relation formed by the teacher with the class, bear very importance for performing an optimal teacher role. Researches applying the ethnographic approach provided a quantitative analysis of the classroom dialogues (Greeno 2006; Jordan and Henderson 1995) and emphasised the primacy of learning as a social system (Erickson 2006).

Later, attention was directed not only to observation of interactions made during a certain lesson but to trying to explore the expressions of behaviour and personal characteristics that reflected the teacher's generalisable interaction shown in pedagogical situations. Of these personality theories, we must highlight the interpersonal teacher behaviour model (IPC-T) elaborated by Wubbels et al. (1985), which was created by adapting Leary's Interpersonal Circumplex (IPC) model (Leary 1957) in an educational context.

According to the establishment, in Timothy Leary's IPC model:

- the variables of interpersonal behaviour make a circular continuum (circumplex);
- its characteristics bear two dimensions: (1) control (direction), the end values of which are dominance and submissiveness, and (2) affiliation, the dipoles of which are love, agreeableness, friendliness and warmth and hate, feud and hostility;
- the characteristics of interpersonal behaviour are counter-pairs that mutually condition each other;

- its variables organise into behaviour patterns and form roles;
- it is also characterised by the measure of insistence to roles since the more a certain feature appears in a certain role, the more difficult it is to transform the given role and change the behaviour.

Leary described the interpersonal behaviour of personality (Interpersonal Check List, ICL) at five levels, and he elaborated a query for the first (public communication), the second (conscious communication) and the fifth (evaluation of the ego ideal): evaluation and characterisation by the peers and the professional taking part in the interaction; conscious self-evaluation; and diagnostic analysis in terms of the ego ideal or value order (Leary 1957; Leary and Harvey 1956).

ICL was used in pedagogical surveys, as well; for example, one researcher examined how interpersonal relationships affect learning outcomes (Martin 2014). During the promotion of career socialization in teacher training, it was confirmed that the ego-ideal evaluation of students strengthened where a consciously designed development program was applied (Balázsné Csuha 1993).

During the most recent years, several researches have dealt with examination of the teacher–student relation system (e.g. Telli et al. 2007; Wubbels 2014; Passini et al. 2015; Misic et al. 2021; Kanczné Nagy and Csehiová 2021). One of the most important findings of these was that good interpersonal relationships have a positive impact on learning both in and outside the classroom (Goh and Fraser 1998; den Brok et al. 2004).

To explore classroom communication, and within that the interpersonal relation system between the students and the teacher, Theo Wubbels et al. (1985) adapted the Leary theory and elaborated the model of the teacher's interpersonal behaviour (Teacher Interpersonal Circle, IPC-T), which is based on the circumplex model and has been modified several times since (Wubbels and Levy 1991; Wubbels and Brekelmans 1998; Wubbels 2014; Pennings and Mainhard 2016).

The original Wubbels' IPC-T model (Wubbels et al. 1985) wished to explore the quality of the relationship between the teacher and the students (closeness or proximity) on the horizontal axis and the person directing this relation on the vertical axis (impact or influence). Excessive values of relationship quality are (1) teacher cooperation (cooperation), (2) refusal to work together or teacher isolation (opposition), and (3) lack of cooperation. The poles of control of the relationship (influence) are teacher dominance and compliance or submission. The IPC-T model includes eight octants, each describing a certain prototype of teachers' interpersonal behaviour.

Leary's circumplex model was further developed by specifying the dimensions (Horowitz and Strack 2011): (1) communion or affiliation and (2) agency or control.

Communion refers to interpersonal proximity, joining, initiation of contacts, cooperation, inclusion and affiliation; it describes the level of emotional relatedness that the individual is able to transmit, the scale of which goes from isolation to keeping in contact with others. Thus, affiliation expresses the degree to which the teacher is able to create various forms of cooperation with the students.

Agency and control refer to interpersonal influence and restraint and show the level of one's endeavours to achieve superiority, domination and control; this scale

leads from yielding to autocratic power mania or influencing. So control reflects the degree to which the teacher is able to exert an impact on the class and influence the students with his/her will.

Each octant of the IPC is made of the weighted combination of these two dimensions. For example, the leading or directing behaviour prototype inherits dominance more strongly than cooperation, while it is just the other way round with the helpful behaviour prototype.

The developed version of the IPC was also reflected in the IPC-T model developed by Wubbels et al. (2012) and Brekelmans et al. (2011), so the eight behaviour prototypes were named like this (starting from the upper right quarter, clockwise):

- directing
- helpful
- understanding
- compliant
- uncertain
- dissatisfied
- confrontational
- imposing.

It is important to add that in terms of both the IPC and the IPC-T, corrections rather concern the naming and labelling of the two main dimensions and the eight prototypes and not the core of the Leary model serving as the base. As Wubbels put it in relation to his latest researches, the IPC-T model is apt to introduce the general behavioural attitudes by means of the interpersonal technical terms, so they can help students assess how a certain teacher behaves in class (Wubbels et al. 2012; Wubbels 2014; Mainhard 2015; Sun 2018).

Within the IPC-T model, the contiguous octants or behaviour prototypes have positive correlative relations, while the opposite ones have negative correlative relations, and the prototypes taking the positions 90° from each other have in principle no relationship (Wubbels et al. 1985). We must remark, though, that most of the research (Misbah et al. 2015; Passini et al. 2015) has proved this assertion only partially. Regarding certain interpersonal teacher behaviour prototypes, the situation is the same as with the IPC model. A moderately high level of agency or control can be attended by either strong or weak affiliation or proximity. In the previous case, one will see a helpful and friendly interpersonal teacher manner, while in the latter one we find confrontational or rebuking behaviour.

The original Questionnaire on Teacher Interaction (QTI) containing 77 items was elaborated in Dutch (Wubbels et al. 1985) in order to survey how students assess their teacher's classroom activity in terms of the two IPC-T dimensions, agency or control and communion or proximity. They also elaborated a query by which the teacher could evaluate his/her own interpersonal activity. This offered the opportunity to compare the way the class saw him/her and how the given teacher saw him/herself. In addition, a query measuring the teacher's ideal interpersonal behaviour was also elaborated.

The items of the QTI were ordered to the interpersonal teacher behaviour prototypes of the IPC-T model. The students were asked to evaluate each item on a five-grade Likert scale (Never … Always).

In the next step, the first English version of the query was made, which was, after checking its validity, reliability and usability, applied in the United States (Wubbels and Levy 1991; Wubbels and Levy 1993). The internal consistency of the measuring tool proved to be very similar to that of the Dutch version (Cronbach-alpha (Dutch)= 0.61–0.90; Cronbach-alpha (American)=0.75–0.88). The Dutch research involved 1105 students and 66 teachers, while the American one covered 1606 students and 66 teachers. The 48-item version was adopted first in Australia; this also provides the base for our study. In Australia, 489 students at the 11th and 12th grade and specialised in biology filled in the query, and reliability proved to be similar again (Cronbach-alpha (Australian)= 0.63–0.83) (Fisher et al. 1995).

A great advantage of the QTI is that it can be used for several purposes. It is apt to get the students' evaluation concerning a given teacher or the best teacher who teaches or has ever taught them. They can express their opinions about the interpersonal behaviour they think is ideal and the teacher can also evaluate his/her own relevant activity. This way, the researches will be able to compare these elements.

Examining 792 pupils and 46 teachers of mathematics and nature sciences in Australia, Wubbels et al. (1993) found that, according to the pupils' evaluation, teachers do not generally reach the scores of the ideal teacher, and also differ from the teacher thought to be the best. It is a remarkable finding that the best teachers are stronger directing personalities, are helpful and more understanding, and are at the same time less uncertain, dissatisfied and confrontational than teachers in general. When the concerned teachers were asked to evaluate their own interaction activities, they appraised themselves little better than the class, so they believed they stood closer to the ideal picture than the pupils thought.

Another Dutch research (Wubbels et al. 1991) looked for interrelations between the learning performance and the QTI averages and found that the more strict, directing, helpful and friendly a teacher is, the better learning outcomes the pupils will produce. In opposition to this, the impacts of the types of interpersonal teacher behaviour positioned below the horizontal axis are rather negative in terms of the learning performance. Regarding the proximity dimension, the more a teacher is cooperative, the better the affective performance and the students' sense of responsibility and autonomy will be (Wubbels et al. 1991). The teacher's helpfulness and assertive leader behaviour have a positive impact on these attitudes of the pupils.

Levy, Créton and Wubbels (1993) compared the Dutch, Australian and American data where the students were asked to compare the interpersonal behaviour of their best and worst teachers. The best teachers were strong directing individuals, helpful and understanding, while those assessed as worst were confrontational and dissatisfied.

In another research implemented in the Netherlands, eight types of interpersonal behaviour were identified by cluster analysis (Wubbels et al. 2006): (1) prescriptive,

demanding and directive, (2) authoritative, (3) tolerant – authoritative, (4) tolerant, (5) uncertain – tolerant, (6) uncertain – aggressive, (7) repressive, (8) "drudging". Pupils could take the biggest cognitive and affective advantage of the teacher behaviours (1) and (2), but the smallest one of (5) and (6).

In another Australian research, Fisher and Rickards (1998) used a 64-item QTI query, involving 3994 pupils and modifying, adding or deleting several items. The reliability of this measurement tool was similar to that of the previous ones (Passini et al. 2015). This version was translated into and used in several languages, e.g., French, Greek, Hebrew, Malay, Korean, Turkish, Italian and Indonesian (Passini et al. 2015). The reliability of these measuring tools varies on a wide scale (Cronbach-alpha: 0.57–0.93), the η^2, which indicates the explained variance between the certain groups (proportion of variance accounted for), was between 0.12 and 0.45 and proved, partially or totally, the circumplex structure.

The 48-item QTI query was applied in Singapore, Malaysia, Greece and China (Fisher et al. 1995; Passini et al. 2015; Sun et al. 2018). In their paper, Fisher et al. (1995) presented six case studies based on which they considered the 48-item QTI query to be valid and reliable. The measuring tool proved to be a valuable information source for the teachers in comparing their own self-evaluations with the students' opinions, which clearly served their professional development. The QTI also allowed the teachers of natural sciences who attended the research to compare themselves to the ideal interpersonal behaviour.

2. Goals, Questions, Methods and Samples

As presented above, Leary described his thoughts about the ego ideal as the fifth level of the interpersonal behaviour of personality, and he also developed a diagnostic query for this issue. This served as the base for Wubbels et al. (1991) when elaborating a measurement tool that aimed to explore the ideal teacher interaction or interpersonal behaviour. After Wubbels (2014) three measurement tools were developed by Fisher et al. (1995): the first one for pupils to evaluate a given teacher, a second one for the self-evaluation of the given teacher and a third to describe the interpersonal behaviour considered ideal by the given teacher.

We used the third one and asked pedagogue students what they thought about the teacher's ideal interpersonal behaviour.

We applied the Hungarian translation of the 48-item QTI query introduced by Fisher et al. (1995) in an online version. The original query uses a 0 … 4 scale and then transforms it into a 1 … 5 scale. We did the same.

The English query was translated by two experts from English to Hungarian, and then back. The Hungarian version was checked and tried in a pilot survey, and then the phraseology was refined.

This research involved 336 students of four Hungarian-speaking teacher training institutions of four countries (Slovakia, Ukraine, Romania and Serbia) (Table 1).

Institution	Pre-school teacher	Teacher in lower classes	Teacher in upper classes	Pre-school teacher and teacher in lower classes	Total
J. Selye University, Komárno, Slovakia (JSU)	130	0	67	0	197
Ferenc Rakoczi II Transcarpathian Hungarian College of Hungarian Education, Berezhany, Ukraine (FRTHC)	6	12	41	0	59
Partium Christian University, Oradea, Romania (PCU)	0	0	20	17	37
University of Novi Sad, Hungarian Language Teacher Training Faculty, Subotica, Serbia (UNS HLTTF)	10	33	0	0	43
Total	146	45	128	17	**336**

Table 1. Students involved in the research (own editing)

The students' demographical data were as follows:

- Grade: 1. 69.6%; 2. 26.8%; 3. 3.6%
- Training: full time – 84.5%; correspondence – 15.5%
- Sex: female – 82.4%; male – 17.6%
- Place of residence: village/small settlement – 61.6%; small town – 32.1%; city – 6.3%
- Country of secondary school leaving exam: Hungary – 21.7%; Slovakia – 37.8%; Romania – 10.4%; Ukraine – 17.6%; Serbia – 12.5%
- Language of secondary school: Hungarian – 89.0%; Slovak – 3.0%; Ukrainian – 2.7%; Serb – 0.3%; bilingual, one of them Hungarian – 5.1%
- Type of secondary school: technical school – 51.8%; grammar school – 48.2%
- Own child: none – 88.4%; 1–2 children – 10.8%; 3 or more – 0.9%
- High grade degree: none – 96.4%; BA – 1.8%; MA – 1.8%
- Place of residence during studies: home – 46.7%; sublet – 7.7%; hostel – 44.6%; with relatives or friends – 0.9%
- Distance between residence and the university: 0–10 km – 17.0%; 11–100 km – 64.9%; 101–200 km – 7.1%; 201–300 km – 6.8%; 301+ km – 4.2%.

During the research, we searched for answers to the following questions:

- What opinions do Hungarian-speaking pedagogue students of the Carpathian Basin have about the ideal teacher interaction?

- Are there any significant differences between the certain QTI variables in terms of the three examined background variables (specialisation, university and country of secondary school leaving exam)?

3. Results

In the 48-item query, each of the eight octants includes six items that are mixed up in the query. The subject does not know which item belongs to which prototype of interpersonal teacher behaviour. The average values of the variables are between 1 and 5; 1 means that the given characteristic is not part of the ideal interpersonal behaviour, while 5 means that it is a strong attribute. Table 2 presents the reliability values of the certain octants in terms of the whole and some partial samples.

There are three factors that exert considerable influence on reliability: the homogeneity of the measured population, the number of the items and their scale. In our case, the population was made of students attending Hungarian-speaking teacher training in the Carpathian Basin, most of them in the first grade.

We presented the Cronbach-alpha reliability indicators in Table 2 and Figure 1, and we introduced the results in relation to some sub-samples. We can state that the Hungarian version of the QTI 48-item query can reliably investigate the opinions of the students attending teacher training in the Carpathian Basin about ideal interaction.

Prototypes of interpersonal teacher behaviour	Whole sample	Specialisation*	University**	Type of secondary school***
Directing (DC)	0.711	0.722/0.709/0.682	0.717/0.696/0.666/0.679	0.721/0.704
Helpful (CD)	0.757	0.784/0.669/0.754	0.805/0.628/0.659/0.635	0.768/0.737
Understanding (CS)	0.736	0.708/0.723/0.759	0.752/0.609/0.702/0.752	0.732/0.742
Compliant (SC)	0.676	0.702/0.615/0.661	0.686/0.654/0.651/0.682	0.644/0.706
Uncertain (SO)	0.768	0.806/0.691/0.752	0.793/0.652/0.791/0.689	0.804/0.679
Dissatisfied (OS)	0.756	0.741/0.759/0.766	0.746/0.738/0.743/0.778	0.770/0.733
Confrontational (OD)	0.688	0.711/0.652/0.718	0.703/0.608/0.605/0.758	0.740/0.675
Imposing (DO)	0.804	0.817/0.741/0.786	0.823/0.849/0.708/0.747	0.794/0.813

*pre-school teacher/teacher of lower classes/teacher of upper classes; ** JSU/PCU/ UNS HLTTF/ FRTHC; *** vocational secondary school/grammar school

Table 2. The Cronbach-alpha values of the QTI octants (own editing)

Table 3 presents the descriptive statistical indicators of the whole sample in terms of the types of interpersonal teacher behaviour. According to these data, the teacher students of the Carpathian Basin think that a teacher's ideal interaction is characterised by high values of being directing, helpful and understanding and low values of being uncertain, dissatisfied and confrontational. It was only the imposing (DO) and the compliance (SC) dimensions in which we found differing opinions concerning the ideal interpersonal conduct (at the same time, in these two cases deviation values were the highest). It is not by chance that we can see normal distribution only at these two variables.

	DC	CD	CS	SC	SO	OS	OD	DO
Mean	4.50	4.46	4.45	2.77	1.36	1.62	1.59	2.76
Standard deviation	0.414	0.445	0.439	0.553	0.499	0.524	0.483	0.663
95% Conf. int. low	4.45	4.42	4.40	2.71	1.30	1.57	1.54	2.69
95% Conf. int. upper	4.54	4.51	4.49	2.83	1.41	1.68	1.64	2.83
Normal distribution	-	-	-	+	-	-	-	+

Table 3. The descriptive statistical indicators of the QTI variables (own editing)

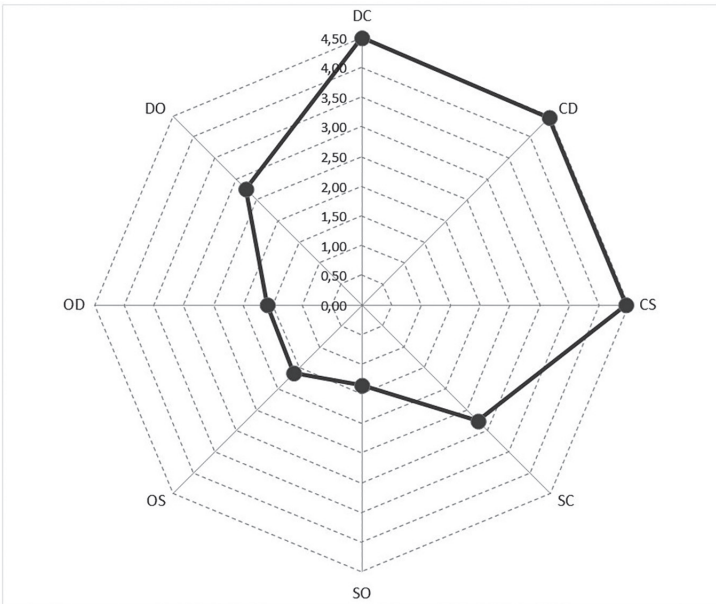

Figure 1. QTI variables in the circumplex diagram (own editing)

We examined the QTI variables in terms of the following background variables, as well: grade, specialisation, institution, country of secondary school leaving exam. Table 4 presents the averages and deviation of the sub-samples by the background variables. To compare the averages, we used the Mann-Whitney and the Kruskal-Wallis methods concerning variables DC, SO, CS, OD, CD and OS, while we used the ANOVA test with variables DC and SC.

	DC	CD	CS	SC	SO	OS	OD	DO
I. grade M (234 pers.)	4.5100	4.5100	4.4537	2.7849	1.3440	1.6660	1.6261	2.7892
I. grade SD	0.4247	0.4385	0.4361	0.5724	0.5165	0.5253	0.4746	0.7059
II. grade M (90 pers.)	4.4389	4.3556	4.4037	2.7593	1.4130	1.5426	1.5444	2.7204
II. grade SD	0.3930	0.4464	0.4504	0.5004	0.4662	0.5105	0.5088	0.5619
pre-school teacher M (145 pers.)	4.5149	4.5379	4.5057	2.8540	1.3644	1.6437	1.6241	2.6368
pre-school teacher SD	0.4148	0.4478	0.4046	0.5951	0.5401	0.5136	0.4894	0.6868
Teacher of lower classes M (45 pers.)	4.6000	4.3741	4.5407	2.6037	1.2667	1.4852	1.4481	2.6963
Teacher of lower classes SD	0.3850	0.3943	0.3813	0.4902	0.4225	0.4934	0.3673	0.5885
Teacher of upper classes M (128)	4.4258	4.3919	4.3372	2.7135	1.3893	1.6758	1.6185	2.9245
Teacher of upper classes SD	0.4203	0.4618	0.4894	0.5291	0.4977	0.5503	0.5221	0.6367
JSU M (197 pers.)	4.4941	4.4839	4.4349	2.7978	1.3680	1.7267	1.6489	2.7673
JSU SD	0.4254	0.4740	0.4575	0.5777	0.5309	0.5486	0.4998	0.6908
PCU M (20 pers.)	4.4083	4.5250	4.3917	3.0417	1.3667	1.5167	1.7500	3.0250
PCU SD	0.3646	0.3678	0.2875	0.3780	0.4379	0.4521	0.4423	0.7380
UNS HLTTF M (43 pers.)	4.6589	4.4690	4.6163	2.6434	1.2481	1.4264	1.3953	2.6550
UNS HLTTF SD	0.3272	0.3921	0.3343	0.5462	0.4761	0.4532	0.3655	0.5755

FRTHC M	4.3851	4.3276	4.3592	2.6322	1.4167	1.5144	1.5172	2.7270
FRTHC SD	0.4272	0.4257	0.4915	0.5249	0.4717	0.4634	0.5089	0.6035
School leaving exam HU* M (73 pers.)	4.4703	4.5320	4.4292	2.8858	1.3516	1.6804	1.6233	2.7603
School leaving exam HU SD	0.4601	0.4695	0.4730	0.6148	0.5035	0.5547	0.4623	0.6431
School leaving exam SK* M (127 pers.)	4.5066	4.4554	4.4357	2.7533	1.3819	1.7493	1.6732	2.7612
School leaving exam SK SD	0.4068	0.4763	0.4528	0.5487	0.5492	0.5467	0.5276	0.7147
School leaving exam RO* M (35 pers.)	4.5286	4.5810	4.4571	2.9571	1.3143	1.4762	1.6190	2.9333
School leaving exam RO SD	0.3604	0.3088	0.2781	0.3821	0.3722	0.4281	0.4094	0.7050
School leaving exam UA* M (59 pers.)	4.3814	4.3192	4.3503	2.6412	1.4237	1.5254	1.5254	2.7260
School leaving exam UA SD	0.4244	0.4269	0.4919	0.5251	0.4707	0.4671	0.5084	0.5983
School leaving exam SRB* M (42 pers.)	4.6627	4.4841	4.6389	2.6349	1.2222	1.4048	1.3611	2.6627
School leaving exam SRB SD	0.3303	0.3840	0.3034	0.5499	0.4503	0.4358	0.2920	0.5803

* HU: Hungary, SK: Slovakia, RO: Romania, UA: Ukraine, SRB: Serbia.

Table 4. The descriptive statistical indicators of the QTI variables by some background variables (own editing)

We found significant differences in terms of the grade concerning variables CD (Mann-Whitney U=9039.500; p=0.004), SO (Mann-Whitney U=8912.000; p=0.041), OS (Mann-Whitney U=8912.000; p=0.031) and OD (Mann-Whitney U=8909.500; p=0.029).

Comparing the two, first-grade students tend to think that it is rather the directing, helpful, dissatisfied and confrontational features that should be more stressed about teacher interaction, while according to the students in the second grade it is uncertain manner.

The research involved students from three different pedagogy specialisations: pre-school teacher, teacher of lower classes and teacher of upper classes. Except for dissatisfaction and uncertainty, we found significant differences concerning each variable: DC (χ^2=8.193; p=0.017), CD (χ^2=10.104; p=0.006), CS (χ^2=10.283; p=0.006), SC (Levene stat.=0.699; p=0.498; F=4.307; p=0.014), OD (χ^2=6.694; p=0.035), DO (Levene stat.=0.738; p=0.479; F=6.838; p=0.001).

	DC	CD	CS	SC	SO	OS	OD	DO
Pre-school teacher		***		***			***	*
Teacher in lower classes	***	*	***	*	*	*	*	
Teacher in upper classes	*		*		***	***	***	***

*: lowest average, ***: highest average in terms of the three specialisations.

Table 5. The biggest and smallest averages of the QTI octants by specialization (own editing)

Pre-school teachers thought that the ideal teacher interaction would include being helpful, compliant and confrontational the most and being imposing the least. Teachers of lower classes emphasised being directing and understanding as characteristics of the ideal teacher interaction more than their peers, and they thought that compliance and confrontation belonged here the least. The teachers of upper classes had the most definite opinion concerning imposing manner, while they were the least resolute in terms of the rest of the characteristics. Table 5 summarises the data presented above. It can be stated that several of the upper-class teacher students think that the attributes of the ideal teacher include denial of cooperation in the proximity dimension. Pre-school and lower-class teachers prefer cooperation with the pupils much more. Thus, it is not by chance that the upper classes of the Hungarian bilingual primary schools in the Carpathian Basin are dominated by teacher-focused working methods.

Our third background variable was the institution. Concerning this aspect, except for the evaluation of the imposing manner, we found significant differences in terms of each QTI variable: DC (χ^2=12.100; p=0.007), CD (χ^2=10.195; p=0.017), CS (χ^2=8.935; p=0.030), SC (Levene stat.=1.546; p=0.203; F=3.579; p=0.014), SO (χ^2=10.471; p=0.015), OS (χ^2=20.894; p=0.000), OD (χ^2=20.120; p=0.000).

	DC	CD	CS	SC	SO	OS	OD	DO
JSU						***		
PCU		***		***			***	***
UNS HLTTF	***		***		*	*	*	*
FRTHC	*	*	*	*	***			

*: lowest average, ***: highest average in terms of the three specialisations.

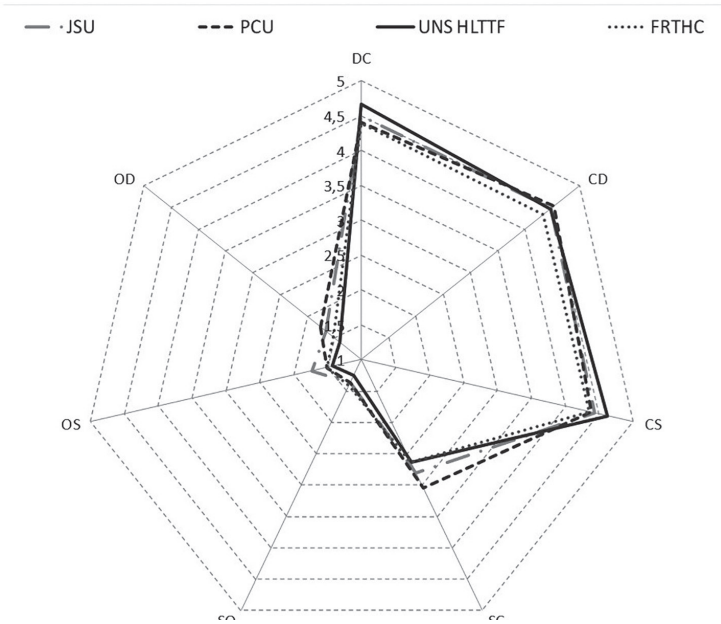

Table 6. The highest and lowest averages of the QTI octants by institutions (own editing)

Figure 2. Significant differences in the QTI variables by institutions (own editing)

The students of the Ferenc Rakoczi II Transcarpathian Hungarian College of Hungarian Education (UA) thought that cooperation with the pupils was part of the ideal teacher interaction less than the students of the other universities in the Carpathian Basin; however, the students of Subotica (SRB) took the opposite standpoint. It was the students in Komárno (SK) who most considered dissatisfaction to be an attribute of teacher interaction. The opinions of the students at the Partium Christian University (RO) were rather contradictory. They produced the highest averages concerning two opposing attributes: having a compliant but imposing manner. Besides these, they thought that helpful and confrontational behaviours belonged to the ideal teacher interaction style more than the students of the other universities (Table 6, Figure 2).

We examined the Transylvanian students (RO) in the imposing–compliant dimension more thoroughly, using cluster analysis. We found three clusters the basis

of which proved to be strictness (Figure 3): rather compliant (+), rather imposing, medium imposing (•) – averagely or below averagely compliant (▾).

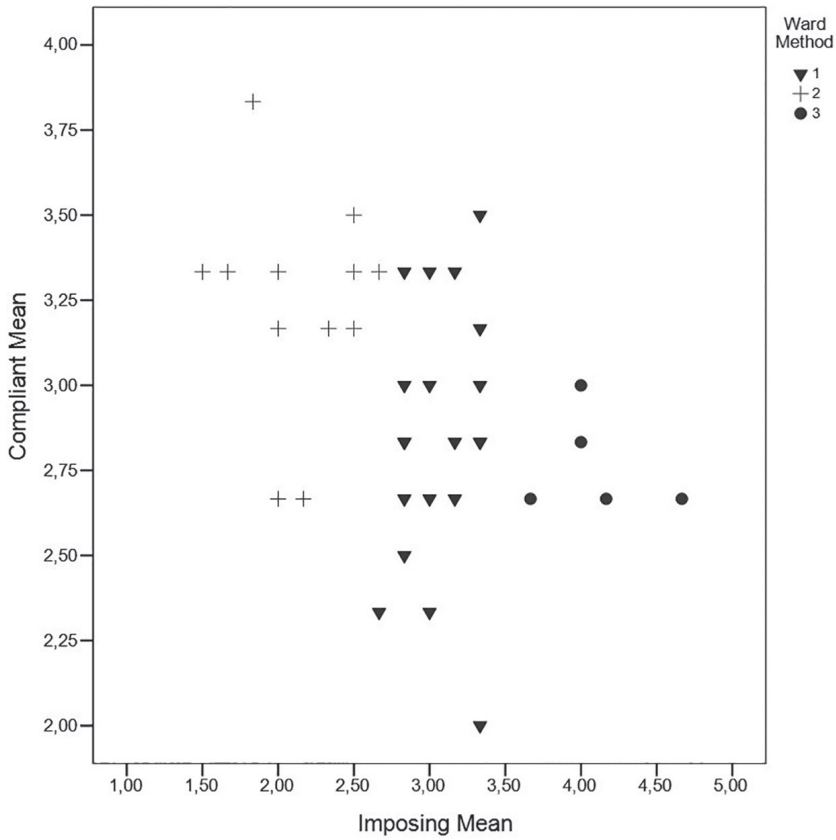

Figure 3. Student groups of the PCU in the Imposing – Compliant dimension (own editing)

The reason for the high polarity is, as indicated by Figure 3, that some students strongly prefer an imposing manner as part of the ideal teacher behaviour, while others choose a compliant one.

The opinions of the students in Subotica were polarised in another way (Figure 4): neither imposing nor compliant (•), rather imposing (♦) and rather compliant (+). As compared to the previous one, the clusters shifted to the less imposing direction.

As for the Transylvanian students, the cluster centres appeared like this (DO; SC) (hierarchic method):

- rather compliant (+): 2.1389; 3.2361
- rather imposing (•): 4.100; 2.7667
- medium imposing – averagely or below averagely compliant (♦): 3.0583; 2.8500.

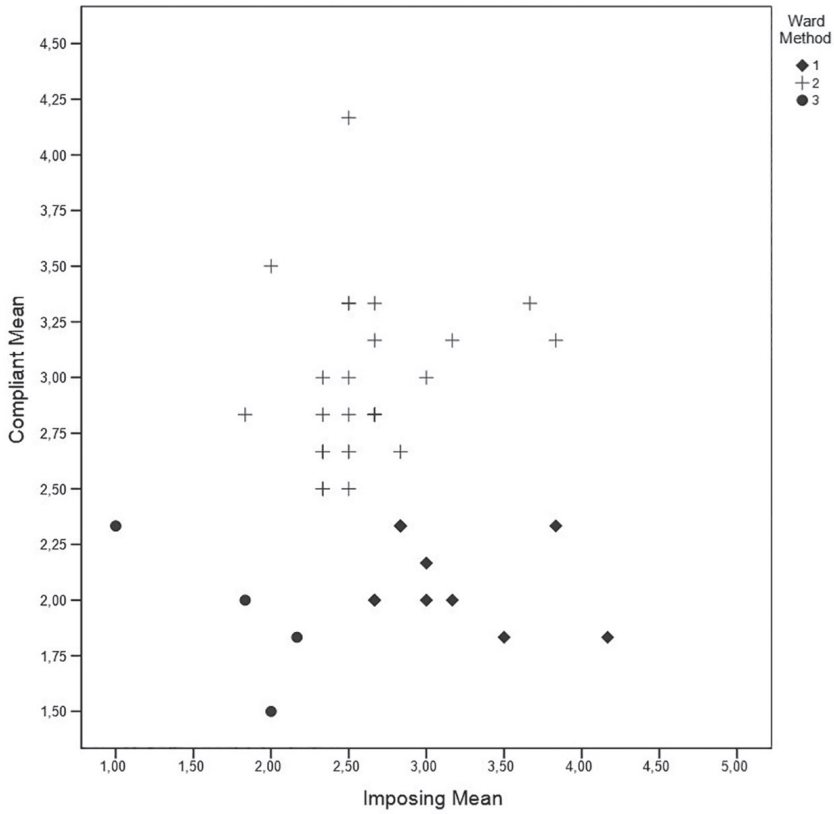

Figure 4. Groups of the UNS HLTTF students in the Imposing – Compliant dimension (own editing)

The groups differ from each other in terms of both the DO (F=5.712; p=0.007) and the SC (83.484; p=0.000) variables. The clusters isolated by the Ward method account for 83.1% of the DO and 25.1% of the SC variables.

	Rather compliant (12 pers.)	**Rather imposing (5 pers.)**	**Medium imposing – averagely or below averagely compliant (20 pers.)**
Rather compliant (12 pers.)		2.02	0.99
Rather imposing (5 pers.)	2.02		1.04
Medium imposing – averagely or below averagely compliant (20 pers.)	0.99	1.04	

Table 7. Distance between the clusters on the DO–SC axis for PCU students (own editing)

We also made the reliability and validity test of the cluster analysis for which we used the K-means algorithm. The cluster centres agreed with those described above. Table 7 presents the distance between the clusters.

As for the students in Subotica (Serbia), the cluster centres were as follows (DO; SC) (hierarchic method):

- rather imposing (♦): 3.1364; 2.0161
- rather compliant (+): 2.5952; 2.9583
- neither imposing nor compliant (•): 1.7500; 1.9167.

The groups differ from each other significantly in terms of both the DO (F=14.838; p=0.000) and the SC (F=36.116; p=0.000) variables. The clusters isolated by the Ward method account for 42.6% of the DO variable and 64.6% of the SC one.

We also made a reliability and validity test of the cluster analysis, for which we used the K-means algorithm. However, the cluster centroids differ from those gained with the hierarchic method:

- rather imposing (♦): 3.19; 2.19 (minor difference)
- rather compliant (+): 2.64; 3.07 (minor difference)
- neither strict nor compliant (•): 2.09; 2.36 (bigger difference).

Table 8 presents the distance of the clusters.

	Rather imposing (12 pers.)	**Rather compliant (20 pers.)**	**Neither imposing nor compliant (11 pers.)**
Rather imposing (12 pers.)		1.03	1.12
Rather compliant (20 pers.)	1.03		0.89
Neither imposing nor compliant (11 pers.)	1,12	0.89	

Table 8. Distance between the clusters on the DO–SC axis in the case of the UNS HLTTF students (own editing)

The teacher students of Hungarian nationality in the four countries involved in the research had significantly differing opinions about how much helpful (CD), compliant (SC) and dissatisfied (OS) behaviour was part of the ideal teacher interaction (CD: χ^2=10.800; p=0.013; SC: Levene stat.=1.127; p=0.343; F=3.348; p=0.010; OS: χ^2=11.572; p=0.009). It was the students in Oradea (Romania) who thought most strongly that helpfulness and compliance belong to the ideal teacher interaction; the students in Berezany (Ukraine) (as for the CD) and those in Subotica (Serbia) (as for the SC) were less of this opinion. Concerning dissatisfaction, it was the SK (Slovakia) who thought that this attitude was part of the teacher interaction, while those in Serbia kept this the least true.

The variables imposing and compliant were categorised. After they were formed into three categories (min. – M-0.5*SD; M-0.5*SD – M+0.5*SD; M+0.5*SD – max.), it can be stated that the two variables interrelate significantly (χ^2=9.822; p=0.044).

The cross-tabulation analysis revealed the connection system of these two variables. Disregarding the fact that almost 13% of the students (43 persons) took contradictory standpoints on this issue (both strict and compliant or neither strict nor compliant), nearly 10% (33 persons) voted definitely for compliant and approximately the same number (35 people) chose imposing, while the two variables are in an opposing relation (teacher interaction cannot be compliant and imposing at the same time) (Table 5). About 20% of the students (71 persons) voted for average imposingness and compliance. Consequently, there were only 20% (68 people) whose standpoint was polarised on the dichotomous imposing–compliant scale (Figure 5).

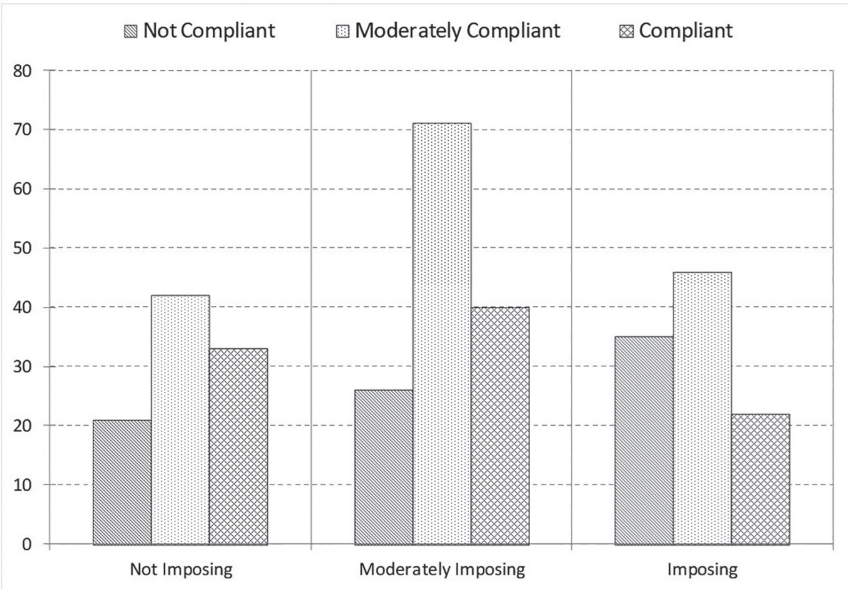

Figure 5. Mutual judgement of imposingness and compliance (own editing)

4. Conclusions

In the first section of our paper, we gave an overview of the theoretical background of teacher interaction, focusing on Wubbel's theory and the international results of the QTI measuring tool.

Relying on the query published by Darrell Fisher, Barry Fraser and John Creswell (1995), we adapted the 48-item version of the QTI to Hungarian.

In this paper, we presented the outcomes of our research conducted with the involvement of students taking part in Hungarian-speaking teacher training in the Carpathian Basin (336 persons).

We have formed the following responses to the questions put at the beginning of our survey:

- According to students of Hungarian-speaking teacher training in the Carpathian Basin, the most important features of the ideal interpersonal behaviour

are firmness of directing manner, helpfulness and understanding. According to them, confrontational and, primarily, uncertain and dissatisfied characteristics do not belong to this interaction. In terms of these variables, the students' opinions were very polarised.

- We found significant differences in relation to some of the QTI variables in terms of each of the background variables (grade, specialisation, institution, country).

First-grade students tend more to think that being directing, helpful, dissatisfied and confrontational have bigger weight in teacher interaction, while according to those in the second grade it is uncertainty that is more important.

Pre-school teachers and teachers of lower classes prefer cooperation with the pupils more than teachers of upper classes. This last group had the most definite opinions on whether a teacher should have an imposing manner and the least definite ones about the rest of the characteristics.

The universities involved in the research formed significantly differing opinions about each of the variables, except for being imposing.

It is the students in Ukraine who least thought that the ideal teacher interaction included cooperation with the students, while those in Serbia had the most opposing idea on this issue.

The students of the Partium Christian University took rather contradictory standpoints concerning two opposing attributes: compliant and imposing; they produced the highest average in terms of both variables. They also gave bigger emphasis to helpful and confrontational behaviour as part of the ideal teacher interaction than the students of other universities.

In terms of the country of the secondary school leaving exam, we detected significant differences in terms of helpfulness, compliance and dissatisfaction.

The students having taken their exams in Transylvania (Romania) thought most strongly that helpful and compliant behaviour belonged to the ideal teacher interaction, while in terms of helpfulness it was those in Ukraine who thought this the least and the ones in Serbia in terms of compliance. Concerning dissatisfaction, the students in Slovakia thought that this attitude belonged to the teacher interaction, while those in Serbia agreed less with this.

References

Amidon, Edmund, and John B. Hough. *Interaction analysis: Theory, research, and application.* Reading: Addison Wesley, 1967.

Balázsné Csuha, Mária. 'Személyiségfejlesztő csoportmunka tapasztalatai a pedagógusképzésben a Leary-féle interperszonális lista alapján.' (Experiences of personality development teamwork in teacher education based on Leary's interpersonal list). *In Acta Academiae Paedagogicae Agriensis Nova Serie Tom. XXI. Az Eszterházy Károly Tanárképző Főiskola Tudományos Közleményei*, edited by Tamás Pócs, and Rózsa V. Raisz, 251–260. Eger: Eszterházy Károly Tanérképző Főiskola, 1993. http://publikacio.uni-eszterhazy.hu/2907/1/251-260_Balazsne%20Csuha.pdf

Berliner, David, and Robert C. Calfee. *Handbook of educational psychology*. New York: Routledge, 2004.
https://doi.org/10.4324/9780203053874

Brekelmans, Mieke, Tim Mainhard, Perry den Brok, and Theo Wubbels. 'Teacher control and affiliation: Do students and teachers agree?' *Journal of Classroom Interaction* 46, no. 1 (2011): 17– 26.
https://www.researchgate.net/publication/254899596_Teacher_control_and_affiliation_Do_students_and_teachers_agree

Brekelmans, Mieke, Theo Wubbels, and Perry den Brok. 'Teacher experience and the teacher–student relationship in the classroom environment.' In *Studies in educational learning environments: An international perspective,* edited by Swee Chiew Goh, 73–100. Singapore: New World Scientific, 2002.
https://doi.org/10.1142/5014

den Brok, Perry, Mieke Brekelmans, and Theo Wubbels. 'Interpersonal teacher behaviour and student outcomes.' *School Effectiveness and School Improvement* 15, no. 3–4 (2004): 407–442.
https://doi.org/10.1080/09243450512331383262

Dunkin, Michael, and Bruce Biddle. *The study of teaching*. Holt: Rinehart & Winston, 1974.

Erickson, Frederick. 'Definition and analysis of data from videotape: Some research procedures and their rationales.' In *Handbook of complementary methods in education research*, edited by Judith J. Green, Gregory Camilli, and Patricia B. Elmore, 177–191. New York: Lawrence Erlbaum Associates, 2006.
https://doi.org/10.4324/9780203874769.ch10

Fisher, Darrell, Barry Fraser, and John Creswell. 'Using the Questionnaire on Teacher Interaction in the professional development of teachers.' *Australian Journal of Teacher Education* 20, no. 1 (1995).
http://dx.doi.org/10.14221/ajte.1995v20n1.2

Fisher, Darrell, and Tony Rickards. 'A Comparison of Teacher-Student Interpersonal Behavior in Secondary Science Classes in USA, Singapore and Australia.' In *The Annual Meeting of the National Science Teachers Association,* Las Vegas: National Science Teachers Association, 1998.
https://files.eric.ed.gov/fulltext/ED424089.pdf

Flanders, Ned. 'Interaction analysis and in-service training.' In *The social psychology of teaching*, edited by Arnold Morrison, and McIntyre, 63–73. Middlesex: Penguin Books, 1977.

Goh, Swee Chiew, and Barry J. Fraser. 'Teacher interpersonal behaviour, classroom environment and student outcomes in primary mathematics in Singapore.' *Learning Environments Research* 1, no. 2 (1998): 199–229.

Greeno, James G. 'Theoretical and practical advances through research on learning.' In *Handbook of Complementary Methods in Education Research*, edited by Judith J. Green, Gregory Camilli, and Patricia B. Elmore, 795–822. New York: Lawrence Erlbaum Associates, 2006.
https://doi.org/10.4324/9780203874769.ch45

Horowitz, Leonard, and Stephen Strack. *Handbook of interpersonal psychology: Theory, research, assessment, and therapeutic interventions*. New York: John Wiley & Sons, 2011.

Jordan, Brigitte, and Austin Henderson. 'Interaction analysis: Foundation and practice.' *Journal of the Learning Sciences* 4, no. 1 (1995): 39–103.
https://www.jstor.org/stable/1466849

Kanczné Nagy, Katalin, and Agáta Csehiová. 'The role of socialization, social relation and sensation from the perspective of teacher candidates.' *AD ALTA Journal of Interdisciplinary Research* 11, no. 2 (2021): 112-115. http://doi.org/10.33543/1102

Koul, Rekha, and Darrell L. Fisher. 'Cultural background and students' perceptions of science classroom learning environment and teacher interpersonal behaviour in Jammu, India.' *Learning Environments Research* 8, no. 2 (2005): 195–211.

Leary, Timothy, and Joan S. Harvey. 'A methodology of measuring personality changes in psychotherapy.' *Journal of Clinical Psychology* 12, no. 2 (1956): 123–132. https://doi.org/10.1002/1097-4679(195604)12:2<123::AID-JCLP2270120205>3.0.CO;2-7

Leary, Timothy. *Interpersonal diagnosis of personality; a functional theory and methodology for personality evaluation*. New York: John Wiley & Sons, 1957.

Levy, Jack, Hans Créton, and Theo Wubbels. 'Perceptions of interpersonal teacher behavior.' In *Do you know what you look like? Interpersonal relationships in education*, edited by Theo Wubbels, and Jack Levy, 26–40. London: Falmer Press, 1993.

Mainhard, Tim. 'Liking a tough teacher: Interpersonal characteristics of teaching and students' achievement goals.' *School Psychology International* 36, no. 6 (2015): 559–574. https://doi.org/10.1177/0143034315608235

Martin, Andrew. 'Interpersonal relationships and students' academic and non-academic development.' In *Interpersonal relationships in education: From theory to practice*, edited by David Zandvliet, Perry den Brok, Tim Mainhard, and Jan van Tartwijk, 9–24. Rotterdam: Sense Publishers, 2014.

Mehan, Hugh. *Learning lessons*. Cambridge, MA: Harvard University Press, 1979.

Misbah, Zainun, Judith Gulikers, Ridwan Maulana, and Martin Mulder. 'Teacher interpersonal behaviour and student motivation in competence-based vocational education: Evidence from Indonesia.' *Teaching and Teacher Education* 50 (2015): 79–89.

Misic, Gorana, Margaryta Rymarenko, and Helga Dorner. 'Becoming a teacher in higher education: Creating an academic development program to catalyse doctoral students' professionalization.' *Hungarian Educational Research Journal* 11, no. 3 (2021): 246-253. https://doi.org/10.1556/063.2021.00068

Passini, Stefano, Luisa Molinari, and Giuseppina Speltini. 'A validation of the questionnaire on teacher interaction in Italian secondary school students: The effect of positive relations on motivation and academic achievement.' *Social Psychology of Education* 18, no. 3 (2015): 547–559. https://doi.org/10.1007/s11218-015-9300-3

Pennings, Helena, and Tom Mainhard. 'Analyzing teacher–student interactions with state space grids.' In *Complex dynamical systems in education*, edited by Matthijs Koopmans, and Dimitrios Stamovlasis, 233–271. New York: Springer, 2016. https://doi.org/10.1080/00220973.2019.1578724

Sun, Xiaojing, Tim Mainhard, and Theo Wubbels. 'Development and evaluation of a Chinese version of the Questionnaire on Teacher Interaction (QTI).' *Learning Environments Research* 21, no. 1 (2018): 1–17. https://doi.org/10.1007/s10984-017-9243-z

Telli, Sibel, Perry den Brok, and Jale Cakiroglu. 'Teacher–student interpersonal behavior in secondary science classes in Turkey.' *Journal of Classroom Interaction* 41, no. 2 (2007): 31–40. https://www.jstor.org/stable/23869791

Wubbels, Theo. 'Teacher–student relationships in class: A future for research.' *Pedagogische Studien* 91, no. 5 (2014): 352–363.

Wubbels, Theo, and Mieke Brekelmans. 'The teacher factor in the social climate of the classroom.' In *International handbook of science education*, edited by Barry J. Fraser, and Kenneth Tobin, 564–580. Dordrecht: Kluwer Academic, 1998.

Wubbels, Theo, and Jack Levy. 'A comparison of interpersonal behaviour of Dutch and American teachers.' *International Journal of Intercultural Relations* 15, no. 1 (1991): 1–18. https://doi.org/10.1016/0147-1767(91)90070-W

Wubbels, Theo, and Jack Levy. *Do you know what you look like? Interpersonal relationships in education.* London: Falmer Press, 1993.

Wubbels, Theo, Mieke Brekelmans, Perry den Brok, and Jan van Tartwijk. 'An interpersonal perspective on classroom management in secondary classrooms in the Netherlands.' In *Handbook of classroom management: Research, practice and contemporary issues*, edited by Carolyn M. Evertson, and Carol S. Weinstein, 1161–1191. Erlbaum: Mahwah Lawrence, 2006. https://doi.org/10.4324/9780203874783

Wubbels, Theo, Mieke Brekelmans, and Herman Hooymayers. 'Interpersonal teacher behavior in the classroom.' In *Educational environments: Evaluation, antecedents and consequences*, edited by Barry J. Fraser, and Herbert J. Walberg, 141–160. Elmsford: Pergamon Press, 1991.

Wubbels, Theo, Mieke Brekelmans, and Herman Hooymayers. 'Comparison of teachers' and students' perceptions of interpersonal teacher behavior.' In *Do you know what you look like? Interpersonal relationships in education*, edited by Theo Wubbels, and Jack Levy, 57–71. London: Falmer Press, 1993.

Wubbels, Theo, Hans A. Créton, and Herman P. Hooymayers. *Discipline problems of beginning teachers, interactional teacher behavior mapped out.* Chicago: Annual meeting of the American Educational Research Association, 1985. http://files.eric.ed.gov/fulltext/ED260040.pdf

Wubbels, Theo, Perry den Brok, Jan van Tartwijk, and Jack Levy. *Interpersonal relationships in education: An overview of contemporary research*. Leiden: Sense Publishers. 2012.

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Pilot study on applying various research methodologies to investigate the effectiveness of e-learning materials

The COVID-19 pandemic had a major impact on higher education. Students were required to adopt a more independent way of learning, and instructors had to re-design courses to fit the digital space. Increasingly frequent e-learning research provides substantial support for the expansion of online education. The aim of this article is to investigate the effectiveness of e-learning materials among university students using a variety of research methodologies (Groningen Sleep Quality Scale, psychomotor vigilance task, verbal fluency and digit span tests, NASA Task Load indeX and eye tracking). In a pilot study conducted in a laboratory environment, 15 participants were divided into three groups and assigned to study from prepared course pages using content-equivalent e-learning materials. The results demonstrated that the applied research methodologies were appropriate for investigating the issue, allowing the pilot study to reveal a set of criteria encompassing the preferences of students for course structures and e-learning materials.

Keywords: *e-learning, learning effectiveness, learning materials, pilot research*

Acknowledgement

The authors wish to thank the participants for their time and help during the research. We would also like to express our appreciation to György Becker for providing the video-based e-learning content. This research has been carried out as part ofthe project no. TKP2020-NKA-02 which has been implemented with the support provided from the National Research, Development and Innovation Fund of Hungary, financed under the Tématerületi Kiválósági Program funding scheme.

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How to cite this article:

Szabó, Bálint, et al. “Pilot study on applying various research methodologies to investigate the effectiveness of e-learning materials”. *Információs Társadalom* XXII, no. 2 (2022): 93–116. *https://dx.doi.org/10.22503/inftars.XXII.2022.2.6*

1. Introduction

The COVID-19 epidemic and the restrictive measures taken to slow it down necessitated a rapid transition in educational institutions around the world (Batdı, Doğan and Talan 2021), and also presented an opportunity to explore the potential of digital education and adapt the learning environments to meet the current needs. Due to the temporary cessation of classical forms of classroom training, instructors, with the active participation and feedback of students, have laid the foundations for a modern, innovative, and new training system for the 21st century, in which the tools of online education have become an integral part of their daily lives. Students were required to adapt to more independent learning and an agenda based on it, and instructors were required to rethink and redesign course content and the manner in which it was conveyed.

When designing e-learning materials, it is important to consider aspects of knowledge transfer that are otherwise self-evident or natural. These include, but are not limited to, aspects such as enhancing learning experiences and knowledge acquisition effectiveness. Nedeva and Dineva (2013) highlighted the role of the instructor, whereas Steen (2008) emphasised the platform development capabilities necessary for effective e-learning. Important and appropriate instructions play an important role in the learning process as well. Clark and Mayer's theory of e-learning course development and their collection of multimedia principles serve as an essential foundation for all previous e-learning development (Clark and Mayer 2016).

Angeliki, Asimina and Eleni (2005) outlined the general characteristics of effective e-learning, which include successful learning achievement, simple accessibility, consistent and accurate messages, ease of use, relevant, entertaining, and memorable content, and reduced training costs. In contemporary and effective e-learning environments, curriculum development and the validation of activity-based teaching methodologies through learning tasks take precedence over content-centricity (Ollé et al. 2016). Increasing student engagement, reducing the risk of dropping out of the teaching-learning process, and the emergence of online teaching methods comparable to the methodology and learning organisation of the face-to-face classroom environment all contributed to the improvement of learning effectiveness (Ollé 2018).

Theories and developments in the field of instructional design have emerged that have assigned a significant role to the direct involvement of the instructor in the design of online courses and e-learning materials (Isaias, Sampson and Ifenthaler 2020; Nilson and Goodson 2021).

The various trends in the use of e-learning (e.g., standard course pages, video-based teaching content, activity-based practical exercises, or modular, object-orientated online courses) in higher education have resulted in solutions of varying quality. As a result, the significance of analysing the path to effective teaching via various e-learning materials has increased.

2. Theoretical background

2.1 Contributing factors of learning effectiveness

We have decades of knowledge and development experience regarding the creation of online courses and digital learning content. Developer practice and applied research conducted during this time period demonstrate that effective e-learning cannot be reduced to the presentation of cutting-edge learning materials using state-of-the-art technology. E-learning success factors are complex systems, in which the curriculum design systems, the trainers, the methodological experts, the institutional quality of service, and, of course, the infrastructure play a significant role (Monda 2014). Compared to the importance of the field, scientific research on the methodological functionality of online courses is grossly underrepresented. The most influential studies examine the relationship between course design and learning effectiveness (Saleh and Salama 2018; Kouis et al. 2020).

The rapidly changing and evolving technological environment has captured efficiency primarily in the learning experience design paradigm and its underlying frameworks in recent years (Hokanson, Clinton and Tracey 2015). By definition, design paradigm integrates educational psychology, teaching methodology, and the development of learning environments (Clark and Mayer 2016). One of its guiding principles is that we cannot plan a student's learning independently of all other factors, but we can design learning experiences, learning tasks, and environments (such as course pages) to make learning more effective and experiential. It is preferable not to plan for the phenomenon of learning but rather to create an environment and process that facilitates knowledge acquisition for the learner.

Learning experience design advances the traditional instructional design model by placing a much greater emphasis on the needs of the learner and the learning environment that can be created. The objective is to create immersive environments where learning tasks and learning activities can increase engagement. According to the findings of Neelen and Kirschner (2020), it is advisable to design learning environments that are effective, efficient, and enjoyable. According to Clark (2021), learning is a process in which emotions, attention, and motivation determine effectiveness and efficiency.

Therefore, learning environment has a significant impact on study motivation and behaviour. Students tend to increase their study motivation and effort during the studying period when they are aware of an upcoming examination. It is crucial to distinguish between the mediated and the direct effects of retrieval and testing on performance. When the retrieval itself has a positive impact on memory performance, but the student does not receive feedback following it, we can speak of direct effects. When a student modifies their behaviour in response to a testing event or receives additional information regarding their performance, mediated effects are observed (Roediger III and Karpicke 2006).

Several studies have investigated the complex relationship between student engagement, student interaction with the online learning environment, and learning performance (Moubayed et al. 2020; Shah and Barkas 2018; Lee, Song and Hong 2019; Rajabalee and Santally 2021; Cole, Lennon and Weber 2021). There are no identical e-learning environments or educational situations. Therefore, research has not identified the most significant factors that determine learning performance. Nevertheless, immersive and interactive e-learning environments have a positive effect on learning effectiveness, according to the findings of all major studies.

To design an effective learning environment, it is necessary to comprehend and model learning, as well as be familiar with the cognitive psychology of the learner. Additionally, it is essential to understand which tasks and online activities can assist the student in learning effectively (Kirschner and Hendrick 2020). Goal, attention, recall, motivation, the learning environment, and assessment of learning performance are key aspects in the design of effective learning (Dirksen 2015).

From students' perspective, expectations regarding the quality of education, including e-learning, are increasing currently (Sushkova et al. 2020), so an effective learning environment is crucial to university student satisfaction as well (Lacka and Wong 2021).

2.2. Mental fatigue

The above-mentioned contributing factors can influence the effectiveness of learning, and mental fatigue is also an important consideration.

Fatigue is a long-studied phenomenon that was originally believed to be a subjective experience. Initial observations have shown that as fatigue increases, blood pressure drops significantly, pacing slows, and response to stimuli increases, which can be explained by a decrease in nerve activity. High levels of fatigue lower motor activity, not only in the currently active (working) but also in the relatively resting organ areas, demonstrating that mental fatigue extends to the motor nerves as well. Fatigue lengthens the reaction time, making it more difficult to reproduce thoughts, thereby seizing control of the peripheral and central nervous systems (Myers 1937).

Nowadays, we can define mental fatigue as reduced alertness during monotonous and repetitive tasks (Roy, Charbonnier and Bonnet 2014), or as experiencing some sort of difficulty in maintaining an adequate level of performance on a task (Zhang, Zheng and Yu 2008). It can also be defined as a psychobiological condition that results from a strenuous, prolonged cognitive activity or occurs as a result of exercise (Trejo et al. 2015).

The most prevalent research methods for measuring mental fatigue are direct and indirect methods. In the case of direct methods, mental work-related fatigue is measured with a task requiring mental performance. Psychophysiological measurements are used to measure mental workload fatigue in indirect

methods (for example, by changes in respiration and heart rate, or by changes in the parameters of eye accommodation and eye movements).

There are subjective, behavioural, and psychophysiological manifestations of mental fatigue. It is subjectively experienced as fatigue, lack of motivation, decreased alertness, and energy deficiency. Mental fatigue can be observed objectively in the performance of a given task (e.g., a decrease in accuracy and/or an increase in reaction time).

Psychophysiological tools (such as electroencephalography (EEG) that measures brain activity) can also be used to monitor mental fatigue on a cognitive level, although they do not necessarily involve the subjective, behavioural, and psychophysiological areas. Subjectively, one may experience fatigue, but cognitively and behaviourally it does not manifest if one is able to counteract its effects with a cognitive strategy. Thus, although fatigue can be detected on a behavioural level, the individual does not experience it consciously (Cutsem et al. 2017).

Mental fatigue is a complex phenomenon that is influenced by a variety of factors, including environmental characteristics, a person's health status, vitality, and motivation in a given situation. Fatigue induces numerous alterations in mood, motivation, and information processing. Consequently, attention and interest decrease, and anxiety, frustration, or boredom can occur, making it difficult to continue the task or, in the case of learning, to acquire and record information (Zhang, Zheng and Yu 2008). At the cognitive-behavioural level, reaction time and the effectiveness of performance and decision-making deteriorate. On a subjective level, fatigue and drowsiness may be indicative.

According to studies, mental fatigue is not solely caused by the length of time spent on a particular task. Möckel, Beste and Wascher (2015) assume that the interaction between adaptation and motivational effects in the engagement of a task modulates neurophysiological parameters and also performance.

In psychophysiological characteristics, the effects of mental fatigue can be observed in eye movements and pupillometry, with fewer blinks, dry eyes, and eye muscle fatigue (Williamson and Chamberlain 2005). Examining the relationship between pupil size and task engagement, Hopstaken et al. (2015) found that task engagement was a determining factor. As involvement in the task decreases, the pupil diameter becomes larger. If a participant experiences mental fatigue, we detect slow-wave activity (such as alpha and theta) in the entire cortex using EEG (Dawson, Searle and Paterson 2014).

Throughout high mental workload, pilots and drivers demonstrated an increase in the EEG theta band and a decrease in the alpha band power. In addition, due to the transition between mental workload and mental fatigue, there was an increase in theta, delta, and alpha band EEG power. During drowsiness, increased eye blink rate and decreased heart rate values were observed (Borghini et al. 2014).

Mental fatigue is an incremental and increasing process that can impair information processing (Roy, Charbonnier and Bonnet 2014). However, the effect of mental fatigue on the processes of learning and memory is not so one-sided. According to one study, despite the fact that mental fatigue impairs performance on

explicit learning tasks, it can have a positive effect on tasks that do not require cognitive control. Borragán et al. (2016) found that mental fatigue can improve performance in automatic, procedural forms of learning.

It appears that fatigue has no effect on performance of a simple memory task. Mental fatigue can be characterised by a decline in executive control. Executive control is the ability to regulate motor and perceptual processes in order to respond adaptively to novel stimuli or shifting environmental demands (e.g., task requirements) (van der Linden, Frese and Meijman 2003).

2.3. Previous research and relevance

The effectiveness of e-learning has been studied for a very long time. Several studies, employing a variety of research methodologies, have investigated the factors that contribute to the effectiveness of e-learning: Grogan (2015) focused on the role of social and cognitive presence as well as course design utilising content analysis; Hrastinski (2008) investigated the benefits and limitations of asynchronous, synchronous e-learning through interviews and discussion analysis; Chigeza and Halbert (2014) examined educators' knowledge within the context of an e-learning redesign project; Karaksha et al. (2014) conducted a comparative study to evaluate the educational benefits of e-learning tools. Almansoori and Akre (2016) used interviews and questionnaires to summarise the factors influencing the effectiveness of blended learning, including student, faculty, and course characteristics, as well as social aspects. Since the COVID-19 pandemic, this field has become even more popular (Alqahtani and Rajkhan 2020; Maatuk et al. 2021). Due to the constant and rapid changes of learning environments, additional research is necessary.

3. Aim of the research and methodology

The aim of the recent study was to investigate the effectiveness of different e-learning materials using a variety of research methodologies (Figure 1), while taking mental fatigue into account. For this purpose, a pilot study was conducted within the framework of a comparative series of eye tracking experiments (Figure 1).

Eye tracking technology is now widely used because it enables the measurement of unconscious responses to visual stimuli, allowing for a comprehensive understanding of an individual's learning behaviour. There are numerous types of eye movement, with fixations and saccades being the most significant in terms of eye tracking technology. Fixations are typically 200–600 ms-long eye movements during which actual information acquisition and cognitive processing of visual input stimuli take place (Holmqvist et al. 2011). Saccades are rapid, ballistic eye movements that occur between fixations during which the visual system does not acquire new information (Szabó 2020). This information can be represented visually in a variety of ways (Duchowski 2017), the most common of which is the heatmap visualisation, in which all eye movements are displayed collectively. The most frequently observed

points are marked in red, while the least watched areas are marked in a cooler, greener colour. This enabled us to obtain useful information regarding the precise direction of the gaze in the learning environments (see Figures 2 and 5–6).

3.1. Preliminary data collection

Before the learning phase, we used a variety of research methodologies to ensure that the 15 participants in the three groups did not differ significantly in health, demographics, or basic working memory processes (see Section 3.4) that could fundamentally influence learning. The following research methodologies were applied for the collection of preliminary data (Figure 1):

- **Health and demographics:** We gathered demographic and health-related information first in order to exclude participants with neurological or psychiatric disorders. There were no participants to exclude.
- **Groningen Sleep Quality Scale:** We measured daily subjective sleep quality using the Groningen Sleep Quality Scale (GSQS) (Simor et al. 2009). In the 15-item questionnaire, participants self-evaluate the quality of their previous night's sleep. The range of scores is 0 to 14 (where the higher score indicates poorer quality of sleep).
- **Digit span tests:** We used the forward (digit span forwards (DSF)) and backward (digit span backwards (DSB)) versions of the digit span test (Leung et al. 2011). Participants were required to recite the sequence following the verbal presentation of the digits. If the participant recited a trial correctly, the subsequent trial would begin. If at least three of the four trials in a certain span were correctly recalled, the next span's digits were presented; otherwise, the task ended (Racsmány et al. 2005).
- **Fluency tasks:** We applied phonological (PFT), semantic (SFT), and verbal fluency tasks (VFT) to evaluate the participant's verbal functioning (Passos et al. 2014). We selected these tasks because they can be administered and scored quickly (Rofes et al. 2019). In the PFT, participants were asked to generate as many words as possible beginning with 'K' in one minute. In the SFT, participants were instructed to generate fruit names, while in the VFT, they were to generate verbs. In each task, proper nouns such as city names and the same word with a different suffix were considered errors, as were intrusions, perseverations, and derivations.

3.2. Psychomotor vigilance task (PVT)

The Psychology Experiment Building Language (PEBL) version of the PVT was used before and after the learning phase to determine whether learning caused mental fatigue (Figure 1) (Basner and Dinges 2011). PVT is an adequate method to detect behavioural alertness as it measures the exact reaction time of the participants. In the PVT, participants were instructed to immediately press the 'space bar' in response to a red circle. We reduced the number of trials to 12, so we used a shorter version of the PVT.

3.3. Post data collection

After the experiments, we implemented additional research methodologies to quantitatively and qualitatively evaluate the learning phase. The following research methodologies were used for post data collection (Figure 1):

Task Load Index: At the end of the experiment, the NASA Task Load indeX (TLX) was applied to provide information on the amount of workload experienced during a given task along several sub-dimensions (Febiyani, Febriani and Ma'Sum 2021). From the points given to these workload dimensions on a scale of 0 to 100 and based on the subjective comparison of the dimensions to each other, we derived a percentage TLX value expressing the participants' perception of their workload (Afifah 2021).

Knowledge Test: After the experiment, learning level was measured in accordance with course objectives using a knowledge test, allowing for an objective comparison of the learning outcomes of the three groups.

Interview: The experiment concluded with a personal interview exploring the insights of various digital learning materials, students' educational habits, and the causes of fatigue or any learning difficulties.

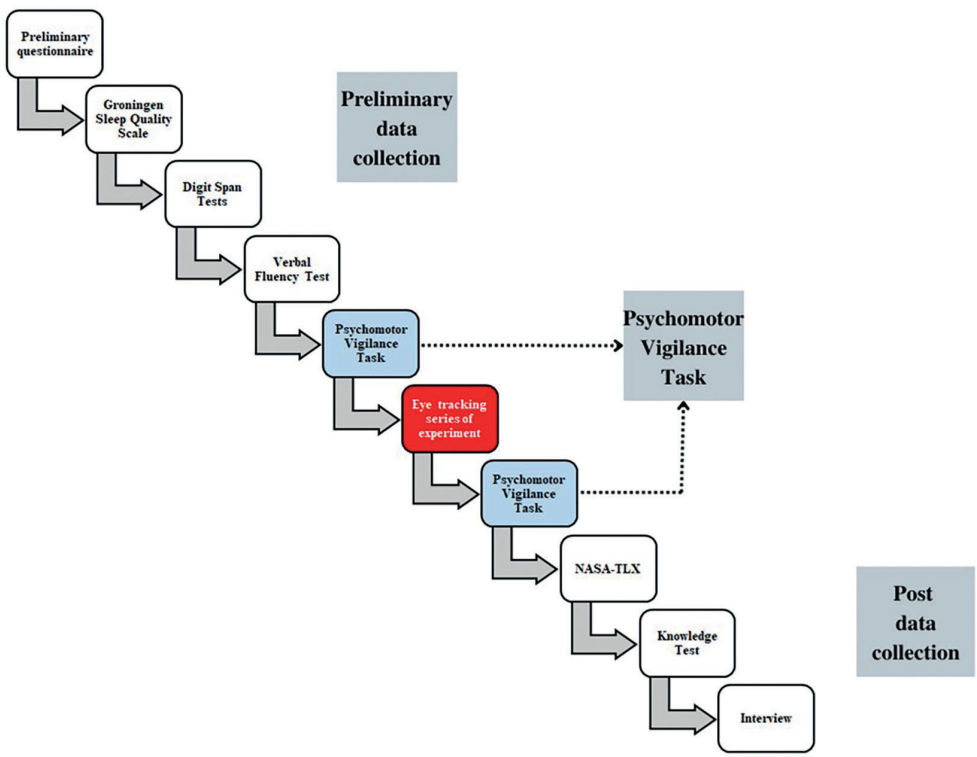

Figure 1. Research plan (own edition)

3.4. Research set-up

In e-learning materials for course pages, supporting students' learning activity is a fundamental developmental task in addition to visual appearance (Martin and Betrus 2019). The general principles and known educational-psychological solutions for providing learning activity do not offer clear development schemes in terms of the target group of students and the educational content, allowing them to be linked to individual developments in each case. Consequently, the development of the same curriculum using different methodological approaches and a comparative analysis of learning outcomes are essential. Content-equivalent but methodologically different courses ensure the comparability of fatigue and learning effectiveness in different learning environments.

In the present research, participants (n=15) were divided into three groups using different course pages designed with different methodological approaches, but with equivalent content: this was ensured by similar or equally effective learning tasks, practice tests with self-checking options, learning methodology descriptions for students, and methodological guidelines (Table 1). The first course page (for Group 1) concentrated on textual content, activity modules, practice tasks, and self-evaluation questions. The second design (for Group 2) featured standard e-learning material: the content was edited based on a screen-script that could be navigated, and was partially interactively displayed. The key component of the third solution (for Group 3) was a voice-narrated teacher presentation.

	Group 1: Modular object-oriented course page	**Group 2: Standard e-learning course page**	**Group 3: Video-based course page**
Learning methodology guidelines for the course	✓	✓	✓
Learning methodology guidelines for the module	✓	✓	✓
Curriculum with illustrative images	✓ Non-interactive Text-based Static	✓ Semi-interactive Text-based Navigable	✓ Semi-interactive Video-based Navigable
Multiple choice question	✓		
Interactive task (e.g. matching)	✓	✓	✓
Question with feedback report	✓		
Practice test with self-checking option	✓	✓	✓

Table 1. Methodological characteristics of the course pages (own edition)

Students' potential learning time was nearly equivalent to 35 minutes, based on preliminary trial learning. The experiment was conducted in a laboratory setting, where participants were required to master e-learning content after locating the assigned Product Experience course using the Moodle e-learning framework. The Product Experience course was selected due to its popularity among students at Budapest University of Technology and Economics (BME). The primary objective of the course was to provide insights into product experiences and their (interdisciplinary) scientific background. After presenting the fundamental psychological knowledge of the topic, the subject discussed unique aspects of the product experience from the product's and a human's perspectives. In the context of the present study, participants learned about various psychological school approaches.

3.5. Sample group

After a preliminary screening, students from BME and the Corvinus University of Budapest (BCE) who were interested in the Product Experience course and had no prior knowledge were recruited for the study. Five men and 10 women participated in the research; seven were BCE students and eight were BME students from entirely different fields. The participants were between the ages of 19 and 25, had an average age of 21.5, and had studied for an average of 15 years (Table 2).

Group	ID	Gender	Age	Education experience (in years)	University	Major
1	P01	Male	24	18	BME	Engineering and Management
	P02	Female	20	13	BCE	Finance and Accounting
	P08	Male	22	14	BCE	Management and Administration
	P12	Female	22	16	BME	Engineering and Management
	P15	Female	21	14	BCE	Business Informatics
2	P05	Female	22	16	BME	Mechanical Engineering
	P07	Male	19	13	BCE	Business Informatics
	P10	Male	25	19	BCE	Engineering and Management
	P13	Female	20	14	BCE	Trade and Marketing Management
	P14	Female	22	15	BME	Engineering and Management

3	P03	Female	19	13	BCE	Trade and Marketing Management
	P04	Female	19	13	BCE	Finance and Accounting
	P06	Female	23	16	BME	Engineering and Management
	P09	Male	23	16	BME	Engineering and Management
	P11	Female	22	16	BME	Engineering and Management

Table 2. Information on interviewees (own edition)

It can also be said that the grade point average (GPA) of the participants' completed semesters was 4.099 (σ=0.471) on average (on a 5-point Likert scale). Their result on the DSF test was 5.2 (σ=1.014), while it was 4.0 (σ=1.195) on DSB. For this sample, the scores on the fluency tests were 18 (σ=4.088) on PFT, 18.6 (σ=4.239) on SFT and 22.8 (σ=4.632) on VFT for the present sample (Table 3).

Group	ID	GPA	DSF	DSB	PFT	SFT	VFT
1	P01	3.29	6	4	17	14	13
	P02	4.6	4	4	18	22	24
	P08	4.55	7	4	15	18	28
	P12	4.59	3	4	11	17	21
	P15	4.33	5	3	17	24	24
2	P05	4.58	7	7	16	20	22
	P07	4.32	6	6	18	19	22
	P10	3.32	5	3	19	29	22
	P13	3.94	5	3	28	11	28
	P14	3.81	5	3	15	16	19
3	P03	4.43	5	5	25	18	27
	P04	4.43	5	3	18	17	22
	P06	3.91	5	3	19	20	26
	P09	3.44	5	4	19	18	29
	P11	3.95	5	4	15	16	15

Table 3. Preliminary results related to the participants (own edition)

Participants were assigned to the three groups based on the results of the digit span test and VFTs, as well as their GPA, so that there were no significant differences between them along these indicators (i.e., the p-values in Table 4 are greater than 0.05 in all cases). Due to the low number of items, values between groups were comparable using the Mann-Whitney U test as a non-parametric alternative to an independent sample t-test.

Groups	1 vs 2	1 vs 3	2 vs 3
GPA	U=7; W=22; Z=-1.15; p=0.25	U=7; W=22; Z=-1.15; p=0.25	U=11; W=26; Z=-0.31; p=0.75
DSF	U=9.5; W=24.5; Z=-0.65; p=0.52	U=12.5; W=27.5; Z=0; p=1	U=7.5; W=22.5; Z=-1.49; p=0.14
DSB	U=11.5; W=26.5; Z=-0.22; p=0.82	U=12; W=27; Z=-0,12; p=0.9	U=12; W=27; Z=-0.11; p=0.091
PFT	U=7; W=22; Z=-1.16; p=0.25	U=4; W=19; Z=-1.8; p=0.07	U=11; W=26; Z=-0.32; p=0.75
SFT	U=12; W=27; Z=-0.1; p=0.92	U=10.5; W=25.5; Z=-0.42; p=0.67	U=11; W=26; Z=-0.32; p=0.75
VFT	U=11.5; W=26.5; Z=-0.21; p=0.83	U=9; W=24; Z=-0.73; p=0.463	U=9,5; W=24,5; Z=-0.65; p=0.52

Table 4. Mann-Whitney test statistics on group differences (own edition)

3.6. Hypotheses

Before the test, six hypotheses regarding the effectiveness of e-learning materials were formulated. The following are examples:

Hypothesis 1: The type of e-learning material has an impact on students' motivation.

Hypothesis 2: The type of e-learning material has an impact on fatigue.

Hypothesis 3: The type of e-learning material has an impact on workload.

Hypothesis 4: The type of e-learning material has an impact on knowledge test scores.

Hypothesis 5: The type of e-learning material has an impact on reaction time.

Hypothesis 6: The knowledge test score is dependent on the GSQS, the GPA, and the time required to complete the test.

4. Results

4.1. Results of the hypothesis tests

For the purpose of examining the hypotheses, the GPA, the GSQS, the motivation points derived from the interviews, the number of fatigue key presses, the TLX value, the time required to complete the test in seconds, the percentage on the knowledge test, and the average reaction time on the PVT tests were collected (Table 5).

Group	ID	GPA	GSQS	Motivation	Number of fatigue key presses	TLX [%]	Time required to complete the test [sec]	Knowledge test [%]	PVT1	PVT2
1	P01	3.29	3	8	3	46	229	40	302.14	291
	P02	4.6	2	6	0	32	470	60	350.59	315.93
	P08	4.55	2	5	2	69	615	80	300.81	287.93
	P12	4.59	3	5	6	66	611	72	409.75	429.31
	P15	4.33	2	10	2	57	358	92	359.36	353.22
2	P05	4.58	2	7	3	64	311	68	365.99	390.76
	P07	4.32	9	9	3	39	424	84	314.11	302.92
	P10	3.32	9	5	0	27	352	88	336.77	379.47
	P13	3.94	3	8	2	50	410	84	324.11	318.12
	P14	3.81	5	8	3	41	340	52	356.59	345.37
3	P03	4.43	3	8	4	68	565	64	297.75	301.29
	P04	4.43	2	8	2	50	295	72	342.43	364.23
	P06	3.91	9	6	1	57	502	68	368.91	360.08
	P09	3.44	0	10	0	57	285	80	318.53	294.16
	P11	3.95	5	7	1	63	500	60	292.92	299.81

Table 5. Results related to hypothesis testing (own edition)

The data for Hypothesis 1 was gathered through interviews. On a 10-point Likert scale, participants were required to rate their subjective perception of their motivation during learning. The participants' subjective assessment of their motivation indicates an upward trend: for Group 1 the average was 6.8 (σ=2.168), for Group 2 it was 7.4 (σ =1.517), and for Group 3 it was 7.8 (σ =1.483). However, the Mann-Whitney U test reveals that there is no significant difference between the three groups (U=10,

W=25, Z=-0.535, p=0.592; U=8, W=23, Z=-0.961, p=.337; U=11.5, W=26.5, Z=-0.216, p=0.829). Thus, Hypothesis 1 is rejected, so the current sample does not prove that the type of e-learning material has an impact on students' motivation.

Similarly, in the case of Hypothesis 2, the number of fatigue key presses shows a decreasing trend regarding the groups: 2.6 (σ=2.19), 2.2 (σ=1.3), and 1.6 (σ=1.52). Hypothesis 2 is also rejected because the difference between the groups is not significant (U=12, W=27, Z=-0.110, p=0.913; U=8.5, W=23.5, Z=-0.851, p=0.395; U=9, W=24, Z=-0.747, p=0.548). Therefore, the present sample does not demonstrate that the type of e-learning material has an impact on fatigue.

The examination of Hypothesis 3 was based on the TLX values, which are the highest for Group 3 (on average 59%, σ=6.749). This value was lower for the remaining two course pages: 54% (σ=15.17) for Group 1 and 44.33% (σ=13.65) for Group 2. Since the difference is not statistically significant (U=7, W=22, Z=-1.149, p=0.251; U=11, W=26, Z=0.317, p=0.751; U=4.5, W=19.5, Z=-1.681, p=0.093), Hypothesis 3 was also rejected. The present sample does not prove that the type of e-learning material has an impact on workload.

In relation to Hypothesis 4, it can also be said that the results of the knowledge test demonstrate an increasing trend in the averages: 69% (σ=19.88), 74% (σ=12.20), and 79% (σ=9.55). Hypothesis 4 cannot be accepted because the difference between the groups is not statistically significant (U=10, W=25, Z=-0.524, p=0.6; U=11.5, W=26.5, Z=-0.211, p=0.833; U=7.5, W=22.5, Z=-1.051, p=0.293). The current sample does not provide evidence that the type of e-learning material has an impact on knowledge test scores.

The Wilcoxon signed-rank test can be used to examine Hypothesis 5 due to the line-by-line comparison of PVT times for the participants. Due to the small sample size, we utilised this method as a non-parametric alternative to a paired-sample t-test. Despite the fact that PVT times decreased in four cases in Group 1, three cases in Group 2, and only two cases in Group 3, the difference between the groups is not statistically significant (Z=-0.944, p=0.345, Z=-0.405, p=0.686; Z=-0.135, p=0.893). This also indicates that the hypothesis is rejected in the current sample, so it cannot be demonstrated that the type of e-learning material has an effect on reaction time.

Hypothesis 6 can be examined by Spearman correlation as the knowledge test percentage, time required to complete the test, GSQS, and GPA variables do not all follow normal distribution based on the Kolmogorov-Smirnov tests. Since the correlation coefficients differ significantly from 0 in both instances (ρ=0.065, p=0.819; ρ=0.069, p=-0.806; ρ=0.003, p=0.992), Hypothesis 6 was also rejected. This means that the knowledge test score is not dependent on GSQS, GPA, or the time required to complete the test.

4.2. Eye tracking results

The heatmap of Group 1 demonstrates that the main course page was viewed in accordance with the nature of the learning environment: the text boxes were hardly viewed by the participants, while they focused primarily on the given points, which they had to master step-by-step. Based on the findings, we can conclude that on text-oriented course pages, written content received more attention than images (Figure 2).

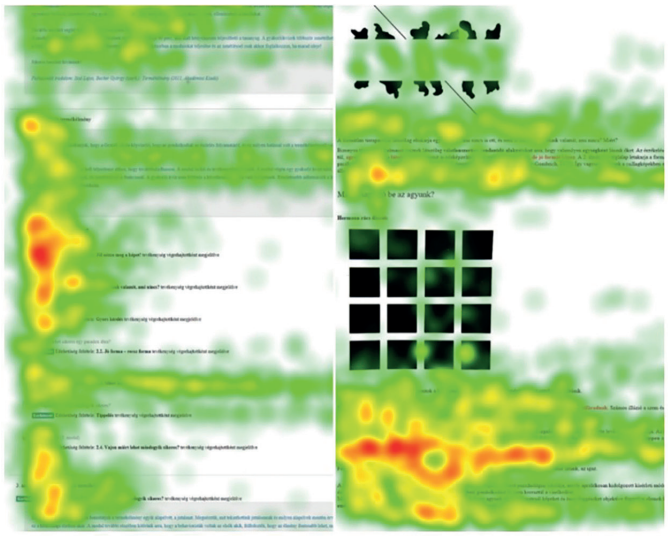

Figure 2. The heatmaps in Group 1: main course page (left) and a subpage example (right) (own edition, created in Tobii Studio)

The eye tracking software enables the selection of various areas of interest (AOIs) (Figure 3), thereby enabling the quantification of which parts of the course pages were the most significant to the participants. The most often used indicators for AOI analysis are the number of fixations and the number of visits (return to the selected AOIs), as they represent the subjective importance of the AOIs (Hámornik et al. 2013).

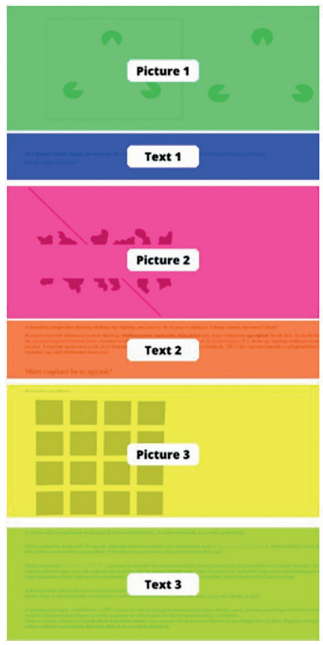

Figure 3. Defining AOIs in Group 1 (own edition, created in Tobii Studio)

On the basis of the data retrieved for the selected AOIs in Figure 3, it is possible to conclude that the total numbers of fixations and visits are higher for all participants when viewing text content (Table 6).

Group 1	Number of fixations							
	Picture 1	**Picture 2**	**Picture 3**	**Total**	**Text 1**	**Text 2**	**Text 3**	**Total**
P01	8	45	17	**70**	50	106	392	**548**
P02	4	12	14	**30**	21	71	208	**300**
P08	9	31	30	**70**	23	135	317	**475**
P12	91	159	60	**310**	26	90	503	**619**
P15	6	45	71	**122**	42	117	315	**474**
Group 1	Number of visits							
	Picture 1	**Picture 2**	**Picture 3**	**Total**	**Text 1**	**Text 2**	**Text 3**	**Total**
P01	6	37	14	**57**	39	61	215	**315**
P02	3	4	11	**18**	8	21	77	**106**
P08	5	12	15	**32**	10	31	44	**85**
P12	42	69	31	**142**	15	50	144	**209**
P15	4	13	24	**41**	7	20	40	**67**

Table 6. Quantitative information for the selected AOIs (own edition)

The Wilcoxon signed-rank test enables line-by-line comparisons of these data. Accordingly, the number of fixations and number of visits indicators differ significantly (Z=-2.023, p=0.043 in both instances). Thus, it can be concluded that text content received greater attention in Group 1 than images.

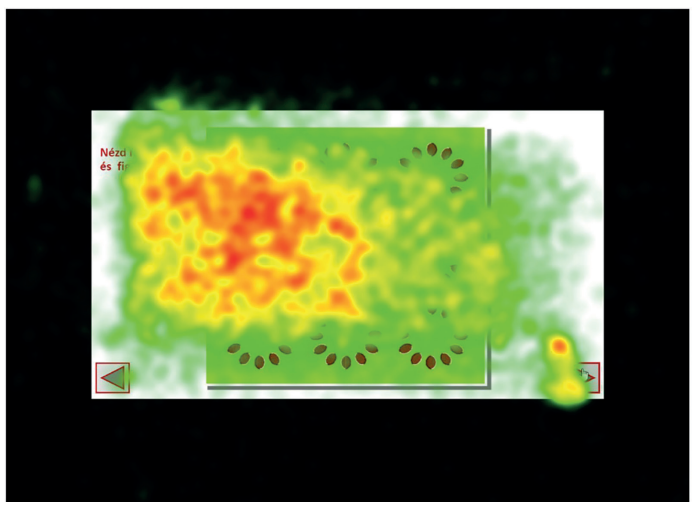

Figure 4. The heatmap in Group 2 for the whole e-learning material (own edition, created in Tobii Studio)

In Group 2, images and texts appeared together in the e-learning material, so the gaze remained predominantly within the learning area, as demonstrated by the resulting heatmap (Figure 4). This demonstrates that the participants were able to focus on the e-learning material sufficiently (with an average number of visits of 50.7 for the learning area with a standard deviation value of 40.577).

In Group 3, in addition to the e-learning content, the academic received appropriate attention during the learning process, as the resulting heatmap demonstrates (Figure 5). The participants' eyes returned an average of 125.8 times (σ=48,215) to the lower right corner, where the university professor was present, indicating the significance of this region. During the interviews, the participants in this group emphasised that the credibility of the instructor in the video was of primary importance.

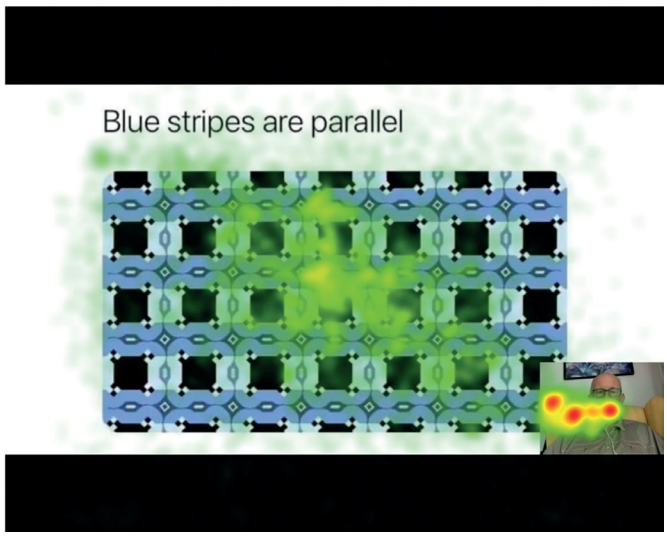

Figure 5. Heatmap example of participants in Group 3
(own edition, created in Tobii Studio)

4.3 Results of the interviews

The vast majority of students can learn effectively in complete silence, according to data collected regarding their learning environments and habits. Only two of the respondents mentioned background music. The interviews also revealed that most students like to study in the evening/night, and only one of them marked dawn as an ideal time to learn. Some justified their late-night studying by mentioning procrastination or the fact that their work schedules allow them to do it. In terms of posture, some students prefer to study in front of a computer or while sitting on the bed, while others prefer to study while lying on the bed or walking. The interviewees also mentioned adequate lighting, a clean environment, sufficient space, and the presence of plants in several instances. Regarding location, a family environment, an apartment, and a dormitory with their own room were highlighted.

In terms of learning strategy, in addition to repeatedly re-reading digital content, the majority of students learn from the notes they take during comprehending the material. Some also facilitate note-taking visually (e.g. using highlighters). Several interviewees remarked that they like video-based e-learning content because they can process it at their own pace (they can stop it, speed it up, etc.). Some of the interviewees stated that completing practice tests and previous exams also facilitates the acquisition of new information.

Most students realised that they were becoming tired when they could no longer 'grasp the material' after reading it multiple times, when their attention wandered, or when they felt drowsy all of a sudden. According to the interviewees, physical symptoms also indicate that they are already exhausted: headaches, back pain, numbness in the neck, and eye fatigue were cited. Many of the students used the phrase 'that's enough' to describe how they feel when they have studied for too long. Symptoms of fatigue experienced during the current experiment included the above-mentioned responses for those participants who pressed the fatigue indicator button.

Students have varying strategies for what to do if they become tired while studying. Most of them take breaks during which they consume coffee, water, or soft drinks. Some revitalise themselves by moving (standing up, walking, exercising, yoga), while others interact with the ones surrounding them (mostly in the form of conversation). Several students mentioned using their cell phones, browsing the Internet, and playing video games as a method of relieving fatigue.

Students expect online learning materials to be concise above all else. Importantly, the materials and course pages as a whole should be engaging, well-organised, aesthetically pleasing, and filled with practical examples.

Comments on the teaching material to be acquired within the framework of the experiment were evaluated separately along with the three groups. Four of the five participants in Group 1 enjoyed the provided e-learning content. In addition to processing difficulties and 'boring' sections, the undeveloped and poorly structured modular, object-oriented course page with a large amount of text was cited as a problem.

Participants in Group 2 overwhelmingly rated the standard, navigable e-learning material as 'good' and 'interesting'. It was easy to navigate and understand, but they disliked the excessive image sizes and dated design ('where an image floated across the entire screen was very confusing').

All five students in Group 3 liked the video-based teaching materials because the professor was always visible, making the learning experience more personal. Four of them also enjoyed using the course page, while one had a technical issue and could not comment positively. The poor design of the slides behind the video, the illegibility of the reversed texts, and the lack of text contrast contributed to their dislike.

5. Conclusion

We used both qualitative and quantitative research methods within the scope of this study. Multiple tests, eye tracking, and interviews complemented each other, demonstrating the methodological soundness of the research plan. Due to the small sample size of the current pilot study, the hypotheses had to be rejected because no

significant results were obtained. However, trends can almost always be observed; these indicate that, as the number of respondents increases, the differences between the groups will also be statistically confirmed. Despite the increasing/decreasing averages predicting differences between groups in the pilot study, it appears that the type of instructional material has an effect on the effectiveness of e-learning. The values for motivation and knowledge test scores increased between groups, whereas the subjective perception of fatigue decreased. Only the change in workload values shows no trend. Moreover, based on the changes in reaction time observed in the current pilot study, it appears that video-based course pages are the most effective form of learning materials. Moreover, interviews provide a complete picture of student preferences regarding effective e-learning materials. On the basis of the results, it is recommended to upload brief, concise video content that should be supplemented with additional materials (e.g. a slide show). Regarding professors' personalities, authenticity was emphasised, whereas written materials must be concise and interesting. The students also emphasised the importance of a large number of practice tests as a necessity for an engaging course page.

5.1. Limitations and future work

Due to the coronavirus pandemic, the study could not be conducted before the middle of the summer break. As a result, it was significantly more difficult to recruit students, which may have affected their motivation and attitude. In the pilot study, the hypotheses had to be rejected because no significant results were obtained due to the small number of items used. However, trends can almost always be observed; these indicate that it would be worthwhile to continue research by increasing the number of respondents in order to statistically confirm the differences between the groups. In addition, mental fatigue can be monitored objectively through the use of eye tracking data. According to eye tracking studies, a number of fatigue-correlated metrics, including pupil diameter, blinking, constriction velocity and amplitude, and saccadic metrics, have been identified (Benedetto et al. 2011; Morad et al. 2000). In cognitively demanding tasks, the correlation between saccadic parameters (e.g., velocity) and fatigue has been studied extensively. Researchers found that as fatigue increases, saccade velocity decreases in a variety of task settings (Stasi et al. 2013, 2015); therefore, we intend to evaluate this indicator in the near future.

References

Afifah, Fadilla Nur. 'Comparative Analysis of Mental Expenses for End-Level Students in Dealing with Online and Direct Learning with the NASA-TLX Method.' *Turkish Journal of Computer and Mathematics Education* 12, no. 4 (2021): 764–770. https://doi.org/10.17762/turcomat.v12i4.561

Almansoori, Suaad, and Vishwesh Laxmikant Akre. 'Roadmap for Enhancing Efficiency and Effectiveness of Blended E-Learning in Higher Education: A UAE Case Study.' *International Journal of Education and Information Technologies* 10, no. 1 (2016): 176–185.

Alqahtani, Ammar Y., and Albraa A. Rajkhan. 'E-Learning Critical Success Factors during the Covid-19 Pandemic: A Comprehensive Analysis of e-Learning Managerial Perspectives.' *Education Sciences* 10, no. 9 (2020): 216–231. https://doi.org/10.3390/educsci10090216

Angeliki, P., M. Asimina, and B. Eleni. 'When Instruction Meets Design: Embedding Instructional Theory Paper.' In *Proceedings of International Association for Education and Training*. Rome, Italy: N/A, 2005.

Basner, Mathias, and David F. Dinges. 'Maximizing Sensitivity of the Psychomotor Vigilance Test (PVT) to Sleep Loss.' *Sleep* 34, no. 5 (2011): 581–591. https://doi.org/10.1093/sleep/34.5.581

Batdı, Veli, Yunus Doğan, and Tarık Talan. 'Effectiveness of Online Learning: A Multi-complementary Approach Research with Responses from the COVID-19 Pandemic Period.' *Interactive Learning Environments* (2021): 1–34. https://doi.org/10.1080/10494820.2021.1954035

Benedetto, Simone, Marco Pedrotti, Luca Minin, Thierry Baccino, Alessandra Re, and Roberto Montanari. 'Driver Workload and Eye Blink Duration.' *Transportation Research Part F: Traffic Psychology and Behaviour* 14, no. 3 (2011): 199–208. https://doi.org/10.1016/j.trf.2010.12.001

Borghini, Gianluca, Laura Astolfi, Giovanni Vecchiato, Donatella Mattia, and Fabio Babiloni. 'Measuring Neurophysiological Signals in Aircraft Pilots and Car Drivers for the Assessment of Mental Workload, Fatigue and Drowsiness.' *Neuroscience & Biobehavioral Reviews* 44, no. 7 (2014): 58–75. https://doi.org/10.1016/j.neubiorev.2012.10.003

Borragán, Guillermo, Hichem Slama, Arnaud Destrebecqz, and Philippe Peigneux. 'Cognitive Fatigue Facilitates Procedural Sequence Learning.' *Frontiers in Human Neuroscience* 10, no. 1 (2016): 1–10. https://doi.org/10.3389/fnhum.2016.00086

Chigeza, Philemon, and Kelsey Halbert. 'Navigating E-Learning and Blended Learning for Pre-Service Teachers: Redesigning for Engagement, Access and Efficiency.' *Australian Journal of Teacher Education (Online)* 39, no. 11 (2014): 133–146.

Clark, Donald. *Learning Experience Design: How to Create Effective Learning That Works*. New York: Kogan Page, 2021.

Clark, Ruth C., and Richard E. Mayer. *E-Learning and the Science of Instruction: Proven Guidelines For Consumers and Designers of Multimedia Learning.* New Jersey: Wiley & Sons, 2016.

Cole, Andrew W., Lauren Lennon, and Nicole L. Weber. 'Student Perceptions of Online Active Learning Practices and Online Learning Climate Predict Online Course Engagement.' *Interactive Learning Environments* 29, no. 5 (2021): 866–880. https://doi.org/10.1080/10494820.2019.1619593

Cutsem, Jeroen van, Samuele Marcora, Kevin de Pauw, Stephen Bailey, Romain Meeusen, and Bart Roelands. 'The Effects of Mental Fatigue on Physical Performance: A Systematic Review.' *Sports Medicine* 47, no. 8 (2017): 1569–1588. https://doi.org/10.1007/s40279-016-0672-0

Dawson, Drew, Amelia K. Searle, and Jessica L. Paterson. 'Look before You (S)leep: Evaluating the Use of Fatigue Detection Technologies within a Fatigue Risk Management System for the Road Transport Industry.' *Sleep Medicine Reviews* 18, no. 2 (2014): 141–152. https://doi.org/10.1016/j.smrv.2013.03.003

Dirksen, Julie. *Design for How People Learn*. Indianapolis: New Riders, 2015.

Duchowski, Andrew T. *Eye Tracking Methodology: Theory and Practice*. New York: Springer, 2017.

Febiyani, Anastasia, Atik Febriani, and Jauhar Ma'Sum. 'Calculation of Mental Load from E-Learning Student with NASA TLX and SOFI Method.' *Jurnal Sistem Dan Manajemen Industri* 5, no. 1 (2021): 35–42. https://doi.org/10.30656/jsmi.v5i1.2789

Grogan, Deirdre. 'Disentangling the Threads: Analysing Synchronous Online Discussions.' *Creative Education* 6, no. 3 (2015): 338–349.

Hámornik, Balázs Péter, Erika Hlédik, Eszter Józsa, and Emma Lógó. 'Termékattribútumok vizuális keresése tejtermékek csomagolásán: Az érdeklődési övezetek (AOl) kijelölésének két módszerének összehasonlítása.' *Marketing & Menedzsment* 47, no. 3 (2013): 43–52.

Hokanson, Brad, Gregory Clinton, and Monica Tracey. *The Design of Learning Experience.* New York: Springer, 2015.

Holmqvist, Kenneth, Marcus Nyström, Richard Andersson, Richard Dewhurst, Halszka Jarodzka, and Joost van de Weijer. *Eye Tracking: A Comprehensive Guide to Methods and Measures*. Oxford: Oxford University Press, 2011.

Hopstaken, Jesper F., Dimitri van der Linden, Arnold B. Bakker, and Michiel A. J. Kompier. 'The Window of My Eyes: Task Disengagement and Mental Fatigue Covary with Pupil Dynamics.' *Biological Psychology* 110 (2015): 100–106. https://doi.org/10.1016/j.biopsycho.2015.06.013

Hrastinski, Stefan. 'Asynchronous and Synchronous E-Learning.' *Educause Quarterly* 31, no. 4 (2008): 51–55.

Isaias, Pedro, Demetrios G. Sampson, and Dirk Ifenthaler. *Online Teaching and Learning in Higher Education*. New York: Springer, 2020.

Karaksha, Abdullah, Gary Grant, S. Niru Nirthanan, Andrew K. Davey, and Shailendra Anoopkumar-Dukie. 'A Comparative Study to Evaluate the Educational Impact of E-Learning Tools on Griffith University Pharmacy Students' Level of Understanding Using Bloom's and Solo Taxonomies.' *Education Research International* (2014). https://doi.org/10.1155/2014/934854

Kirschner, Paul A., and Carl Hendrick. *How Learning Happens: Seminal Works in Educational Psychology and What They Mean in Practice*. London: Routledge, 2020.

Kouis, Dimitrios, Konstantinos Kyprianos, Parthena Ermidou, Pamagiotis Kaimakis, and Alexandros Koulouris. 'A Framework for Assessing LMSs e-Courses Content Type Compatibility with Learning Styles Dimensions.' *Journal of E-Learning and Knowledge Society* 16, no. 2 (2020): 73–86. https://doi.org/10.20368/1971-8829/1135204

Lacka, Ewelina, and Tse Chiu Wong. 'Examining the Impact of Digital Technologies on Students' Higher Education Outcomes: The Case of the Virtual Learning Environment and Social Media.' *Studies in Higher Education* 46, no. 8 (2021): 1621–1634. https://doi.org/10.1080/03075079.2019.1698533

Lee, Jeongju, Hae-Deok Song, and Ah Jeong Hong. 'Exploring Factors, and Indicators for Measuring Students' Sustainable Engagement in e-Learning.' *Sustainability* 11, no. 4 (2019): 985–996. https://doi.org/10.3390/su11040985

Leung, Jess L. M., Gary T. H. Lee, Y. H. Lam, Ray C. C. Chan, and Jimmy Y. M. Wu. 'The Use of the Digit Span Test in Screening for Cognitive Impairment in Acute Medical Inpatients.' *International Psychogeriatrics* 23, no. 10 (2011): 1569–1574. https://doi.org/10.1017/S1041610211000792

Maatuk, Abdelsalam M., Ebitisam K. Elberkawi, Shadi Aljawarneh, Hasan Rashaideh, and Hadeel Alharbi. 'The COVID-19 Pandemic and E-Learning: Challenges and Opportunities from the Perspective of Students and Instructors.' *Journal of Computing in Higher Education* (2021): 1–18. https://doi.org/10.1007/s12528-021-09274-2

Martin, Florence, and Anthony Karl Betrus. *Digital Media for Learning: Theories, Processes, and Solutions*. New York: Springer, 2019.

Monda, Eszter. 'eLearning sikertényezők: Egy eLearning projekt elemzése.' *Információs Társadalom* 14, no. 1 (2014): 29–51. https://dx.doi.org/10.22503/inftars.XIV.2014.1.2

Möckel, Tina, Christian Beste, and Edmund Wascher. 'The Effects of Time on Task in Response Selection – An ERP Study of Mental Fatigue.' *Scientific Reports* 5, no. 1 (2015): 1–9. https://doi.org/10.1038/srep10113

Morad, Yair, Hadas Lemberg, Nehemiah Yofe, and Yaron Dagan. 'Pupillography as an Objective Indicator of Fatigue.' *Current Eye Research* 21, no. 1 (2000): 535–542.

Moubayed, Abdallah, Mohammadnoor Injadat, Abdallah Shami, and Hanan Lutfiyya. 'Student Engagement Level in an E-Learning Environment: Clustering Using k-Means.' *American Journal of Distance Education* 34, no. 3 (2020): 137–156. https://doi.org/10.1080/08923647.2020.1696140

Myers, Charles. S. 'Conceptions of Mental Fatigue.' *American Journal of Psychology* 50 (1937): 296–306. https://doi.org/10.2307/1416638

Nedeva, Veselina, and Snejana Dineva. 'Design and Development of Efficient E-Learning Courses.' In *Proceedings of the 11th International Conference on Virtual Learning*, 108-115. Bucharest, Romania: Bucharest University Press, 2013.

Neelen, Mirjam, and Paul A. Kirschner. *Evidence-Informed Learning Design: Creating Training to Improve Performance*. New York: Kogan Page, 2020.

Nilson, Linda B., and Ludwika A. Goodson. *Online Teaching at Its Best: Merging Instructional Design with Teaching and Learning Research*. New Jersey: John Wiley & Sons, 2021.

Ollé, János. 'Oktatástervezés: A tevékenységközpontú digitális tananyag strukturális és módszertani sajátosságai.' In *Iskolakultúra és Környezetpedagógia*, 59–68. Budapest, Hungary: ELTE Eötvös Kiadó, 2018.

Ollé, János, László Hülber, Henrik Sablik, and Ágnes Kocsis. 'Development of a New Activity-Based Instructional Design Model.' In *EDEN Conference Proceedings*, 63–69. Budapest, Hungary: European Distance and E-Learning Network, 2016.

Passos, Valéria Maria de Azeredo, Paulo Caramelli, Isabella Benseñor, Luana Giatti, and Sandhi Maria Barreto. 'Methods of Cognitive Function Investigation in the Longitudinal Study on Adult Health (ELSA-Brasil).' *Sao Paulo Medical Journal* 132, no. 3 (2014): 170–177. https://doi.org/10.1590/1516-3180.2014.1323646

Racsmány, Mihály, Ágnes Lukács, Dezső Németh, and Csaba Pléh. 'A Verbális Munkamemória Magyar Nyelvű Vizsgálóeljárásai.' *Magyar Pszichológiai Szemle* 60, no. 4 (2005): 479–506. https://doi.org/10.1556/mpszle.60.2005.4.3

Rajabalee, Yousra Banoor, and Mohammad Issack Santally. 'Learner Satisfaction, Engagement and Performances in an Online Module: Implications for Institutional e-Learning Policy.' *Education and Information Technologies* 26, no. 3 (2021): 2623–2656. https://doi.org/10.1007/s10639-020-10375-1

Roediger III, Henry L., and Jeffrey D. Karpicke. 'The Power of Testing Memory: Basic Research and Implications for Educational Practice.' *Perspectives on Psychological Science* 1, no. 3 (2006): 181–210. https://doi.org/10.1111/j.1745-6916.2006.00012.x

Rofes, Adrià, Vânia de Aguiar, Bronte Ficek, Haley Wendt, Kimberly Webster, and Kyrana Tsapkini. 'The Role of Word Properties in Performance on Fluency Tasks in People with Primary Progressive Aphasia.' *Journal of Alzheimer's Disease* 68, no. 4 (2019): 1521-1534. https://doi.org/10.3233/JAD-180990

Roy, Raphaëlle N., Sylvie Charbonnier, and Stephane Bonnet. 'Eye Blink Characterization from Frontal EEG Electrodes Using Source Separation and Pattern Recognition Algorithms.' *Biomedical Signal Processing and Control* 14, no. 1 (2014): 256–264. http://dx.doi.org/10.1016/j.bspc.2014.08.007

Saleh, Mostafa, and Reda Mohamed Salama. 'Recommendations for Building Adaptive Cognition-Based E-Learning.' *International Journal of Advanced Computer Science and Applications* 9, no. 8 (2018): 385–393. http://dx.doi.org/10.14569/IJACSA.2018.090850

Shah, Raj Kapur, and Linda Barkas. 'Analysing the Impact of E-Learning Technology on Students' Engagement, Attendance and Performance.' *Research in Learning Technology* 26, no. 1 (2018). https://doi.org/10.25304/rlt.v26.2070

Simor, Péter, Ferenc Köteles, Róbert Bódizs, and György Bárdos. 'A Questionnaire Based Study of Subjective Sleep Quality: The Psychometric Evaluation of the Hungarian Version of the Groningen Sleep Quality Scale.' *Mentálhigiéné És Pszichoszomatika* 10, no. 3 (2009): 249–261. https://doi.org/10.1556/mental.10.2009.3.5

Stasi, Leandro L. di, Andrés Catena, José J. Cañas, Stephen L. Macknik, and Susana Martinez-Conde. 'Saccadic Velocity as an Arousal Index in Naturalistic Tasks.' *Neuroscience & Biobehavioral Reviews* 37, no. 5 (2013): 968–975. https://doi.org/10.1016/j.neubiorev.2013.03.011

Stasi, Leandro L. di, Michael B. McCamy, Sebastian Pannasch, Rebekka Renner, Andrés Catena, José J. Cañas, Boris M. Velichkovsky, and Susana Martinez-Conde. 'Effects of Driving Time on Microsaccadic Dynamics.' *Experimental Brain Research* 233, no. 2 (2015): 599–605.

Steen, Henry L. 'Effective ELearning Design.' *MERLOT Journal of Online Learning and Teaching* 4, no. 4 (2008): 526–532.

Sushkova, Aigul, Albina Bilyalova, Dinara Khairullina, and Chulpan Ziganshina. 'E-Learning Efficiency: Linguistic Subject Taught via Electronic Educational Resources.' *Advances in Intelligent Systems and Computing* 1114, no. 1 (2020): 197–206. http://dx.doi.org/10.1007/978-3-030-37737-3_18

Szabó, Bálint. ‘A szemmozgáskövetés története és felhasználási lehetőségeinek bemutatása az e-Kereskedelemben.’ *Információs Társadalom* 20, no. 1 (2020): 127–151. https://doi.org/10.22503/inftars.XX.2020.1.6

Trejo, Leonard J., Karla Kubitz, Roman Rosipal, Rebekah L. Kochavi, and Leslie D. Montgomery. ‘EEG-Based Estimation and Classification of Mental Fatigue.’ *Psychology* 6, no. 5 (2015): 572–589.

Van der Linden, Dimitri, Michael Frese, and Theo F. Meijman. ‘Mental Fatigue and the Control of Cognitive Processes: Effects on Perseveration and Planning.’ *Acta Psychologica* 113, no. 1 (2003): 45–65. https://doi.org/10.1016/s0001-6918(02)00150-6

Williamson, Ann, and Tim Chamberlain. *Review of On-Road Driver Fatigue Monitoring Devices*. Sydney: NSW Injury Risk Management Research Centre, 2005.

Zhang, Chong, ChongXun Zheng, and XiaoLin Yu. ‘Evaluation of Mental Fatigue Based on Multipsychophysiological Parameters and Kernel Learning Algorithms.’ *Chinese Science Bulletin* 53, no. 12 (2008): 1835–1847.

The *techne* as producer of outdated humans

This article aims at showing how the philosopher G. Anders develops his ontology of technology as described in his *Outdatedness of Mankind*, volumes I and II. The article is structured in the following manner: first, there will be a discussion on the role played by the machine in the Andersian philosophy of technology. Second, there will be an analysis on the mechanism through which radio and television alter the traditional anthropomorphic notion of 'experience' through the creation of phantoms and matrices. Third, there will be an exemplification of the consequences of humanity's progressive detachment from the awareness of its *praxis* through the Andersian notion of the 'Promethean Gap'.

Keywords: *Techne, Anders, Promethean Gap, outdated, machines*

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How to cite this article:
Ursitti, Filippo. "The techne as producer of outdated humans".
Információs Társadalom XXII, no. 2 (2022): 117–127.
https://dx.doi.org/10.22503/inftars.XXII.2022.2.7

1. Anders' first revolution and the emergence of the machine

Even though the two volumes composing the *Outdatedness of Mankind* were published twenty-five years apart – the first text appeared in 1956 and the second in 1980 – they were framed as one single comprehensive unit that discusses a common theme, namely, *techne* as 'subject of history'. The motives of Anders' research are rooted in the traumatic experience of the frightening development of the capitalist society and the mass conformism growth after the Second World War (Portinaro 2003, 58).

In this post-war context, Anders developed his theory of the 'Promethean Gap' *(Gefalle)* to describe the everyday growing distance between humanity and the world of its objects. In other words, it is the idea that technology has made – in the last century – such a step forward with the automatisation of the productive processes as to render superfluous and outdated humanity and its faculties to the point where humans almost feel inadequate for the world (Portinaro 2003, 59).

For Anders, the upsurge of technology to totalising power is recognised as the process of overturning the relations between humans and their needs (means and aims), since in this new era the means are the only source of justification of humans' needs and objectives. This technological upturn was accomplished through three distinct phases – three 'revolutions' – through which Anders defines the philosophical framework of human fate:

- The first revolution coincides with the coming into existence of the machine.
- The second revolution begins when the needs become commodities.
- The third revolution corresponds with the substitution of humans with machines.

The first phase started as soon as the 'principle of the machine' – that is, the fabrication of machines, or at least of pieces of machines – was introduced (Anders 2007, 9). This appears to be a decisive moment for Anders because it symbolises the substitution of the 'tool' with the 'machine', leading to the process of outdating (*Antiquierheit)* the 'human' in the sense that we handle a tool while the machine controls us (Anders 1987, 55).

If a tool (*Gerät*), intended as an expansion or extension of a human's limb, is under the complete will of its user, who is using it to pursue his or her own needs, then the machine is presented as independent from the human's will. The machine is capable of producing not simply commodities but means of production that, independent from their usage, will be 'means' for continuing the production. By being 'consumed', they produce something new: the situation in which it becomes necessary to produce further machines (Anders 2007, 10). The human presence in this entire process is minimal; people only participate at the beginning of this chain of production (as manual labourers) or at the end (as consumers), while the process seems to be guided by an immanent necessity that defines its aim, namely, iteration of automatisation. Inspired by an electrical blackout that occurred in the USA in 1965, Anders formulated his preliminary reflections on the nature of *techne* in general and of machines in particular in ten theses:

1. Machines expand both qualitatively and quantitatively; every machine aims, to maintain its best performance, for a condition where its indispensable external processes occur with the same mechanical precision as its internal one.

2. The expansionistic impulse of the machine is insatiable; therefore, it cannot be stopped.
3. The number of existing machines diminishes.
4. Machines degrade to parts of machines, cogs of mega-machines; hence, they become ontologically inferior to the whole of which they become a part.
5. Machines become one unique machine that tends towards the abolition of plurality.
6. The bigger the mega-machine is, the more threatened are the single components.
7. In this interdependency between the mega-machine and the plurality of smaller machines grows the danger of failure or even of catastrophe; therefore, it is characteristic of this technological world to grant some degree of autonomy to its single components to avoid a disaster.
8. Machines must be able to preserve themselves, in case of calamity, in one or more of their pieces.
9. One of the principal duties of machines consists in regulating the growth of the mega-machine.
10. *Techne* is not an absolute evil; there is a *techne* that is indispensable for the development of vast areas of the world. Thus, one of the duties of the philosophy of technology is to discover the dialectical point at which our 'yes' to *techne* must change into scepticism or a severe 'no'.

The expansion of the machine is not just a technical change; indeed, it involves a drastic modification in the society as a whole. In its impulse towards expansion, the machine tends to include what it is not yet under its control, so that energy, things, and people are just possible goods to be confiscated (Anders 2007, 101) and consumed.

All of those who become part of the mechanical process become means: the triumph of the world of apparatuses consists in the fact that it has deleted the difference between technical and social forms, thus making them indistinguishable (Anders 2007, 99). The reasoning behind Anders' choice of the word 'apparatus' (*Apparat*) relies on the fact that it can be used to identify both a physical-technical object – for example a computer – and the enterprise that 'contains' in itself humans and many singular machines that together act according to the principles of technical character.[1]

The dream of the machines is to match with each other in increasing proportions so that they can reach an 'ideal state' of existence in one perfect mega-machine that contains and surpasses all the apparatuses.[2] But this condition should not be confused with what we usually refer to as 'interdependency of production', that is, all products having mutual relations with each other. The high degree of specialisation and differentiation of the singular technical functions, making the functioning of one product dependent on the utilisation of another, imposes the command that

[1] 'To the *techne* do not belong only the "apparatuses" (*apparathafte Dinge*), i.e. the machines together with their products and the effects produced by them. To the *techne* belongs the enterprise in which we are utilised, since we work there, as instrumental parts' (Anders 1981, 180).

[2] In this sense it can be argued that Anders is a technological determinist insofar as he believes that technology does possess a set of properties that impact society in a way that, at best, can only be postponed.

every commodity, once bought, demands the purchase of other commodities; each one is thirsty for another one (Anders 2003, 194).

This first model of the expansion of the machine was later substituted by Anders with the idea of *Volksgemeinschaf*, 'the community of the apparatuses' (Anders 2007, 104), where the components of the machine have only one objective: the conquest of the totality, leading to a situation where nothing would be outside *techne*'s power (Anders 2007, 57). The world as a machine is the truly techno-totalitarian condition towards which we are going (Anders 2007, 58), a condition where 'technique', 'world', and 'society' are just different names for the same thing (Dries 2009, 39).[3]

The revolution represented by the substitution of the tool for the machine is not a mere consequence of the history of production but something concerning the totality of the human world, which now appears as the world of the apparatuses:

> Today singular machines do not exist anymore. The totality is the true machine. Every single one of them is a part, a screw, a cog of the bigger one; a piece which in part satisfies the need for other machines and at the same time imposes the need for others. It would make no sense at all to admit that this system of apparatuses, this macro-apparatus, is a 'means' that is at our disposal for freely achieving our objectives. The system of apparatuses is our world, and 'world' means something different from 'means'; it belongs to a different category (Anders 2003, 38).

In this world, from which it is impossible to escape, humans lose their freedom, surrendering it to their objects. What is changing us, by shaping and deforming us, is not just the objects mediated by the 'means' but the means themselves, which determine the usage of machines, which consequently changes us.

The things produced nowadays are maxims turned into things and modes of repressive usage that tell a story of an inverted domination where humans lose their control over the world that they have created and where they are not able to regain access to the processes that they once started. This 'emancipation of the objects' is carried out in a way in which the action stolen from humanity is given to the machines, which, therefore, represent the 'incarnated making' (*inkarniertes Handeln*), becoming 'pseudo-people' (*Pseudo-Personen*) (Anders 1961, 208). The machine's role being indistinguishable from its mode of usage is cleverly rendered by Anders with the equation *'Habere=adhibere'*, which translates as 'to have' equals 'to use'.

With this progressive growth of autonomy on behalf of the *techne* corresponds the consequential reification of humankind. Humans lose their central role of producers (*homo faber*) and their activities terminate at the extremes of mechanical production: at the beginning as inventors or manual labourers and at the end as consumers. Their natural 'deficiency' and their being anthropologically determined by their needs, on one hand, and their adaptability and plasticity, on the other hand,

[3] 'The world of the apparatuses does not only constitute itself through the model of the *Volksgemeinschaft*; in fact, *mutatis mutandis*, the latter reproduces the former. *Example par excellence* is the National Socialism with its total functionalisation (*Indienstnahme*) of the individual who was technically produced: in a way, in 1933 the radio won [the elections]' (Anders 2007, 255).

are both utilised by the industry for reiterating the consumption, to which humans are forced through the intrinsic power of the commodities. The consumeristic terror is the terror of use. Our universe of apparatuses transforms us into beings that are coerced to use (Anders 2007, 398).

Therefore, it is not unsatisfied needs that push individuals towards commodities; rather, the latter produce the former. We do not end up having that which we need; we end up feeling need for what we have; the needs depend, for their being, on the existence of the commodities. The request becomes a product of the offer, and the needs conform to the products so that at the end they are never other than footprints and reproductions of the needs of the commodities (Anders 2003, 195) which the apparatus uses to sustain itself.

The industry, which needs to equalise the hunger of the commodities as hunger for commodities, is called advertisement. Advertisement is a means of propaganda produced for the sole objective of producing the needs for products that need us since, by liquidating these products, humans guarantee continuation of the production of the commodities themselves (Anders 2007, 10). On one hand, advertisement grants the world of the technical products an ontological status: what irradiates a bigger attraction and power to exhibit itself in the *bellum omnium contra omnes* is valued and recognised as 'being' (Anders 2007, 146). On the other hand, advertisement is a plea for destruction. Through advertisement, consumers are incited to 'ruthlessness', to substitute their old commodities with newer and more fashionable versions of them. Each advertisement is a call for annihilation presented as a functional imperative of the technical apparatus, which has repercussions for our lives.

The ideal of the industry is to imitate the method applied to the industry of consumption, that is, to render as small as possible the gap between production and liquidation of the commodity (Anders 2007, 43). Anders describes this ideal condition using the fairy-tale image of 'The Land of Cockaigne',[4] a world where 'usage' does not exist anymore, and only consumption remains untouched; a world where the industry, in its complexity, is transformed into one industry comprehending all the products of consumption (Anders 2007, 37). The immanent element of destruction contained in the production leads Anders to label the ontology of the industrial era a negative ontology, where 'fluidification' of the object is as characteristic as reification of the non-objective (Anders 2007, 48). Anders here recalls the well-known idea of 'planned obsolescence', the principle according to which goods are produced with an artificially limited useful life after which they become obsolete. In this sense, both objects and humans are ahistoric in the sense that they neither come from the past nor are built for the future; they live only for the present (Anders 2007, 261). The idea of property is liquidated with the objects whose stability is substituted by the alternation of having and not-having (Anders 2007, 42).

In 'the Land of Cockaigne', the immediacy once lost after Adam and Eve were expelled from Eden is restored (Anders 2007, 313); this is the dream of *techne*. Even though its mediation character is incontestable, the apparatus exists to fulfil a de-

[4] 'An imaginary place of extreme luxury and ease where physical comforts and pleasures are always immediately at hand and where the harshness of [...] life does not exist' (Chisholm 1911, 622).

sire, that is, it reduces time and space to a minimum. The time and space between a desire and its realisation are eliminated by the immediate realisation of the desire. Time and space appear as obstacles if they are measured by the Cockaigne standard; the battle against them is the secret motto of this epoch: the abolition of time is the dream of our time. Society without time and space (rather than without classes) is tomorrow's hope (Anders 2007, 317).

In a world dominated by *techne*, humanity loses its sense of time and the possibility of making experience. The lack of temporality consists in the 'deficiency' of our being human: time exists only because we are biological beings; because we never have what we should actually have; because we constantly need to obtain what is necessary. Being-in-time means existing in the mode of not-having or the mode of achieving the *desiderata* (Anders 2007, 319).

But if experience is the way in which humanity can *a posteriori* compensate for its alienation from the world, then it is the mediation form that humanity uses to experience the objective form of the world that *techne* impedes and precludes. This is particularly clear in the entertainment industry where the world is 'served' to us in its *liquid state.* At times it is not even served but rather provided in a totally direct mode to be immediately *used* and *consumed*; by being liquid, *the commodity* is, in the act of its consumption, *liquidated* (Anders 2007, 235).*5* In both radio and television, the objective of our modern efforts seems completed because in each of them the reception of what is transmitted happens in the same moment in which the broadcast begins (Anders 2007, 322). Thus, space and time are replaced by the simultaneity of events. There is not a 'there' anymore; everything is here. Yet, if everything is here, there is no space (Anders 1970, 131).

2. The anthropological consequences of the creation of needs

In relation to the second revolution, involving the creation of needs, Anders wrote an article titled *Spuk im Radio*; it was published in 1930 in the magazine *Anbruch*, edited by T. W. Adorno. In this article Anders maintains that the radio, by allowing reproductions of the same musical piece to multiply simultaneously in different places, destroys the unity and the essence of the artwork. Anders reveals in this short analysis his opinion regarding technical means: they are extremely strange and in need of an interpretation for the fact that *techne* can create phantoms (*akzidentiell Spuk*) (Anders 1930, 66). The example of a phantom Anders gives in his *Spuk im Radio* article is radio-reproduced music. Anders notes that the ubiquity of such music can uninterruptedly continue even when he turns the radio off, because it is still being broadcast from the radios of his neighbours.

Anders notes that no means is only a means (Anders 2003, 123). This leads to the conclusion that effective critiques of the social existent status can be seriously addressed only when messages, mediums, contents, and forms are questioned. This

[5] 'It is for this reason that nowadays we find ourselves in a historic phase where the mode of sensorial reception is neither, as in the Greek tradition, the seeing nor, as in the Jewish-Christian one, the hearing but, rather, the eating'. (Anders 2007, 235, 246).

is particularly true for the mass media of radio and television. They represent a new stage in mass consumption compared to the previous 'media' (cinema and theatre) where the entertainment was 'consumed' collectively, or at least together, by a crowd that was *truly accumulated.* For radio and television, the mass product *is fabricated not only for the mass but en masse* (Anders 2007, 71). The mass of individuals is here substituted by the massification of individuals; the true revolutionary event of our time is the fact that the mass still represents only a quality of the singular and therefore must not be considered an active subject of history (Anders 2007, 81).

The principal consequence of radio and television is transformation of the public en masse. If the former, because of its characteristics (physical distance, separation, and attentive listening), presents itself as better equipped against the dangers of conformism and manipulation, then the latter, by definition, has always had negative meanings (in it the individual loses his or her characteristics: reason, control over passions, and independence of judgement). In attributing to the public the characteristics of the mass, Anders wants to highlight an intrinsic effect of the mass media themselves. Since radio and television are characterised by 'privacy of reception', they seem to realise the idea of a direct exposition of the individual to the action of the media. It is as if the means of mass communication can arrive directly to the singular individuals composing the (mass) public and turn them into slaves. TV devices, according to Anders, deprive their consumers of the word. They rob them of their faculty to express themselves, of the occasion and of the will to speak (Anders 2003, 130), making them *infantile* in its etymological meaning: minors who do not speak (Anders 2003, 132).

With the loss of language, humans lose their capacity to make experience. This is the incredible power brought by the radio and the television: that events themselves, not only the news about them, can be contemporaneously transmitted in every corner of the world in the form of broadcast. The world 'comes to us' and we do not have the need to explore it, thus making unnecessary what, until yesterday, we called *experience* (Anders 2003, 136).

Another consequence of this analysis is 'familiarisation of the world', meaning that people, things, happenings, and alien situations are presented to us as familiar facts, in a familiarised condition (Anders 2003, 139). While alienation means that what is close appears to be distant, in familiarisation everything becomes uniform and close to us. We are transformed, as spectators, in observers of the globe and of the universe (Anders 2003, 140). The motive of this phenomenon is individuated in the 'character of commodity of all phenomena', because: 1) everything that turns into commodity becomes alienated and 2) every commodity must change into something familiar (Anders 2003, 143). The principal objective of familiarisation consists in alienation itself, in hiding the causes and the symptoms of alienation. *Techne* takes from humanity its capacity to realise that it has been estranged from the world. Both familiarisation and alienation are two sides of the same coin: they both lead to the neutralisation of every event that is presented on the screen.[6]

[6] Adorno wrote in Minima Moralia: 'estrangement shows itself precisely in the elimination of distance between people' (Adorno 1978, 41).

The television broadcast defines in a new manner the relationship between humanity and reality by creating a 'new medial situation' (*neue mediale Situation*), in which the singularity consists in its *ontological ambiguity*. Broadcast events are at the same time present and absent, real and apparent; they both are and are not: they are phantoms (Anders 2003, 152). The basic principle of the transmission is to deliver what is simply simultaneous and to make it appear as a genuine presence (Anders 2003, 154). The showed images are phantoms because neither are they images in the traditional sense nor do they possess any materiality inasmuch as they are forms presented as objects (Anders 2003, 187).[7] This causes, on one hand, attenuation of the perception of the difference between reality and fiction in the spectator; on the other hand, the elusive character of the transmissions produces a transformation of our way of making experience. The broadcasts put the receiver *a priori* in a condition in which the difference between direct experience and indirect information is obliterated (Anders 2003, 177). The broadcast object appears on the television screen in its reality but not in the form of relation such as would occur with a news item about itself. And yet, this reality has the same ontological status as news – that is, it is an interpreted reality and not reality itself. This happens because 'news' is a judgement or a proposition with a double structure (subject S and predicate P) that affirms something about an absent object – for example, the wallet is full. But this 'news' does not provide the spectator with either the object itself or its image (the full wallet); it provides only 'something about it'. Of this 'something' the important and truly meaningful aspect for the S is P because the predicate allows the subject to decide how to behave. Inasmuch as the predicate makes it possible to dispose of something which is absent, to include it in the practical dispositions of the subject, the news is a form of freedom. But since it communicates only a part of the absent object, thus underlining only one aspect of it, the news is a form of unfreedom because it is a partial supply, it is a prejudice already (Anders 2003, 176), and as such it limits the addressee, dispossessing the subject of its autonomy.

In the case of the radio the distinction between mediated learning (through news) and immediate learning (through the senses) is clear, but in the television's case such a distinction is completely obliterated because it becomes difficult to say whether we are in front of a thing or a fact (Anders 2003, 177). The ontological 'doubleness' of the television relies on 1) its elusiveness, which causes the images of the television to eliminate the difference between things and news, and 2) its presenting itself as immediate, because it deceives us by pretending to be a fact while it is only a pre-selected aspect of a possible fact and a piece of news to persuade the consumer that it has no intention to persuade him. The use of the recording camera, the choice of images, their editing, and in general every passage of a broadcast event constitutes already a choice presented only from one side and never in its totality. Hence, the television exonerates the spectator from giving his or her own judgement, and as soon as it frees the spectator from the necessity of gaining a direct experience, it

[7] Anders anticipated that form of ambiguous perception of reality that is now called 'virtuality' (Liessmann 2002, 84–85).

forces him or her to accept as reality the pre-formed judgement. The TV deprives the spectator of his or her independence and autonomy of thought.

Broadcasts not only condition the way in which the subject makes experience but also reverberate on reality itself, on which they exercise a truly performative effect. The relation between reality and its transmitted form is characterised by the fact that the happening acquires more social importance in its reproduced form than in its original (Anders 2003, 134), forcing the original to conform itself to its reproduction, overturning the difference between reality and fiction. It is not reality that determines the simulation of TV transmissions; rather, the technical possibilities determine reality (Drews 2006, 69).

To understand this process, Anders goes back to the specific relation between model and reproduced commodity: on one hand, 'being' means plurality. On the other hand, the real must be adequate to its eventual reproductions; it must be transformed according to the copy of its reproductions. Given these circumstances, it is difficult to judge where reality ends and the game starts (Anders 2003, 206), as often happens in the case of sports events.[8]

Since there is no image that does not act as a model, our world is grounded on the images of itself. The world becomes its own inverted imitation. The role played by the matrix is twofold: 1) it shapes the actual events and 2) it outlines the 'soul' of the consumers. From this coincidence between the structure of reality and that of subject – both are preventively shaped – derives dire consequences that determine the character of our epoch. A vicious circle is created in which the resistance between humans and world is vehemently eliminated.

In this way, the resistance that the humanity–world relation was grounded on vanishes, thus causing the world to lose its objective character. In its disappearing the world becomes an 'edible commodity', a 'Land of Cockaigne'. The mutual relationship humanity–world, and *vice versa* world–humanity, is a matter involving two preformed entities. This is a back-and-forth process between a reality shaped by a matrix and a consumer structured by a matrix; it is a spectral affair (Anders 2003, 212).

Referring to the unreality of the world that now becomes reality, Anders affirms that the totality is less true than the entirety of its partial truths; in other words, the falsity is the whole, and only the whole (Anders 2003, 182). With this statement Anders aims at criticising television in its entirety because it constitutes a new relation of humanity with the world (Kramer 1998, 43). Even if each broadcast were to be transmitted according to the truth, the fact that many real things cannot be shown might allow the broadcast to turn them into the totality of an 'already-made' world and the consumer of such totality into an 'already-made' man (Anders 2003, 182).

Thus, the totality of the broadcasts produces a distorted picture of the world, a 'pseudo-model' of the world (Schraube 1998, 131), which becomes the sole condition of the experience. If the world is presented to the mass-man as a totality of fixed schemes, of stereotyped forms of perception and behaviour, the world risks becoming its own representation. The epochal character of this transformation relies on

[8] Anders expresses that phenomenon according to which a happening obtains attention and therefore reality only through the mass media, and to these has to preventively conform.

its precise negation of human specificity. The matrix is, therefore, the fundamental character of modern man. The 'end of the ideologies' consists today in the fact that, instead of lies about the world, we have a falsified world.

3. The Promethean Gap and tomorrow's task

This progressive detachment of humanity from the awareness of its praxis is the core of what Anders calls the 'Promethean Gap'. With this notion Anders believes that he is characterising the *conditio humana* of our time and of all the ulterior epochs (Anders 1991, 74). With the Promethean Gap, Anders refers, first, to the discrepancy between the productive ability (*Herstellen*) of humanity and its capacity of imagining (*Vorstellen*) the consequences of its own producing; and, second, to the everyday growing asynchronisation between humanity and the world of its products and the incapacity of our soul to remain up to date with our production, which makes humanity outdated, a prehistoric species.[9] It is an overturning of Platonism and the result of a dialectical process in which the imagining loses its anticipating character and trudges behind the produced objects while the producing is emancipating itself from the guiding image of the representation positing it in front of the *fiat accompli*.

The term '*Vorstellen*' loses, in this particular case, its own reason because its prefix '*vor*', which means a planned anticipation preceding the realisation of a product, is now liquidated. We face an inverted Platonic situation in which the realised objects come before their *eidos*; they appear before they are imagined in their own magnitude and in their consequences. Hence, the person who used to 'imagine' becomes now the person who 'registers' because she cannot cognitively 'keep up' with what she has done or with the incalculable power that she has gained through her *praxis*. Thus, the fundamental dilemma of our epoch is that we are inferior to ourselves and we are incapable of making an image of what we have done. In this sense we are 'inverted utopians'; while the utopians could not produce what they imagined, we cannot imagine what we produce (Anders 1961, 203). Anders calls this gap 'Promethean' because we are not good enough for the Prometheus within ourselves (Anders 2003, 279). In this way Anders overturns the revolutionary emancipatory connotation of the mythical Titan. Prometheus, lauded by Goethe in a hymn and considered by Marx 'the noblest of the saints in the calendar of philosophy' (Marx 1997, 13–14), truly freed humanity with his gift (fire, a prefiguration of *techne*), but he chained it to a new servitude, that of products.

In the pre-industrial era, the gap between producing and imagining was imperceptible, worthless and harmless; today, that is no longer the case. We cannot connect today's *Vorstellen* to yesterday's emotional level to obtain bigger and more complex sets of emotions as today's scientists base their discoveries on yesterday's *Herstellen*. Through the technological revolution, the distance between humanity's

[9] The invention of the atomic bomb preceded the creation of the anti-nuclear movement as a war precedes its war crime tribunal.

imaginative faculty and its objects' performances has dramatically increased. What should be set in motion today is not a campaign claiming humanity's omnipotence and omniscience but, on the contrary, a movement that realises that, *Vorstellen*-wise, we are inferior to ourselves.

References

Adorno, Theodor W. *Minima Moralia.* London: Verso, 1978.

Anders, Günther. *Antwortet. Interview und Erklärungen.* Berlin: Bittermann, 1987.

Anders, Günther. *Der Blick vom Mond. Reflexionen über Weltraumflüge.* Munich: C.H. Beck, 1970.

Anders, Günther. *Die atomare Drohung: radikale Überlegungen.* Munich: C.H. Beck, 1981.

Anders, Günther. *Essere o non essere, Diario di Hiroshima e Nagasaki.* Torino: Enaudi, 1961.

Anders, Günther. *L'Uomo e Antiquato*, vol. I. Torino: Bollati Boringhieri, 2003.

Anders, Günther. *L'Uomo e Antiquato*, vol. II. Torino: Bollati Boringhieri, 2007.

Anders, Günther. '*Spuk im Radio.*' *Anbruch* 12, no. 2 (1930): 64-66.

Anders, Günther. *Uomo senza Mondo. Scritti sull'Arte e la Letteratura.* Milano: Spazio Libri, 1991.

Chisholm, Hugh. *Encyclopaedia Britannica*. Cambridge: Cambridge University Press, 1911.

Drews, Wilfried. *Die Grenzen von Vorstellung Und Darstellung.* Würzburg: Könighausen & Neumann, 2006.

Dries, Cristian. *Günther Anders.* Padeborn: Fink Verlag, 2009.

Kramer, Wolfgang. *Technokratie als Entmaterialisierung der Welt. Zur Aktualität der Philosophien von Günther Anders und Jean Baudrillard.* Munich: Waxmann, 1998.

Liessmann, Konrad Paul. *Günther Anders.* Munich: C.H. Beck, 2002.

Marx, Karl. *Writings of the Young Marx on Philosophy and Society*. Indianapolis: Hackett Publishing Company, 1997.

Portinaro, Pier Paolo. *Il principio disperazione. Tre studi su G. Anders.* Torino: Bollati Boringhieri, 2003.

Schraube, Ernst. *Auf der Spuren der Dinge. Psychologie in einer Welt der Technik.* Hamburg: Argument, 1998.

The Past, Present and Future of the ELKH Cloud

This review article summarizes the history the Hungarian Scientific Cloud Infrastructure project. This research infrastructure was launched officially on 1 October 2016, funded by the Hungarian Academy of Sciences. With the support of ELKH, the infrastructure's capacity has been substantially boosted; the features and workflows that it offers to scientists were significantly expanded to celebrate the arrival of the year 2022. The article reviews the types of work Hungarian researchers implemented on the infrastructure, thereby providing an overview of the state of cloud-computing enabled science in Hungary.

Keywords: *IT History, IaaS Cloud, MTA Cloud, ELKH Cloud*

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How to cite this article:
Héder, Mihály, et al. "The Past, Present and Future of the ELKH Clouds".
Információs Társadalom XXII, no. 2 (2022): 128–137.
https://dx.doi.org/10.22503/inftars.XXII.2022.2.8

Introduction

This review article enumerates some of the achievements of the Hungarian Scientific Cloud Infrastructure project, which was formerly called MTA (Hungarian Academy of Sciences) Cloud but has now been rebranded to ELKH (Eötvös Lóránd Research Network) Cloud. This research infrastructure was launched officially on 1 October 2016, funded by the Hungarian Academy of Sciences. With the support of ELKH, the infrastructure's capacity has been substantially boosted; the features and workflows that it offers to scientists were significantly expanded to celebrate the arrival of the year 2022.

In their seminal paper, Wilson et al. (2014) explored the landscape of scientific computing and its relationship to science in general. By that time it was evident to everybody that no field of scientific investigation can progress without the use of computers. Further, other than in a few fields, reliance on computers goes way beyond office functions: they must be viewed as scientific instruments and approached accordingly. Already by the end of the first decade of this century a survey showed that a significant number of scientists were implementing scientific software and systems, 90% without prior training for such tasks (Hannay et al. 2009; Prabhu et al. 2011).

As on several occasions before in the history of science, it became clear that there needs to be a division of labour when making these tools. While Galileo was revered for making his own telescopes, his successors in astronomy needed to realise very quickly that this practice is not simply unmaintainable but, except for during the field's initial revolutionary period, presents as an outright disadvantage against their peers in the competition for knowledge. When it comes to the computing infrastructure of science, this change arrived even more rapidly.

Due to the complexity of scientific software and the computational hunger of the infrastructure running it, specialisation of work and consolidation of resources are inevitable. This happened sooner in fields where the needs were most intensive, such as twenty-first-century physics; then, with the applicability of artificial intelligence (AI), it spread to virtually all fields, even those previously thought to be rather untouched, such as philosophy and other fields of the humanities.

It is then crucial for any nation or political or commercial organisation to create the infrastructure of scientific computation in order to remain scientifically competitive; being competitive in science is one of the values accepted virtually everywhere on the planet.

History of the ELKH Cloud

The inevitable consolidation of scientific computing was acknowledged on all institutional levels from individual universities and research centres to large political entities like the EU and beyond. On the national level, in the mid-2010s in Hungary it was natural that the burden of responsibility for establishing this infrastructure fell on the national research network. The organisation not only oversaw the most

important collection of research institutes but also involved itself to some degree in university research through supported research groups (TK – 'Támogatott Kutatócsoportok') as well as through issuing Doctor of Science (DSc) titles to senior scientists, often required for full professor positions at Hungarian universities.

So, the work began to establish the research infrastructure, but, of course, it did not come about without prior know-how. Two institutes – SZTAKI (the Institute for Computer Science and Control) and the Wigner Research Centre for Physics – had already built their own institutional cloud infrastructures, so they had acquired the necessary expertise. It was this knowledge capital, together with generous funding, that made the MTA Cloud possible.

There are several types of cloud that could have been built – Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS) or Software-as-a-Service (SaaS). This series starts at the most flexible offering and ends with the most ready-to-use one. An IaaS cloud offers virtual machines access to CPU (central processing unit) and GPU (graphics processing unit) power, complete with the necessary virtualised network and storage, on top of which scientists can build their own platform without the need to interact directly with hardware; this saves all the concern over server room maintenance, electrical supply and so on.

However, the logic of increasing the complexity of scientific computing made it necessary for the infrastructure to be maintained by a specialist team, and not the scientists themselves; increasingly, too, this does not stop at the infrastructure level. As scientific computing platforms are becoming more and more elaborate, maintenance is becoming a profession of its own. As certain tools that implement the workflows of a scientific field reach a certain maturity and share of uptake by the scientist end-users – that is, they become quasi-standard tools of a field – the incentives become aligned for offering them as a ready-made platform (PaaS), so as to save even more effort for the scientists. The ultimate endpoint of this evolution, just like in any other domain of software, is SaaS, where the offering needs only to be configured and loaded with data.

The MTA Cloud provided an IaaS for its users, but this may serve as a basis for possible extensions to PaaS or SaaS. It was an inevitable choice as, technically, an IaaS is a perfect starting point for building PaaS solutions; in turn, a PaaS is required for SaaS. But a shift towards PaaS and SaaS is also inevitable for the aforementioned reasons.

Evolution of the user base over time

Natural science was very well served by the MTA Cloud in its first five years of existence. The cloud's user base was initially provided by the two founding institutions, SZTAKI and the Wigner Research Centre for Physics. This soon grew to include the partners of these institutes, both from Hungary and from abroad. After it became clear that interest in this system was increasing, the entire Hungarian research institute network was onboarded. Currently, the user base is being expanded further, towards small and medium-sized enterprises (SMEs) and the gov-

ernment. Universities also sometimes use this cloud as partners of core institutes, although it needs to be said that for educational institutions there is another cloud available in Hungary.

Life science (broadly construed) has been represented over the past five years by users from the Institute of Evolution (Evolúciótudományi Intézet), the Institute of Ecology and Botany (Ökológiai és Botanikai Intézet), the Balaton Limnological Research Institute (Balatoni Limnológiai Intézet), the Danube Research Institute (Duna-kutató Intézet), the Institute for Soil Sciences (Talajtani és Agrokémiai Intézet), the Biological Research Centre, Szeged (Szegedi Biológiai Kutatóközpont), the Institute of Organic Chemistry (Szerves Kémiai Intézet), the Agricultural Institute (Mezőgazdasági Intézet), the Institute of Enzymology (Enzimológiai Intézet) and the Institute of Experimental Medicine (Kísérleti Orvostudományi Kutatóintézet).

The sciences dealing with inanimate nature were on a par in terms of usage with the life sciences, represented by researchers from Konkoly Thege Miklós Astronomical Institute (Konkoly Thege Miklós Csillagászati Intézet), the Research Centre for Astronomy and Earth Sciences (Csillagászati és Földtudományi Kutatóközpont), the Institute for Geological and Geochemical Research (Földtani és Geokémiai Intézet), the Institute for Particle and Nuclear Physics (Részecske- és Magfizikai Intézet), the Institute for Solid State Physics and Optics (Szilárdtest-fizikai és Optikai Intézet), the Atomic Energy Research Institute (Atomenergia-kutató Intézet), the Institute of Technical Physics and Materials Science (Műszaki Fizikai és Anyagtudományi Intézet), the Institute for Nuclear Research (Atommagkutató Intézet), the Wigner Research Centre for Physics (Wigner Fizikai Kutatóközpont) and the Geographical Institute (Földrajztudományi Intézet).

The social sciences were also represented quite well, by the Institute for Sociology (Szociológiai Intézet) and other parts of the Centre for Social Sciences (Társadalomtudományi Kutatóközpont) such as the Institute for Political Science (Politikatudományi Intézet), the Research Institute for Linguistics (Nyelvtudományi Intézet) and the Institute of Economics (Közgazdaság-tudományi Intézet).

Of course, the indispensable mathematics also made use of the cloud, represented by places like the Alfréd Rényi Institute of Mathematics (Rényi Alfréd Matematikai Kutatóintézet). It was also the *subject* of research for SZTAKI, which further conducted a large amount of applied research on the infrastructure.

In 2021 the original MTA Cloud was substantially upgraded to cater for a larger uptake, more varied use cases and more GPU. The current deployment, the ELKH Cloud, enables researchers to use an IaaS cloud that is dynamically adjustable so that its size and type fit perfectly with the projects they have ongoing at the time, without having to go through complicated procurement and deployment procedures. These infrastructures range from simple desktop machines (e.g. MS Windows, Linux) to high-performance computing (HPC) clusters (e.g. SLURM); the flexibility of the ELKH Cloud makes both – and anything in between – possible, including the usage of pre-configured PaaS solutions that users can instantiate. Currently, PaaS and SaaS patterns are provided to cloud users in the form of reference architectures that are then implemented using infrastructure as code (IaC).

The present

Cloud services continue to spread rapidly for both academic and business uses. The factors behind the cloud's popularity have never faded: cloud computing is scalable and flexible, enabling users to utilise it in varying fields and at different scales, and it also represents a consolidation of know-how, alleviating scientists of the need to build infrastructures. In recent years, ELKH has taken over the mantle as caterer of cloud resources to Hungarian researchers; its continuance of operations and the upgrades were made possible by the joint efforts of SZTAKI and the Wigner Research Centre for Physics.

The current (as of the beginning of 2022) infrastructure offers 5904 virtual CPUs, 28 terabytes of RAM and 1248 terabytes of hard disk drive (HDD) capacity complemented by 228 terabytes of solid-state drive (SSD), both three times replicated. Its internal network offers 100 Gb/s.

The time frame of the existence of the current research infrastructure and its institutional predecessors at SZTAKI and Wigner saw an exponential growth in GPU-based machine learning as well as GPU-based simulation. Therefore, the upgraded ELKH Cloud offers substantial GPU resources. The 68 GPUs hosted by the system offer 2400 GB of GPU RAM, yielding 1174 teraflops of single-precision or 584 teraflops of double-precision computing capacity; or, for half-precision (FP16) TensorFlow workloads, 13736 teraflops.

Scientific use cases

The aforementioned shift of emphasis from IaaS to PaaS and SaaS is expressed by the growing number of reference architectures and platforms offered by the ELKH Cloud.

A reference architecture is a pre-arranged set of solutions to a typical scientific workflow – in essence, they are templates that help to kick-start a scientific project while alleviating the complexity of the initial configuration, a very taxing task for the users.

Some of the reference architectures are commonly used cloud stacks all over the world. These include:

- JupyterLab (Granger and Grout 2016), which allows for running JupyterLab notebooks (Bisong 2019) with or without GPU. A JupyterLab notebook is a widely used tool in machine learning research and education;
- Apache Spark (Salloum et al. 2016), which can be coupled with RStudio (Racine 2012) as well as with Python, and which enables big data research and, ultimately, thanks to the versatility of RStudio and Python, any other kind of research;
- Docker Swarm cluster, which is a distributed system of systems solution for engineers (Naik 2016);
- Kubernetes (Luksa 2017), which is a clustered distributed service deployment system;

- TensorFlow (Pang, Nijkamp and Wu 2020), which is a generic machine learning framework; and
- Keras, which is a deep learning framework (Ketkar 2017).

However, the ELKH Cloud also features more advanced solutions that are developed locally by the cloud team. This set of tools includes the Occopus cloud orchestrator, which '*provides a language to specify infrastructure descriptions and node definitions based on which Occopus can automatically deploy and maintain the specified virtual infrastructures in the target clouds*' (Kovács and Kacsuk 2018; Kovács et al. 2018; Lovas, Nagy and Kovács 2018; Lovas et al. 2018; Kacsuk, Kovács and Farkas 2018). An example usage of this is the Apache Hadoop architecture orchestrated by Occopus (Lovas, Nagy and Kovács 2017; Nagy, Kovács and Lovas 2016).

Some typical scientific research requires workflows and pipelines of processing. These are facilitated by Flowbster (Kacsuk, Kovács and Farkas 2018), which is a cloud-oriented workflow system. It was designed to create data pipelines in clouds that could efficiently process very large data sets. The Flowbster workflow can be deployed on the ELKH Cloud, on-demand with the help of the underlying Occopus cloud deployment and orchestration tool.

Moving on to storage, DataAvenue is on offer (Hajnal, Farkas and Kacsuk 2014; Hajnal et al. 2014, 2015, 2018). This data storage management service provides access to different types of storage resource (including S3, sftp, etc.) using a uniform interface.

And, of course, the authentication method matches the user base; with the help of the eduGAIN-enabled Hungarian SAML federation (eduID.hu) and a module developed for OpenStack by the MTA Cloud team (Héder, Tenczer and Biancini 2019), there is no need for local passwords for any users. The authorisation is performed by HEXAA (Tétényi et al. 2015).

International outlook

Science is international and so are the ambitions of the user base of the ELKH Cloud. From the very beginning, it was typical to have international collaborators working on the project. This was achieved by leveraging the eduGAIN worldwide login federation.

However, enabling user mobility alone soon became insufficient. Researchers also expect collaboration between the facilitating institutions. A major vehicle for that collaboration is the European Open Science Cloud (EOSC); another is the European Strategy Forum on Research Infrastructures (ESFRI). In order to integrate with these international efforts, SZTAKI participates in two EU-funded projects. In EGI-ACE the compatibility with other EOSC clouds is ensured, while in the SLICES-SC project we participate in an ESFRI effort that prepares the European usage of the Scientific LargeScale Infrastructure for Computing/Communication Experimental Studies.

Security challenges

As data has become the oil of the twenty-first century, recognition of scientific data as a bearer of value is also increasing in national researcher communities. Data

collection and analysis techniques are applied in more fields of study than ever before. The ELKH Cloud and its sibling project, ELKH Data Repository, are among the leading infrastructures supporting the Open Science and Open Data movements in Hungary. The inclusive attitude of the project attracts many researchers as well as an increasing number of private entities interested in applied research.

As a result of its central role and ease of access, the infrastructure is experiencing an unparalleled volume in terms of ingress (and egress) of heterogeneous research data. Depending on the field of science, this may include data originating from 'clearly' scientific equipment, like astronomical sensors, but also from medical imaging devices, together with patient records necessary for meaningful analysis. Besides similarly clear data protection issues, more subtle considerations are also present in cooperative and applied research scenarios where special intellectual property issues can often arise, for example during scientific analysis of partially anonymised financial transactions or sensor data originating from industrial environments holding trade secrets.

This renders the ELKH Cloud not only an indispensable platform for efficient collaboration but also a cybersecurity target with considerable value. Involvement of national research communities in modern research techniques also implies raising awareness of various underlying issues, introducing individuals to the ever-changing balance between acceptable levels of usability and information security.

For these reasons and in order to keep the legal constituency clear in most cases, a strategic decision was made. The ELKH Cloud is committed to keeping its infrastructure 100% within national borders, utilising the holistic technical competency of the two research institutes that host its data centres. This is achieved while still maintaining support for scale-out operations with different research infrastructures, including well-known public cloud providers.

In order to improve resilience against malicious activities, the infrastructure is engineered considering security requirements from the first step of its planning. All internal and external components are isolated by various containment techniques to the point where they can still provide services as requested. Continuous security monitoring of internal infrastructure components and perimeter defence appliances is complemented by periodic active security scans of the hosted scientific projects. Security incident prevention and management processes are maintained in order to keep the overall attack surface at a minimal level.

User policies are also defined so that the shared responsibility of the infrastructure and its users is clear from the beginning; further, security-related consulting services are included in the primary user support package.

Future of the ELKH Cloud

As with any contemporary scientific infrastructure, both the policy-related and the technical issues need to be addressed in an integrated manner. This is especially important when it comes to protection of the research data. Policy decisions and data

governance may be facilitated with built-in templates and tools, which constitute a future research area.

Another important area of improvement is the implementation of even more PaaS and SaaS functionality and reference architectures. Also, not only are new user-facing features planned but integration of the ELKH Data Repository is also on the agenda. This component allows for long-term storage of data, instead of handling working data as IaaS clouds usually do. Long-term data retention that happens in such a way as to obviate the need for the researcher to worry about maintenance is an important and often requested feature.

Another area of future work is introducing specialised hardware: it is a current trend in AI, for example, that in order to gain performance advantages certain algorithms are implemented not in software but in special-purpose hardware (such as ASICs, which stands for application-specific integrated circuits). Yet another area is the hybrid cloud – in this set-up, on-premise cloud computing can combine its workflows with a public cloud, such as Microsoft Azure or Amazon AWS.

The ELKH Cloud has during the first five years of its existence proven itself to be a popular platform among researchers. This was achieved by the cloud maintainers being responsive to trends in use of the tools of internationally competitive science. This trajectory is a century-long professionalisation and division of labour in the instruments of science. The trend is unlikely to stop; therefore, we expect the ELKH Cloud to grow and become even more extensively used in the future.

References

Bisong, Ekaba. *Building Machine Learning and Deep Learning Models on Google Cloud Platform.* New York City: Apress, 2019.

Granger, Brian E., and Jason Grout. *Jupyterlab: Building blocks for interactive computing.* Slides of presentation made at SciPy, 2016.

Hajnal, Ákos, Zoltán Farkas, and Péter Kacsuk. 'Data avenue: Remote storage resource management.' In *WS-PGRADE/gUSE, 6th IEEE International Workshop on Science Gateways (IWSG)*, 1–5. Dublin, Ireland: International Workshop on Science Gateways (IWSG), 2014.

Hajnal, Ákos, Zoltán Farkas, Péter Kacsuk, and Tamás Pintér. 'Remote storage resource management in WS-PGRADE/gUSE.' In *Science Gateways for Distributed Computing Infrastructures: Development Framework and Exploitation by Scientific User Communities*, edited by Péter Kacsuk, 69–81. New York City: Springer, 2014.

Hajnal, Ákos, István Márton, Zoltán Farkas, and Péter Kacsuk. 'Remote storage management in science gateways via data bridging.' *Concurrency and Computation: Practice and Experience* 27, no. 16 (2015): 4398–4411.

Hajnal, Ákos, Enikő Nagy, Péter Kacsuk, and István Márton. 'Data migration for large scientific datasets in clouds.' *Azerbaijan Journal of High Performance Computing* vol. 1, issue 1(2018): 66–86.
https://doi.org/10.32010/26166127.2018.1.1.66.86

Hannay, Jo Erskine, Hans Petter Langtangen, Carolyn MacLeod, Dietmar Pfahl, Janice Singer, Greg Wilson. 'How do scientists develop and use scientific software?' In *Proceedings of the Second International Workshop on Software Engineering for Computational Science and Engineering*, 1–8. Piscataway, New Jersey: IEEE - Institute of Electrical and Electronics Engineers Inc., 2009.
https://doi.org/10.1109/SECSE.2009.5069155

Héder, Mihály, Szabolcs Tenczer, and Andrea Biancini. 'Collaboration between SAML federations and OpenStack clouds.' *SoftwareX 9* (2019): 44–48.
https://doi.org/10.1016/j.softx.2018.12.003

Kacsuk, Péter, Zoltán Farkas, Miklós Kozlovszky, Gábor Hermann, Ákos Balasko, Krisztián Karóczkai, and István Márton. 'WS-PGRADE/gUSE generic DCI gateway framework for a large variety of user communities.' *Journal of Grid Computing* 10, no. 4 (2012): 601–630.

Kacsuk, Péter (ed.). *Science Gateways for Distributed Computing Infrastructures: Development Framework and Exploitation by Scientific User Communities*. Springer International Publishing, 2014.

Kacsuk, Péter, József Kovács, and Zoltán Farkas. 'The Flowbster cloud-oriented workflow system to process large scientific data sets.' *Journal of Grid Computing* 16 (2018): 55–83.
https://doi.org/10.1007/s10723-017-9420-4

Ketkar, Nikhil. *Introduction to Keras*. New York City: Apress, 2017.

Kovács, József, and Péter Kacsuk. 'Occopus: A multi-cloud orchestrator to deploy and manage complex scientific infrastructures.' *Journal of Grid Computing 16*, no. 19 (March 2018): 1-19.
https://doi.org/10.1007/s10723-017-9421-3

Kovács, József, Péter Kacsuk, and Márk Emődi. 'Deploying Docker Swarm cluster on hybrid clouds using Occopus.' *Advances in Engineering Software 125* (November 2018): 136–145.
https://doi.org/10.1016/j.advengsoft.2018.08.001

Lovas, Róbert, Enikő Nagy, and József Kovács. 'Cloud agnostic orchestration for big data research platforms.' In *Proceedings of the Fifth International Conference on Parallel, Distributed, Grid and Cloud Computing for Engineering*, Paper 15., edited by Péter Iványi, Barry H. V. Topping, and Géza Várady, Dun Eaglais Station Brae. United Kingdom: Civil-Comp Press, 2017.
https://doi.org/10.4203/ccp.111.15

Lovas, Róbert, Enikő Nagy, and József Kovács. 'Cloud agnostic big data platform focusing on scalability and cost-efficiency.' *Advances in Engineering Software 125* (2018): 167–177.
http://dx.doi.org/10.1016%2Fj.advengsoft.2018.05.002

Lovas, Róbert, Attila Farkas, Attila Csaba Marosi, Sándor Ács, József Kovács, Ádám Szalóki, and Botond Kádár. 'Orchestrated platform for cyber-physical systems.' *Complexity* (2018):1–16. Paper: 8281079.
http://dx.doi.org/10.1155%2F2018%2F8281079.

Luksa, Marko. *Kubernetes in Action*. New York, USA: Simon & Schuster, 2017.

Nagy, Enikő, József Kovács, and Róbert Lovas. 'Automated and portable hadoop cluster orchestration on clouds with Occopus for big data applications.' In *Proceedings of the Cracow Grid Workshop '16 CGW 2016*, edited by Marian Bubak, Michał Turala and Kazimierz Wiatr, 47-48. Kraków, Poland: Academic Computer Centre, 2016. ISBN: 978-83-61433-20-0.

Naik, Nitin. 'Building a virtual system of systems using Docker Swarm in multiple clouds.' In *2016 IEEE International Symposium on Systems Engineering (ISSE),* 1–3. Edinburgh, UK: IEEE, 2016.

Pang, Bo, Erik Nijkamp, and Ying Nian Wu. 'Deep learning with TensorFlow: A review.' *Journal of Educational and Behavioral Statistics* 45, no. 2 (2020): 227–248.

Prabhu, Prakash, Thomas B. Jablin, Arun Raman, Yun Zhang,Jialu Huang, Hanjun Kim, Nick P. Johnson, Feng Liu, Soumyadeep Ghosh, Stephen R. Beard, Taewook Oh, Matthew Zoufaly, David Walker, and David I. August. 'A survey of the practice of computational science.' In *Proceedings of the 24th ACM/IEEE Conference on High Performance Computing, Networking, Storage and Analysis,* 19:1–19:12.New York (USA): Association for Computing Machinery, 2011.
https://doi.org/10.1145/2063348.2063374

Racine, Jeffrey Scott. '*RStudio: A Platform-Independent IDE for R and Sweave*.'
Journal of Applied Econometrics, John Wiley & Sons, Ltd. 27, no. 1 (2012): 167-172.

Salloum, Salman, Ruslan Dautov, Xiaojun Chen, Patrick Xiaogang Peng, and Joshua Zhexue Huang. 'Big data analytics on Apache Spark.' *International Journal of Data Science and Analytics* 1, no. 3 (2016): 145–164.

Tétényi, István, Mihály Héder, Zsuzsanna Magyar, and Kristóf Bajnok. 'Open Call Deliverable OCK-DS1.1 Final Report (HEXAA) Paper: OCK-DS1.1.' 2015.
https://geant3plus.archive.geant.net/Documents/HEXAA_final_report.pdf

Wilson, Greg, Dhavide A. Aruliah, C. Titus Brown, Neil Philippe Chue Hong, Matt Davis, Richard Guy, Steven H.D. Haddock, Kathryn Dorsey Huff, Ian M. Mitchell, Mark D. Plumbley, Ben Waugh, Ethan P. White, and Paul Wilson. 'Best practices for scientific computing.' *PLoS Biology 12, no. 1* (2014). e1001745.
https://doi.org/10.1371/journal.pbio.1001745.